…rojects …thorized …struction Started	Total
11.8	$ 663.0
	243.5
.5	38.9
1.8	70.2
	158.2
14.1	1,173.8
.1	34.0
	4.6
	3.0
.1	3.9
	1.9
	34.0
1.5	191.1
73.9	142.8
75.4	333.9
268.7	$8,142.3

…23, 1959.

UNITED STATES ATOMIC ENERGY COMMISSION

Annual Report to Congress

OF THE

ATOMIC ENERGY COMMISSION

FOR

1960

ATOMIC ENERGY COMMISSION · UNITED STATES OF AMERICA

January 1961

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

LETTER OF SUBMITTAL

WASHINGTON, D.C.,
20 January 1961.

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1960 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
JOHN S. GRAHAM.
LOREN K. OLSON.
ROBERT E. WILSON.
JOHN A. MCCONE, *Chairman.*

The Honorable
The President of the Senate.

The Honorable
The Speaker of the House of Representatives.

CONTENTS

PART TWO

Major Activities in Atomic Energy Programs January–December 1960

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APPENDICES

FOREWORD

The record of 1960 shows that atomic energy continues its vital role in our national defense effort. The growth of the atomic power segment of the atomic energy industry has kept pace with the technological progress achieved. Commercial services and supplies of materials are adequate for industry and Government requirements.

Experience is being gained in operating major power reactors. Until now, the principal experience in operating reactors has been either from naval propulsion reactors, or from the Shippingport Atomic Power Station. This year, two more nuclear plants produced electricity—plants with a capacity of 290,000 kilowatts. Within the next 2 years, 648,000 additional kilowatts of nuclear capacity will be completed. By the end of 1962, the installed nuclear capacity will be more than 1,000,000 kilowatts. Operation of these plants will help increase efficiency of design and operation and cut costs.

We are exploring new and radical concepts for power reactors with the objective of reducing further the cost of power from nuclear sources. Construction and operation of reactor experiments and prototypes is deepening and widening our technology. We are applying the know-how of national laboratories and industrial organizations to the tasks of simplifying equipment, improving safety, and cutting fuel cycle costs.

This broad effort will steadily increase our technical competence. However, we cannot predict exactly when we will achieve costs for nuclear power that can be considered competitive with fossil-fueled conventional plants. Three utility organizations advise us that they are considering building large nuclear power plants mainly on the basis of economic considerations. These developments indicate that this country is at least close to the point where investment in large nuclear power plants in certain areas may be considered economical over the life of the plants.

In other countries, the Atoms for Peace program has helped to stimulate interest in putting atomic energy to work in beneficial applications.

Several nuclear power plants should be operating in Western Europe by 1965; one of 150,000 kilowatts by 1963. The Western European nuclear power program has progressed less rapidly than originally expected. The costs of fossil fuels there took a sharp downward turn, so that Western Europe's conventional power costs, formerly much higher, have declined sharply and, in some countries or areas, now are nearly as low as power costs in some areas of the United States.

Recent actions of India and Japan indicate their firm interest in putting nuclear power to work.

Obstacles to further progress in nuclear power for the free world are being eliminated or lessened through the work of international atomic energy organizations with which we cooperate. Safeguards against diversion of nuclear materials from peaceful uses have been approved by the International Atomic Energy Agency. Some progress has been made on provision of indemnification against nuclear accidents. The IAEA and other international agencies expect ultimately to take over many of the responsibilities and functions that now come under bilateral agreements on peaceful uses of atomic energy between the United States and other countries.

The use of radioisotopes continues to expand, and we hope to accelerate this expansion by developmental research to find new uses and techniques. We are exploring new ways of putting radiation to work—in the preservation of foodstuffs and sterilization of medical supplies, or in the production of improved materials with new applications.

Research and development are making broad and continuous contributions to the advancement of scientific knowledge and to the progress of technology for peaceful applications. Some developments contribute promptly to our welfare—for example, the use of radioisotopes in biology and medicine and industry; other benefits are for the long term.

Production of nuclear materials, from mines to fuel elements and nuclear weapons, has continued with steadily improved efficiency and economy, and at rates consistent with national needs.

The domestic mining and milling industry has been placed on a stable basis with production being brought into balance with current military needs and civilian requirements. There is a potential for prompt expansion whenever needed. Domestic sources now supply slightly more than half the total amount of uranium we require annually.

The Commission continues to place firm emphasis upon strengthening safety precautions on uses of radiation in its own operations and those of licensed users of atomic energy. The standards limiting radiation exposures of workers in the industry have been reviewed, established, and promulgated. To assist public understanding of radiation problems, the Commission has initiated full periodic reports to the public on radiation levels in the vicinity of its installations sites for land burial of wastes have been designated on Federal property.

Considerable groundwork has been laid with the States under Public Law 86–373 so that the States may know the steps to be taken to qualify for taking over responsibility for certain areas of radiation regulation and enforcement.

In the field of national defense, the Commission can take satisfaction in having developed and manufactured a variety of nuclear weapons and warheads in ample quantities to meet the current requirements of the Department of Defense. Nuclear weapons have been made available for strategic and tactical air forces and for missile batteries. During 1960, the first submarine armed with nuclear missiles as well as powered with a nuclear reactor—the Polaris missile-carrying U.S.S. *George Washington*—undertook its first routine mission. The world knows we have an ample store of a variety of nuclear weapons—an armament that represents a powerful deterrent against aggression.

Testing of nuclear weapons has been suspended by the United States for more than 2 years. During this period, the United States has participated in negotiations among the nuclear powers with the objective of achieving a treaty on cessation of nuclear weapons tests which would provide adequate safeguards against clandestine testing. These negotiations, and the United States research program to improve the capability of detecting and identifying nuclear tests, are reviewed in the body of this report.

The Commission recognizes that radioactivity from nuclear tests is a source of concern in the minds of many people—regardless of whether or not the fears of fallout radiation are scientifically valid. Accordingly, the Commission would propose that future tests, if any, be conducted underground, or in space beyond the earth's atmosphere, in such a way as not to cause fallout.

This Commission is fully in accord with the national policy of attaining cessation of nuclear weapons tests under a treaty that would establish international controls adequate to assure compliance with its provisions. The Commission, however, also feels a strong sense of responsibility to point out the risks to free world supremacy in nuclear weapons—and the resultant threat to the free world—that are implicit in a continued unpoliced moratorium on weapons testing.

Nuclear weapons development is not a static science. Important advances in weapons design are possible—advances which would have great military significance. They could include improvements in many fields, such as new "battlefield" weapons and improvement of the weight-to-yield ratio of a variety of bombs and warheads. Our weapons scientists are convinced that further nuclear testing would achieve major advances in weapons design.

We must not assume that the United States is the only nation which could achieve dramatic advances in nuclear weapons technology. It is technically possible at present to conduct nuclear tests underground in a clandestine manner, with little or no possibility of detection and identification. Methods also could be developed for conducting tests in outer space—tests that would be extremely difficult to detect and identify. Improved methods of detecting and verifying nuclear explosions, and installation of a control system with provision for an adequate number of inspections of localities where suspicious events have been detected, are necessary if an international agreement is to be adequately monitored.

The military advantages to be gained from clandestine nuclear testing are great, and the probabilities of detecting and identifying clandestine tests are very small. This will be the free world's situation so long as there is an unpoliced *de facto* moratorium on nuclear weapons testing.

The Commission recognizes that a treaty to refrain from nuclear weapons tests under conditions of adequate control might be a significant step toward better international relations. Such a treaty might well point the way toward agreements and controls in important areas of disarmament. The United States has expressed its willingness to forgo weapons development which could be achieved through testing if a treaty were attained that provides adequate means of detecting violations. It would be quite another matter, however, to continue indefinitely a self-imposed moratorium on the testing of nuclear weapons while the means of detecting violations does not exist.

The Atom

Part One

The Atomic Energy Industry in 1960 and Related Activities

Industry And Commission Activities

In this first part of this Annual Report to Congress for the year ended December 31, 1960, the Atomic Energy Commission presents a summary of the present state of the atomic energy industry and developments affecting the industry. Progress under the Commission's program for development of economic nuclear power reactors is reviewed, and activities in the programs through which the Commission supports and assists the industry are described. Part Two reports on progress in other major programs of the Commission and provides details of activities summarized in Part One.

The Nuclear Reactor Industry

Sixty-six civilian and military reactors were under active design or construction in the United States as of mid-1960 with a total estimated cost of $1,328 million exclusive of reactors for propulsion of naval vessels and aircraft and space reactor work.[1] These mid-1960 figures compared with $1,234 million estimated cost of 59 reactors in the same categories as of mid-1959. The estimates are based on surveys conducted each quarter by the Atomic Energy Commission and regularly published as available. The latest figures assembled as of the time of this report were for the quarter ended June 30, 1960.

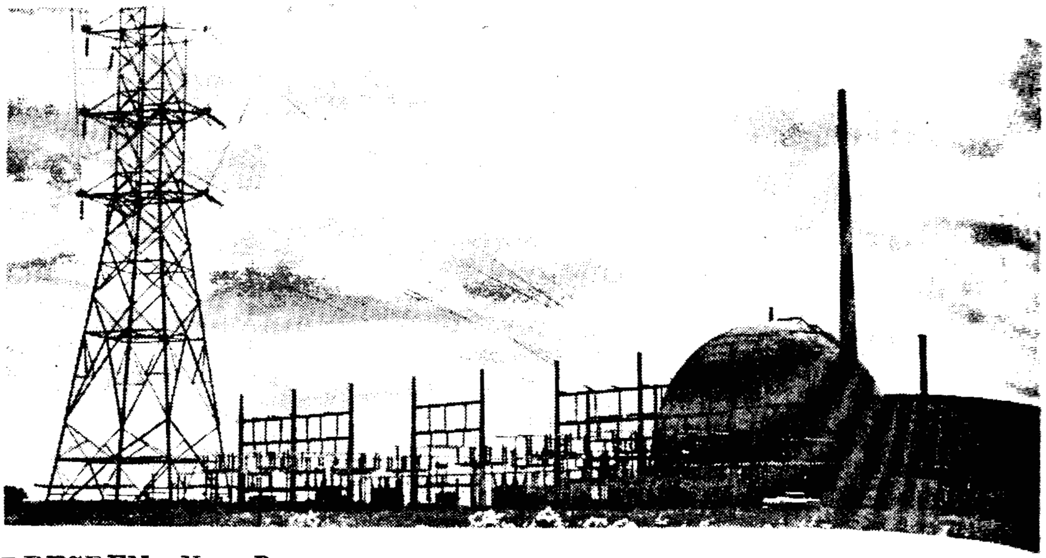
The Commission estimated that the costs incurred for the year ended June 30, 1960 totaled about $641 million for the entire reactor field exclusive of naval propulsion reactors. This figure included $289 million for reactors under active design or construction during the year, some $127 million for aircraft and space reactor work, and about $225 million for other reactor research and development.

Costs for naval propulsion reactors apparently continued to be incurred at about the same levels as last year with 36 reactors authorized or under construction as of June 30, 1960, compared with 40 at an equivalent time the previous year. Nuclear propulsion plants under construction or authorized for installation in naval vessels as of June 30, 1960, had a total estimated cost of $402 million compared with $418 million as of June 30, 1959. By the end of December 1960, an addi-

(Continued on p. 6.)

[1] 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, nonnuclear portions of central station electric power plants, land for sites, and training of operators. An exception is the N.S. *Savannah* on which only the nuclear plant costs are included.

Reactors in 1960



DRESDEN—*New Power*

YANKEE—*New Po*

Operating experience and firm cost data based on routine operations of nuclear central power stations, plus constantly advancing technology, are the keys to the national effort to achieve competitive costs for nuclear power. Two new large nuclear stations started producing power during 1960. (See upper photos) During the next two years, new nuclear stations will add 648,000 kilowatts to the

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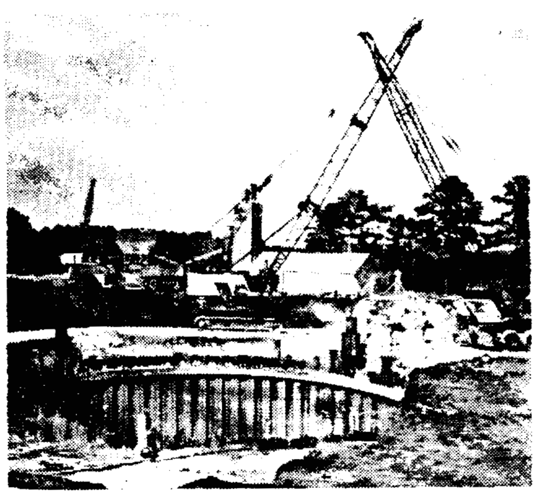
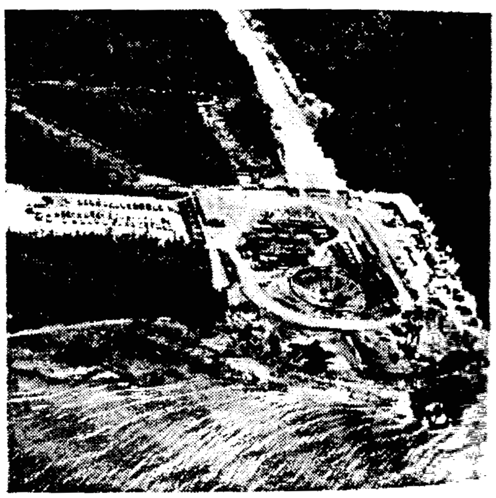
CAROLINAS-VIRGINIA—*New Start*

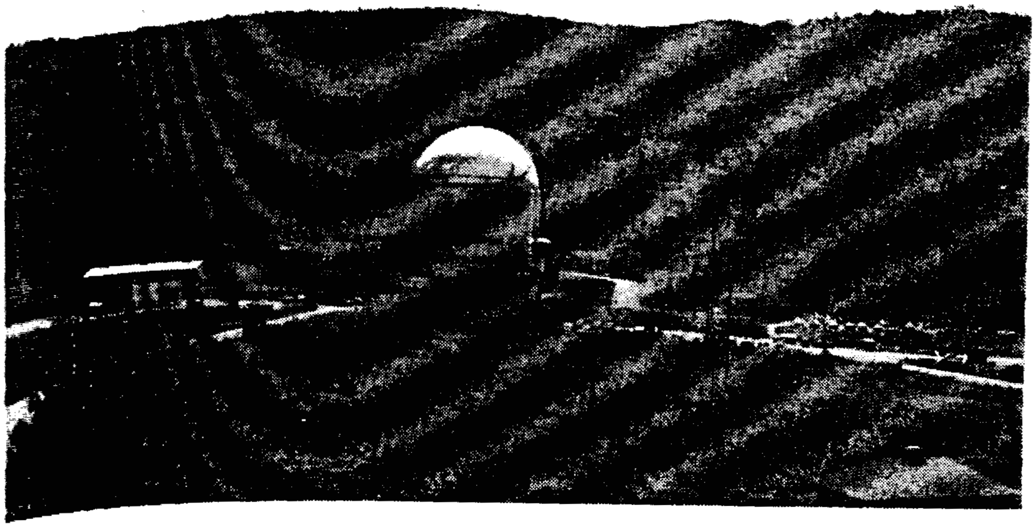


CONSUMERS—*New Start*



BONUS—*New Start*

New Power—New Starts

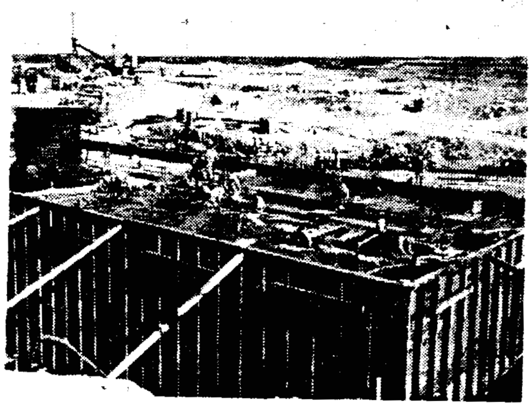


YANKEE—*New Power*

United States' electrical capacity. While operating experience is being gained with these plants, the United States is pushing ahead with the development of other basic reactor concepts. Construction started this year on six prototype and experimental reactors, four of which are pictured below.

BONUS—*New Start*

ORGANIC-COOLED—*New Start*



tional 6 propulsion reactors costing about $50 million had been authorized. Records were not available to show the rate at which costs were incurred against these estimated amounts. Orders for replacement fuel elements for naval propulsion reactors obviously will increase with 14 submarines now operating and 8 other nuclear vessels launched during 1960.

Reactors included in these totals are all those under active design or construction which are listed in Appendix 12, Part I, Civilian Reactors, Part II, Military Reactors, and Part III, Production reactors. Certain reactors listed as "planned" in Appendix 12 are excluded from charts and tables because they were not under active design or construction as of June 30, 1960.[2]

During the latter part of 1960, two more nuclear power plants began producing electricity, adding 290,000 kilowatts to the national nuclear electrical capacity—the Dresden Nuclear Power Station in Illinois, and the Yankee Atomic Electric plant in Massachusetts.

Fifteen power reactor projects now underway are scheduled for completion before the end of 1963. Nearly 300,000 kilowatts of

[2] The excluded reactors in Part I, Appendix 12, are the Improved Cycle Boiling Water Reactor, the Organic Cooled Reactor Prototype, the Small Size Nuclear Power Plant, the Experimental Low Temperature Process Heat Reactor, and the Southern California Edison Co. power plant.

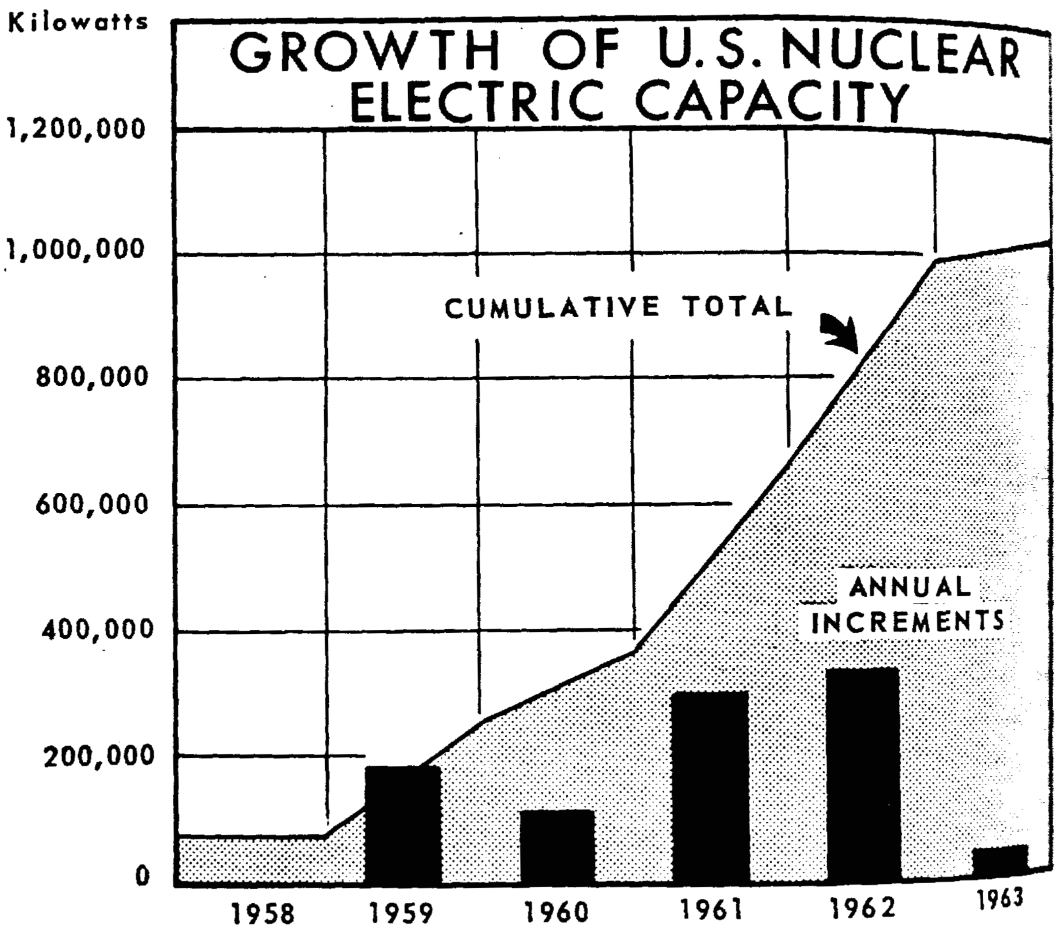


TABLE A.—NUCLEAR

Prior to 1959:[a]
Experimental Boi
Shippingport At
Pa
Vallecitos Boiling
Sodium Reactor
Total:

1959:
Dresden Nuclear
Total:

1960:
Yankee Atomic E
Total:

1961:
Consolidated Edi
Enrico Fermi At
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Experimental Br
Saxton Nuclear
Total:

1962:
Shippingport (P
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1963:
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Electrical Capacity
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TABLE A.—NUCLEAR ELECTRIC GENERATING PLANTS AND CAPACITIES

Prior to 1959:*	
Experimental Boiling Water Reactor (EBWR), Lemont, Ill	4,500 ekw
Shippingport Atomic Power Station (PWR), Shippingport, Pa	60,000 ekw
Vallecitos Boiling Water Reactor (VBWR), Pleasanton, Calif	5,000 ekw
Sodium Reactor Experiment (SRE), Santa Susana, Calif	6,000 ekw
Total:	75,500 ekw
1959:	
Dresden Nuclear Power Station, Morris, Ill	180,000 ekw
Total:	180,000 ekw
1960:	
Yankee Atomic Electric Plant, Rowe, Mass	110,000 ekw
Total:	110,000 ekw
1961:	
Consolidated Edison Thorium Reactor, Indian Point, N.Y	151,000 ekw
Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich	94,000 ekw
Rural Cooperative Power Association plant, Elk River, Minn	17,500 ekw
City of Piqua, Ohio, plant	11,400 ekw
Experimental Breeder Reactor No. 2 (EBR-2), NRTS, Idaho	16,500 ekw
Saxton Nuclear Experimental Reactor Project, Saxton, Pa	3,250 ekw
Total:	293,650 ekw
1962:	
Shippingport (PWR) modification (added capacity)	40,000 ekw
Hallam Nuclear Power Facility, Hallam, Nebr	75,000 ekw
Northern States Power Co. (Pathfinder plant), Sioux Falls, S. Dak	62,000 ekw
Consumers Power Co., Big Rock Point, Mich	50,000 ekw
Pacific Gas and Electric Co., Humboldt Bay, Calif	48,500 ekw
Carolinas-Virginia Tube Reactor, Parr, S.C	15,000 ekw
Experimental Gas Cooled Reactor, Oak Ridge Natl. Lab., Tenn	22,300 ekw
Boiling Reactor Nuclear Superheat Project (BONUS), Punta Higuera, Puerto Rico	16,300 ekw
Yankee second core (added capacity)	26,000 ekw
Total:	355,100 ekw
1963:	
High Temperature Gas Cooled Reactor, Peach Bottom, Pa	40,000 ekw
Total:	40,000 ekw

* Indicated years are based on date of initial, or anticipated, criticality or issuance of operating license.

electrical capacity are to reach criticality in 1961, some 350,000 kilowatts in 1962, and 40,000 in 1963 (see Chart, Growth of U.S. Nuclear Electrical Capacity). Some new power projects were in sight in late 1960. Negotiations have begun on a contract for one Atomic Energy Commission reactor prototype; two other power prototypes have been authorized. A small process heat reactor has been authorized. The estimated total cost for the four reactors is $50 to $60 million. In addition, utilities are actively considering construction of three power reactors in the 300,000 kilowatt class.

The Industry in General

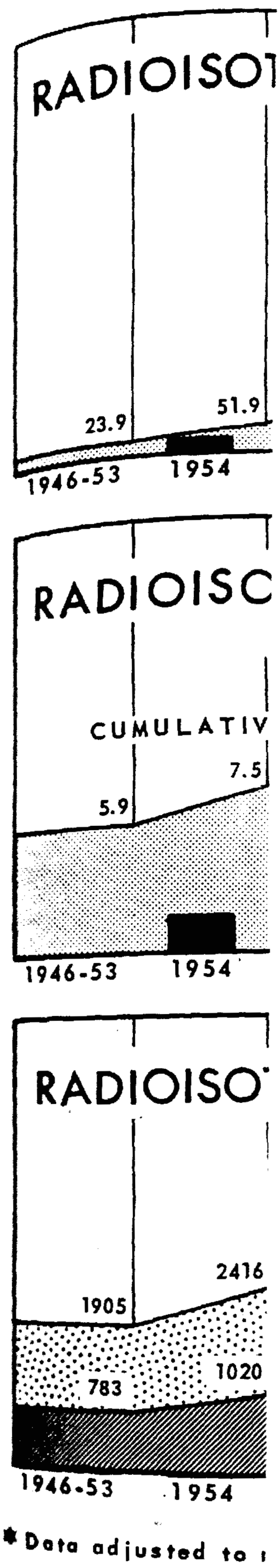
In the atomic energy industry as a whole, about the same number of companies continued to operate as in 1959. Two new companies are entering the uranium concentrate field. One firm, already in the atomic energy field, intends to broaden its activities to include commercial fabrication of fuel elements for nuclear reactors. Another firm was licensed to manufacture plutonium-beryllium neutron sources, a device used, among other purposes, in oil-well logging and previously available only from Commission-owned plants. The first private company initiated reactor production of a radioisotope for chemical use. One corporation curtailed its participation in reactor work and is concentrating upon gamma-irradiation facilities.

A useful measurement of atomic industrial activity is provided by the dollar volume of manufacturers' shipments as compiled annually by the Bureau of the Census. The latest figures available are for 1959, when total shipments were some $245 million, about 50 percent above 1958, and 145 percent above 1957.

Radioisotope Business

The radioisotope segment of the industry continued its steady growth during 1960. Licensed industrial users of radioisotopes increased 11 percent during 1960 after a 16 percent rise during 1959. Because isotope production facilities for fission products were shut down for some 9 months, (see chart), total curies shipped declined 14 percent after a 20 percent rise in 1959 and a 37 percent rise in 1958. The backlog of orders awaiting delivery was many times the total shipped during the previous year.

The continued rise in number of industrial licenses occurred after major manufacturers of gaging equipment began operating under the Commission regulation which permits sale of gages under general licenses, instead of under an individual license for each user. As a consequence, the new licenses usually cover industrial research, use of radiographic equipment, or manufacture of gages, and indicate increased purchases of radioisotope equipment for industrial use. These sales are in addition to equipment marketed to medical and research users.



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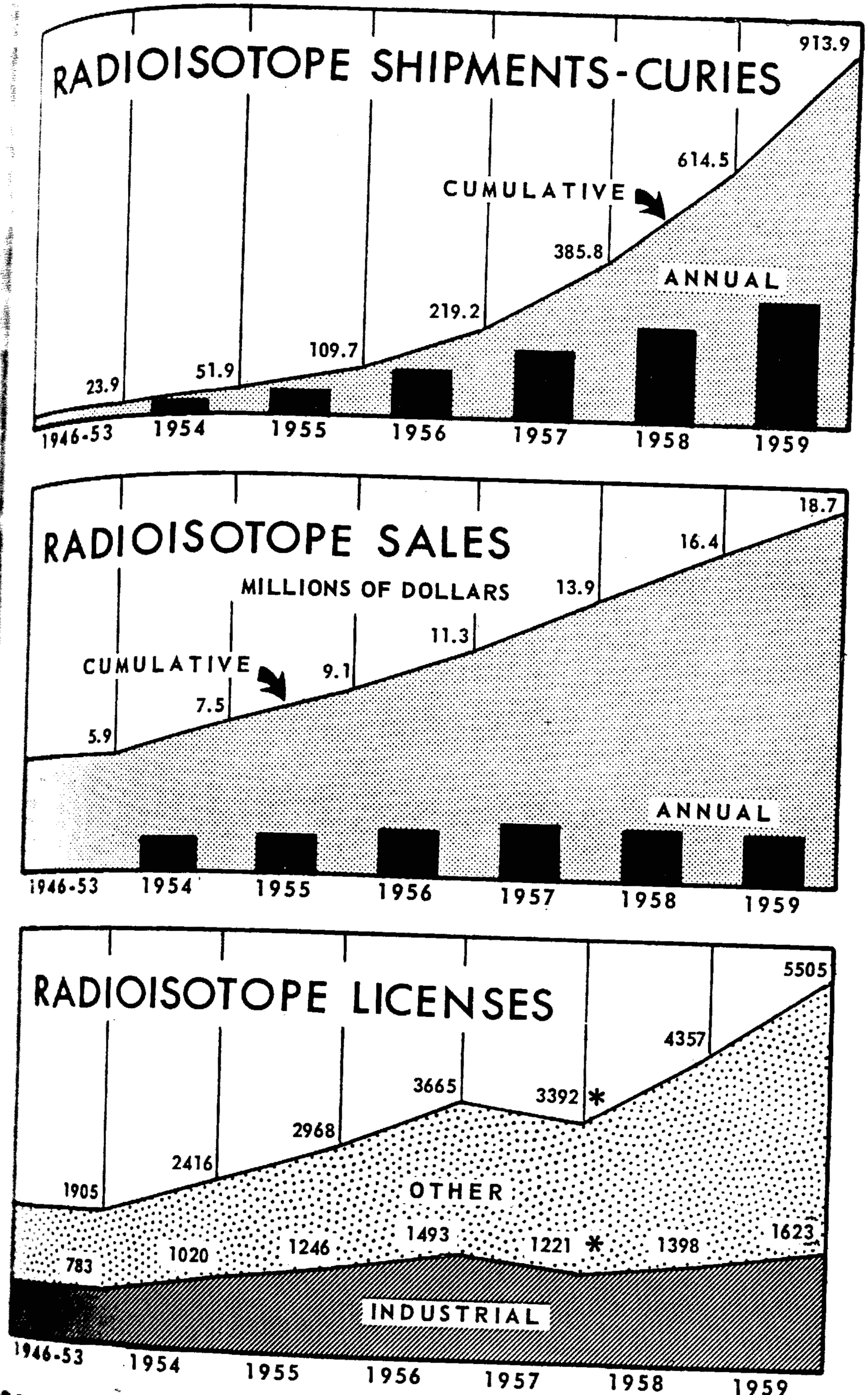

*Data adjusted to new licensing basis

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As of February 10, 1959, when general licensing of gages controlled by a manufacturer's license first was authorized, about 4,000 gages were in use in industry. Use of the general license is at the option of the manufacturer, and not all manufacturers have taken advantage of this arrangement. Those that do use the general license will make regular reports to the Commission on sales. On the basis of these reports and other data, it is estimated that between 5,000 and 6,000 radioisotope gages now are in use, of which some 1,000 gages were marketed during 1960.

In addition, radioisotopes and equipment containing radioactive sources (such as teletherapy devices) are being imported into the United States. During 1959, the latest year compiled by the Bureau of the Census, these imports totaled $1,145,000, more than 80 percent from Canada.

The International Market

During 1960, one small power reactor was ordered from a United States corporation by Japan—a reactor that will use enriched fuel. Japan has not previously favored the use of enriched fuel; its one previous contract for a power reactor was with the United Kingdom for a design using natural uranium fuel.

At least one additional power reactor apparently is expected to be proposed under the European Atomic Energy Community's joint program with the United States in response to the Joint Board's invitation to be issued in 1961, covering reactors to be completed by the end of 1965. One large reactor is being built for completion in 1963.

The power reactor market has not developed in Europe as rapidly as expected in 1958 when Euratom programs first were authorized, chiefly because the greater availability and downward trend in prices of fossil fuels lessened the urgency for nuclear power development.

Foreign countries ordered 4 new research reactors from the United States during 1960. Radioisotopes exported during 1960 had a total value of $1.5 million. Seven research, training or testing reactors built in the United States went into operation abroad during 1960, as did two for production of power—at Kahl-am-Main in the Federal Republic of Germany and at Mol, Belgium.

The vigorous advancement in arrangements for the exchange of information with other countries, particularly with Canada in connection with heavy water moderated power reactors and with the United Kingdom on high temperature gas cooled reactors; the authorization by the International Atomic Energy Agency of a study on sea disposal of radioactive wastes by the Oceanographic Museum in Monaco, the first such study undertaken on an international basis;

and progress in negotiations toward the acceptance of the N.S. *Savannah* in foreign ports; all were indicative of significant long-range advances toward increased industrial applications of reactors throughout the world.

Summary and Highlights

Taken together, these activities and accomplishments of 1960 presented, in the view of the Atomic Energy Commission, a picture of a soundly developing atomic energy industry.

Highlights of industrial development during 1960, and of Commission supporting activities, included the following items:

- Twenty-three civilian power reactor prototypes and experiments estimated to cost $858.4 million were under active design or construction as of June 30, 1960, compared with 18 valued at $747.1 million at the same time the previous year.

- Construction started on 6 power reactor prototypes and experiments during 1960, the same number started during 1959. Three power reactors authorized by Congress were delayed: one by safety considerations affecting the choice of site; one because privately owned utilities did not submit proposals in response to a Commission invitation. Contract negotiations began in November on the third authorized power reactor.

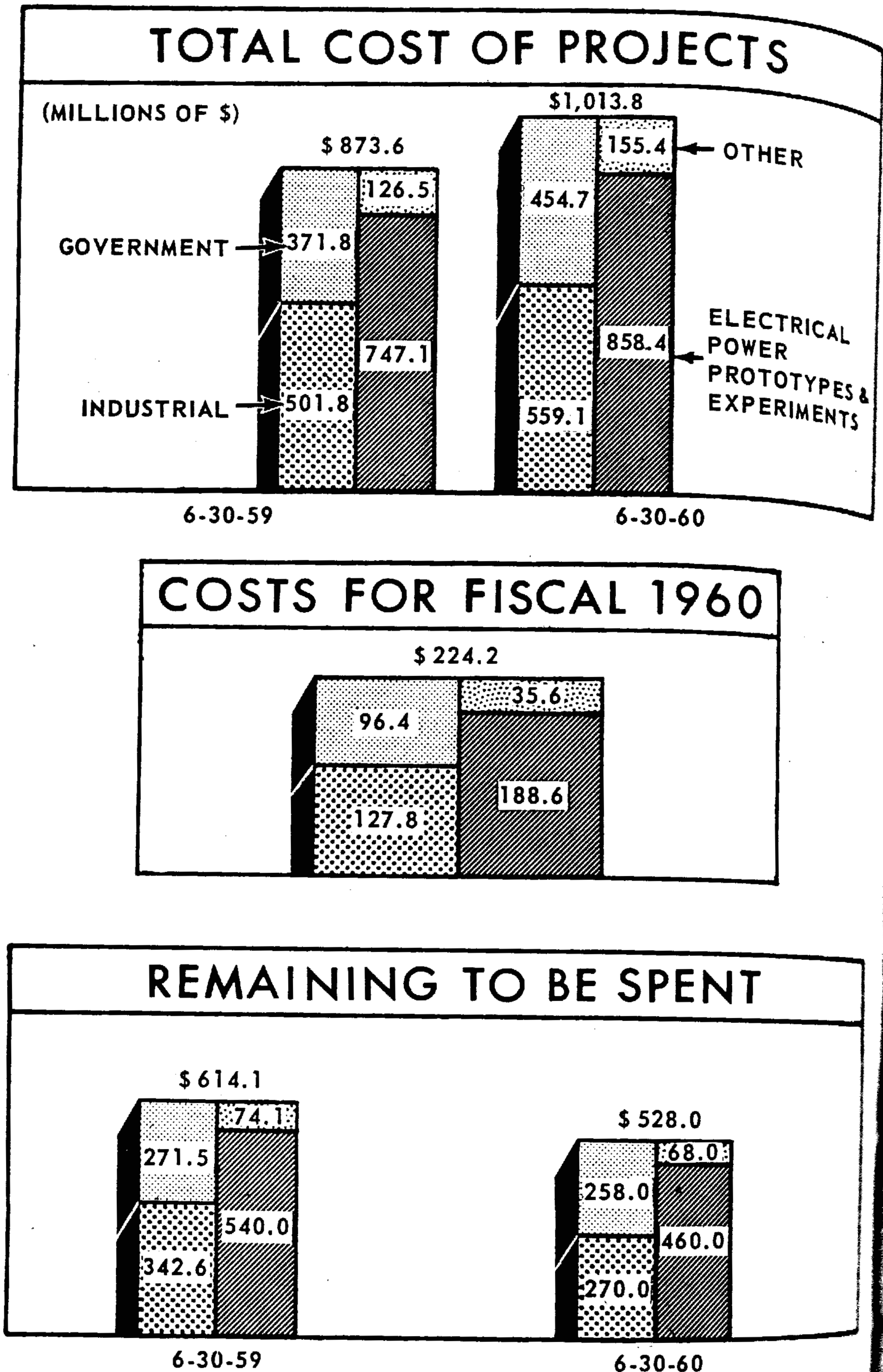
- At Camp Century, Greenland, the first field power plant installed for the military services began to supply power and heat for this arctic outpost.

- Private industrial capacity continued during 1960 to meet or exceed the demands of the nuclear industry in the mining and milling of ores; in the conversion of uranium hexafluoride to forms needed in the production of fuels, and in the fabrication of fuel elements for private and Government reactors.

- Production of uranium oxide concentrates by United States mills rose 8 percent to 17,730 tons for the year ended December 31, compared with the previous 12 months. Domestic production represented 52 percent of total receipts by the Commission compared with 48 percent the year before. Arrangements have been virtually completed for mills to handle ore from developed reserves which had inadequate outlets under the Commission program announced April 2, 1958.[5]

[5] See pp. 5–6, and 353–365, Twenty-fourth Semiannual Report to Congress (January–June 1958).

CIVILIAN REACTOR PROJECTS



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Recovery of unirradiated scrap from Commission operations by commercial firms increased from $116,000 for the year ended June 30, 1959, to $275,000 for the year ended June 30, 1960, to $420,000 for the succeeding 5 months that ended November 30—an increase in those months alone of more than 50 percent over the entire previous year.

ANALYSIS OF REACTOR ACTIVITY

The Commission's report on its program for developing economically competitive power reactors, and the technological progress achieved under that program, are described in the second chapter of this report. In this summary, the Commission reviews some of the factors bearing on the development, growth, and state of the reactor segment of the industry during 1960.

As of June 30, 1960, there were 66 civilian and military reactor projects under active design or construction for use in the United States, (exclusive of naval propulsion, aircraft and space reactors), compared with 59 a year earlier (see table 1).[4] Of the 59 under active design or construction on June 30, 1959, builders had completed 9 before June 30, 1960 at a cost of $55 million. Thus, the 66 reactors under active design or construction during fiscal 1960 included 15 new reactors and a reactor modification, started during that year; the estimated cost was $95 million.

The 9 reactors that were completed in the United States during fiscal 1960 included 7 for research, training, or testing. Two were military prototypes.

The Federal Government, chiefly the Atomic Energy Commission, continued to be the largest investor in these reactor projects, incurring costs of some $161 million during the 1960 fiscal year compared with $28 million by industry and others during the same period. The Federal backlog was $446 million compared with some $270 million remaining to be spent by industry and others (see table 2).

About one-half the Commission's costs for civilian power prototypes and experiments is for research and development. About 80 percent of electric utility costs are for plant and equipment. The distribution of costs for reactors under active design or construction during the fiscal year is shown in table 3.

In carrying forward many of the reactor projects the nuclear industry has reached a stage where it now can follow the construction pattern developed over the years in the conventional power field. Previously, industrial firms, educational institutions and nuclear consultants have played the principal role in the construction of civilian

[4] The two lists of reactors are given in Appendix 13.

TABLE 1.—DOMESTIC REACTOR PROJECTS UNDER DESIGN OR CONSTRUCTION

	At June 30, 1959		Costs incurred July 1, 1959 thru June 30, 1960	At June 30, 1960	
	No. of projects	Total estimated costs		No. of projects	Total estimated costs
		(millions)	(millions)		(millions)
ALL PROJECTS	59	$1,234.1	$289.0	66	[illegible]
CIVILIAN REACTOR PROJECTS	46	$873.6	$224.2	54	[illegible]
Power prototypes and experiments	18	$747.1	$188.6	23	[illegible]
Civilian testing	8	74.6	20.7	7	[illegible]
Civilian research	19	25.4	8.8	23	[illegible]
Merchant ship propulsion	1	26.5	6.1	1	[illegible]
MILITARY REACTOR PROJECTS [a]	12	$190.1	$48.4	11	[illegible]
Military prototypes, experiments, and field plants	7	$163.6	$45.6	5	[illegible]
Military testing	5	26.5	2.8	6	[illegible]
MATERIALS PRODUCTION	1	$170.4	$16.4	1	[illegible]

NOTE: See Appendix 13 for projects included in this tabulation and also in tables 2 and 3, following.

[a] Excluding naval propulsion reactors, and reactors and power units for aircraft and space applications.

TABLE 2.—COSTS AND ESTIMATES BY SOURCE OF FUNDS

	Costs incurred fiscal year 1960	Projects active as of June 30, 1960		
		Total estimated costs of projects	Cumulative costs incurred thru June 30, 1960	Estimated costs to be incurred after June 30, 1960
	(millions)	(millions)	(millions)	(millions)
ALL PROJECTS	$289.0	$1,328.3	$612.1	[illegible]
SOURCE OF FUNDS:				
FEDERAL GOVERNMENT	[a] $148.0	$769.2	$323.0	[illegible]
Atomic Energy Commission [b]	$148.0	$711.7	$281.0	[illegible]
Department of Defense	10.0	41.9	28.4	[illegible]
Other Federal agencies	3.3	15.6	13.6	[illegible]
INDUSTRY AND OTHERS	$127.7	$559.1	$289.1	[illegible]
Privately owned utilities	$110.7	$502.2	$251.8	[illegible]
Publicly owned utilities	10.9	29.2	18.6	[illegible]
Manufacturers & universities	6.1	27.7	18.7	[illegible]

[a] The Commission incurred costs of $399.3 million during fiscal year 1960 in its reactor development program for reactor research and development. Of this total only $61.4 million related directly to projects included here.

[b] AEC costs include depreciation and fuel consumed.

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TABLE 3.—COST

TOTALS
TYPES OF EXPENSE
Plant and equipment
Research and development
Fuel fabrication
Land and land rights
Training
Use charges waived

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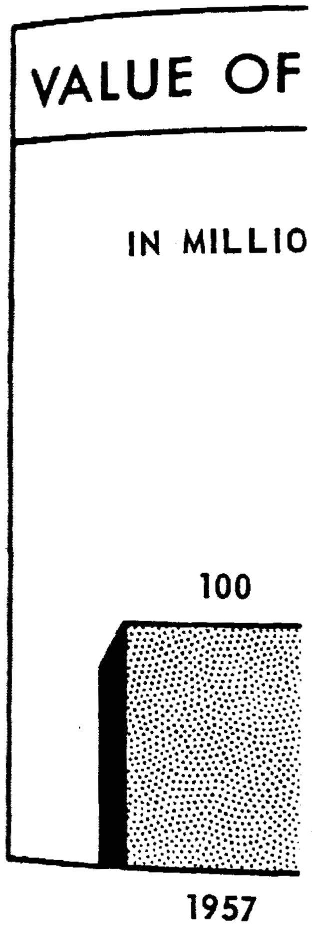

TABLE 3.—COSTS AND ESTIMATES BY TYPES OF EXPENSE

	Costs incurred fiscal year 1960	Projects active as of June 30, 1960		
		Total estimated costs of projects	Cumulative costs incurred thru June 30, 1960	Estimated costs to be incurred after June 30, 1960
	(millions)	*(millions)*	*(millions)*	*(millions)*
Totals	$289.0	$1,328.3	$612.1	$716.2
Types of Expense				
Plant and equipment	$208.3	$907.5	$398.3	$519.2
Research and development	65.0	314.9	181.6	133.5
Fuel fabrication	11.7	59.9	23.4	36.5
Land and land rights	0.4	4.6	3.3	1.3
Training	2.3	14.0	3.8	10.2
Use charges waived	1.3	17.4	1.7	15.7

power reactors because of their experience gained in research and development work. In the pattern now developing, architect engineers are responsible for overall design, the broad parameters for major equipment, and the evaluation of equipment offered by competitive suppliers. Manufacturers design and furnish integrated reactor systems and guarantee performance of the systems. Construction con-

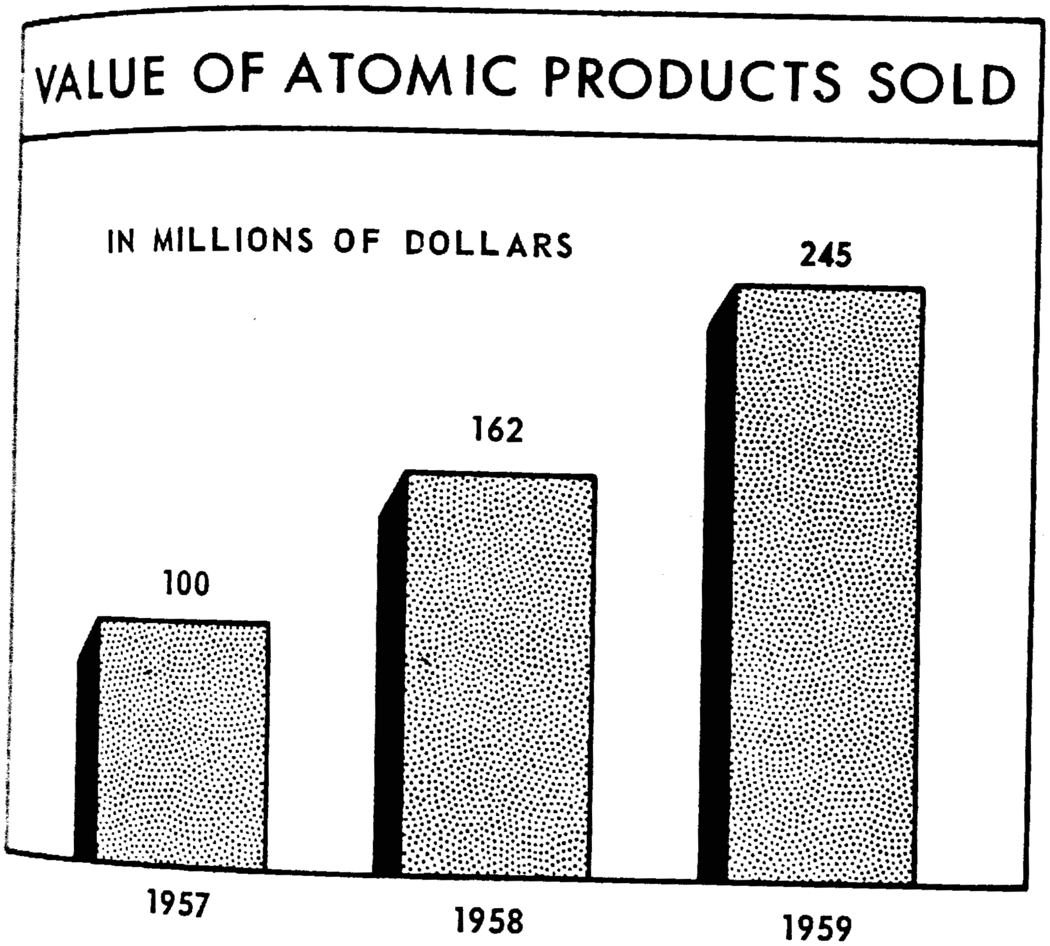

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TABLE 4.—MANUFACTURERS' SHIPMENTS OF KEY ATOMIC ENERGY PRODUCTS[a] 1959, 1958, 1957

(Value—Thousands of Dollars)

Product	1959	1958	1957
Nuclear reactors (includes only those assembled at place of manufacture)	$7,497	$1,156	[illegible]
Reactor components and equipment:			
Primary vessels and tanks	19,989	17,099	[illegible]
Control rod drive mechanisms and components	5,404	7,481	[illegible]
Accessory instrumentation for reactor control	15,933	15,284	[illegible]
Heat exchangers and condensers	27,233	13,799	[illegible]
Pressurizers, components, and auxiliary equipment	3,620	1,758	[illegible]
Pumps	19,455	9,516	[illegible]
Valves	13,984	11,401	[illegible]
Fuel handling equipment	1,747	(c)	[illegible]
Complete reactor fuel elements and control rods	54,845	23,873	[illegible]
Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor	11,773	5,742	[illegible]
Core structurals	5,255	3,908	[illegible]
Specialized reactor components and equipment not included elsewhere	[b] 4,684	[b] 12,935	[illegible]
Hot laboratory equipment	3,700	3,886	[illegible]
Shielding	1,786	(c)	[illegible]
Radiation survey, monitoring and control devices	12,547	*14,799	[illegible]
Radiation counting equipment	16,381	10,387	[illegible]
Radioactive isotopes shipped from non-AEC plants producing isotopes	394	171	[illegible]
Radiation sources and other radioactive materials produced from purchased isotopes	3,748	3,071	[illegible]
Control and measuring devices containing radioactive isotopes	8,897	*3,896	[illegible]
Conversion of enriched uranium metal and compounds	5,986	1,503	[illegible]
Commercial irradiation service		97	[illegible]
Total	244,858	161,762	[illegible]

*Revised.

[a] Data collected by Bureau of the Census.

[b] This product group covers residual items not specifically identified elsewhere and is not comparable from year to year.

[c] Included in "Specialized Reactor Components and Equipment Not Included Elsewhere."

tractors perform their normal role, integrating and coordinating their own activities, as well as those of subcontractors and suppliers, to assure that project schedules are met.

Shipments of key atomic energy products from private manufacturers increased in 1959 over 1958 by 50 percent. (See chart, Value of Atomic Products Sold.) Table 4 summarizes shipments by product groups for the 3 years for which the survey has been made as a joint undertaking by the Bureau of the Census and the Commission.

The Civilian Nuclear Power Program

In spite of some delays the development of atomic power for civilian purposes continued to show encouraging progress during 1960. The effort is carried out through the Commission's program, through va-cooperative arrangements with industry, and through the ately financed efforts of industry.

The 365,000 electrical kilowatt nuclear power capacity of the United —a net addition of 290,000 kilowatts over the previous year— possible the increasing and more rapid accumulation of operat- experience, cost information, and general advancement in reactor nology. The privately financed Dresden Nuclear Power Station the Commonwealth Edison Co., attained full power operation in sending 180,000 electrical kilowatts over transmission lines into cago and northern Illinois. This is considered adequate capacity serve a city of 200,000 population. In November, Dresden was shut because of control rod problems. The 110,000 electrical kilo- Yankee Atomic Electric Co. reactor, which is a cooperative proj- with the Commission located at Rowe, Mass., attained criticality in gust and full-power operation is expected in January 1961. The 22,000 electrical kilowatt boiling water reactor at Elk River, Minn., is scheduled to achieve criticality in early 1961. The 60,000 Shippingport Atomic Power Station, which during 1958 and 1959 provided the bulk of nuclear generating capacity in this country, med operation in April after its first refueling. In September, reactor passed its design lifetime objective of 8,000 equivalent power hours on the natural uranium blanket elements in the core. the basis of nuclear plants now authorized for construction in United States, it is anticipated that a nuclear generating capacity more than one million electrical kilowatts will be in operation by the of 1963. Most of this capacity will come into operation in the -62 period, during which time 15 electricity-producing nuclear ts are expected to go critical. These include a large fraction of demonstration facilities which now appear to be required to help ply the experience and technology essential for economic nuclear er in high cost areas of this country.

Some of the economies that improved technology and repetitive anufacture of fuel elements can accomplish, for example, is evidenced the naval submarine reactor program: Within recent years, the of naval reactor cores has decreased about 40 percent at the same that the useful life of these cores has increased about 70 percent. Evidence of progress toward economically lower nuclear power costs shown during the past year by several offers of leading reactor ufacturers to construct large-scale power reactors with price and formance guarantees which would result in power costs very nearly petitive with conventional costs in high fuel cost areas. A Cali- a utility has sent a letter of intent to a reactor manufacturer to tiate contracts for design and construction of a 360,000 ekw reactor, larger than any yet undertaken in the United States. A second California utility is considering construction of a reactor of similar capacity. A seven-utility group in New York State called the Empire State Atomic Development Associates, Inc., announced on December 7 a research and development program leading to development of a large scale plant of 300,000 to 500,000 ekw. Contracts have been entered into with General Electric Co. to build a 5,000 ekw boiling water superheat reactor experiment at their Vallecitos plant in California and to conduct research and development work on this concept; and with General Atomic Division of General Dynamics Corp. to conduct longer range research and development work on a high temperature gas-cooled concept. The Associates anticipate that one of these research and development programs will result in design of a large-scale plant.

During 1960, reactor construction was started on four new power plants or prototypes, and two experimental reactors. These are:

- The privately financed Saxton Nuclear Experimental Reactor at Saxton, Pa.
- The privately financed Humboldt Bay Power Plant at Eureka, Calif.
- The Consumers Power Co. Reactor, a cooperative project, under the Power Demonstration Reactor Program, at Big Rock Point, Mich.
- The boiling Nuclear Superheat Reactor of the Puerto Rico Water Resources Authority, a cooperative project, under the Power Demonstration Reactor Program, at Punta Higuera, Puerto Rico.
- The Carolinas-Virginia Tube Reactor, a cooperative project, under the Power Demonstration Reactor Program, at Parr, S.C.
- The Experimental Organic Cooled Reactor of the Commission at the National Reactor Testing Station in Idaho.

Safety considerations and site selection problems altered a number of plans during the year. Construction of an experimental low temperature process heat reactor, a Commission project to provide heat to a saline water conversion plant of the Department of Interior, was not undertaken because the originally proposed site did not meet safety criteria, and no other safe site acceptable to Interior was found. Construction of the small pressurized water reactor, planned as a cooperative project with a public power organization, was also delayed because the initially proposed site of otherwise acceptable proposals failed to meet safety standards. After privately owned utilities did not respond to the Commission's invitation to make proposals for constructing and operating an organic cooled prototype reactor under the Power Demonstration Reactor Program, the Commission was

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considering the reactor's construction under a contract for operation by a publicly owned utility or, alternatively, by the Government on a Commission site. Late in 1960, the Commission selected a corporation proposal as a basis for negotiating a contract to construct a Commission-owned improved cycle boiling water reactor for proposed operation by the cities of Los Angeles and Pasadena, Calif.

The United States Court of Appeals for the District of Columbia set aside the Commission's granting of a construction permit for the Enrico Fermi Power Plant in Michigan, but construction of the plant is continuing under a stay pending final resolution of the case by the United States Supreme Court (for details, see section of this report on Licensing and Regulation).

If not revised by the Supreme Court, or clarified by new legislation, this decision could be a serious blow to the progress of power reactor development, especially with reactors which embody new features.

The Commission's program to develop technologies to use plutonium as power reactor fuel moved forward during the year with construction at Hanford of two major experimental facilities needed for this effort. The plutonium fabrication pilot plant, completed in August, is specially designed for working with plutonium. Fuel elements were fabricated in this plant for the first core of the Plutonium Recycle Test Reactor, which attained criticality in November and is expected to attain full power early in 1961. The facility will irradiate plutonium-bearing fuels and will be of major importance in developing an economic plutonium fuel cycle.

Early in 1960 the Commission completed a long-range study of the Civilian Power Program. The purpose of this study,[5] concerned

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[5] Published volumes of the Commission's Civilian Power Reactor Program survey are:
Part I—Summary of Technical and Economic Status As of 1959, (TID–8516), price $1.00.
Part II—Economic Potential and Development Program As of 1959, (TID–8517), price $0.70.
Part III—Book 1, Status Report on Fast Reactors As of 1959, (TID–8518(1)), price $1.00.
Part III—Book 2, Status Report on Pressurized Water Reactors As of 1959 (TID–8518(2)), price $1.25.
Part III—Book 3, Status Report on Aqueous Homogeneous Reactors As of 1959 (TID–8518(3)), price $1.25.
Part III—Book 4, Status Report of Heavy Water Moderated Reactors as of 1959, (TID–8518(4)), price $2.25.
Part III—Book 5, Status Report on Boiling Water Reactor Technology as of 1959, (TID–8518(5)), price $0.60.
Part III—Book 6, Status Report on Sodium Graphite Reactors as of 1959, (TID–8518(6)), price $1.00.
Part III—Book 7, Status Report on Organic-Cooled Power Reactors as of 1959, (TID–8518(7)), price $2.25.
Part III—Book 8, Status Report on Gas-Cooled Reactor Concept, (TID–8518(8)), price $0.55.
Part IV—Plans For Development As of February 1960, (TID–8519), price $0.25.
All of the publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

primarily with large central station nuclear power plants, was to ascertain the status of the technology for various reactor systems, to appraise their economic potential, and to outline future development plans. Much of the technology developed would be applicable also to small power stations.

This study was guided by the program objectives established in 1958 by the Commission:[6]

First: To reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within 10 years (1968).

Second: To assist friendly nations now having high energy costs to achieve competitive levels in about 5 years. This assistance is to be extended mainly through clearly defined programs of cooperation.

Third: To support a continuing long range program to further reduce the cost of nuclear power in order to increase the economic benefits and extend these benefits to wider areas.

Fourth: To maintain the U.S. position of leadership in the technology of nuclear power for civilian use.

Fifth: To develop breeder type reactors to make full use of the nuclear energy latent in both uranium and thorium, recognizing that uranium 235 alone may not be sufficiently plentiful to meet our needs over the long range.

When these objectives first were stated by the Commission, its available information on Western European conditions indicated that economically competitive nuclear power could be attained in Europe by 1963, as indicated in the Commission's second objective. In the last 2 years, however, the costs of conventional fuels have dropped as they became increasingly available, and this has lowered the costs of conventional power so that they approach those in certain sections of the United States. As a consequence, the time when nuclear power is expected to become economically competitive in Europe is much closer than formerly to the time when similar results may be expected in the United States.

For the United States, the short-range objective is to make it possible between now and 1968 for utility owners to choose to build large nuclear plants rather than conventional plants on the basis of economics alone in areas where fossil fuel costs are 35 cents per million BTUs or higher.

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[6] See pp. 4–6, Annual Report to Congress for 1959.

The longer-range objective is to achieve such technological economies as to enable ever-increasing numbers of utility owners to make such choices in widening ranges of locations and plant sizes. A fixed target date for this objective has not been established, but it is expected that during the 1970's substantial progress will have been made toward this goal.

Studies and evaluation have indicated that at least two of the types of nuclear systems under development offer a high possibility of providing economically competitive nuclear power in high fuel cost areas of the United States by 1968, provided that the Commission's program of development and prototype construction is carried out.

The first of these systems, light water moderated and cooled reactors, includes pressurized water and boiling water reactor types. These reactors, fueled with slightly enriched uranium in the form of uranium oxide clad in stainless steel or zirconium, and producing saturated steam for generating turbines, have the greatest background of developed technology in the United States, and seem at this time to be closest to attaining economic nuclear power. Commission studies indicate that, with further development, water reactor technology can be expected to attain the short-range objective for high fuel cost areas. For the long range, such developments as nuclear superheat, engineering simplification, improved fuel performance, and lower fuel costs give promise of further reducing the cost of power from water-cooled reactors.

The second reactor system of short-range economic promise is the organic moderated and cooled reactor. Organic coolants offer the advantages of low operating pressures and fewer corrosion problems, and the technology already developed for water-cooled reactors is widely applicable to these reactors. These advantages are somewhat offset by the fact that the organic materials now used are slowly polymerized by radiation and must be replaced, and by the fact that the heat transfer properties of the system are not as good as those of water cooled reactors. These problems are not considered major obstacles. If present development efforts meet with the success anticipated, there is good reason to believe that this system also will be capable of meeting the short-range objective for high fuel cost areas.

In order to increase the probability that the longer term objective of generally competitive nuclear power will be achieved, and that the most economical systems will be developed, other reactor systems are being investigated. In general, lower construction, operating, and maintenance costs are sought in these systems through higher temperatures, greater neutron economy, and low-cost fuel cycles.

It is doubtful whether any one reactor system will provide all these advantages, or whether any one reactor system will meet all the conditions required by the long-range objective for every location and plant size. The Commission therefore is investigating sodium-cooled thermal and fast reactors, gas-cooled reactors, fluid fuel reactors, and heavy water reactors. The United States also has entered into a cooperative program with Canada which is expected to make substantial contributions to the technology of heavy water reactors cooled with gas or sodium. Present knowledge indicates that high temperature systems cooled with gas or sodium, and particularly those systems which show a high uranium-plutonium conversion ratio, have great potential for meeting the long-range objectives. However, the state of knowledge of these systems is somewhat limited and there are many technical difficulties that must be solved at great expense in time and money before their potential can be realized.

The Commission also has under investigation several new reactor concepts—the so-called advanced reactor concepts—or modifications to concepts. If, after engineering studies, research and development, and evaluation, one or more of these seems promising, a reactor experiment will be built as required to provide the information needed to determine the extent to which the concept can help meet program objectives.

As large central station nuclear applications were the primary subject phase of the long-range study of the Civilian Power Program, studies were initiated in June 1960 to place special emphasis on small power reactors as well as process heat reactors and reactors using radiation to produce commercial chemicals.

The 1959 studies covered the economic and technical status of reactors of more than 75,000 electrical kilowatt capacity. During the past 6 months the Commission staff has been evaluating the economics and required research and development effort needed for nuclear plants below 75,000 ekw capacity in order to devise meaningful and productive development programs for concepts which have a potential in the small power field. In summary, the studies confirm previous views that nuclear power does not offer as great probability of competing with conventional plants in the range of 10,000 to 50,000 kilowatts as it does in the larger sizes. This is largely because many features like shielding, containment, safety precautions, and waste control are almost as expensive for a small plant as for a large plant. Detailed results of the studies will be published in 1961.

PROGRESS I

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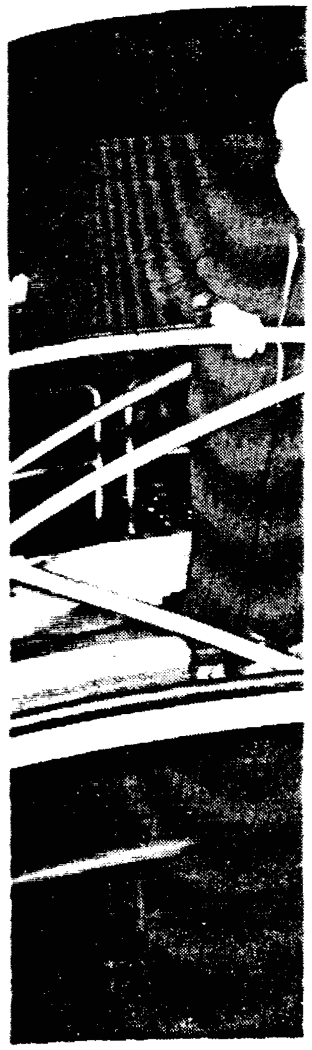

Shippingport Refueling
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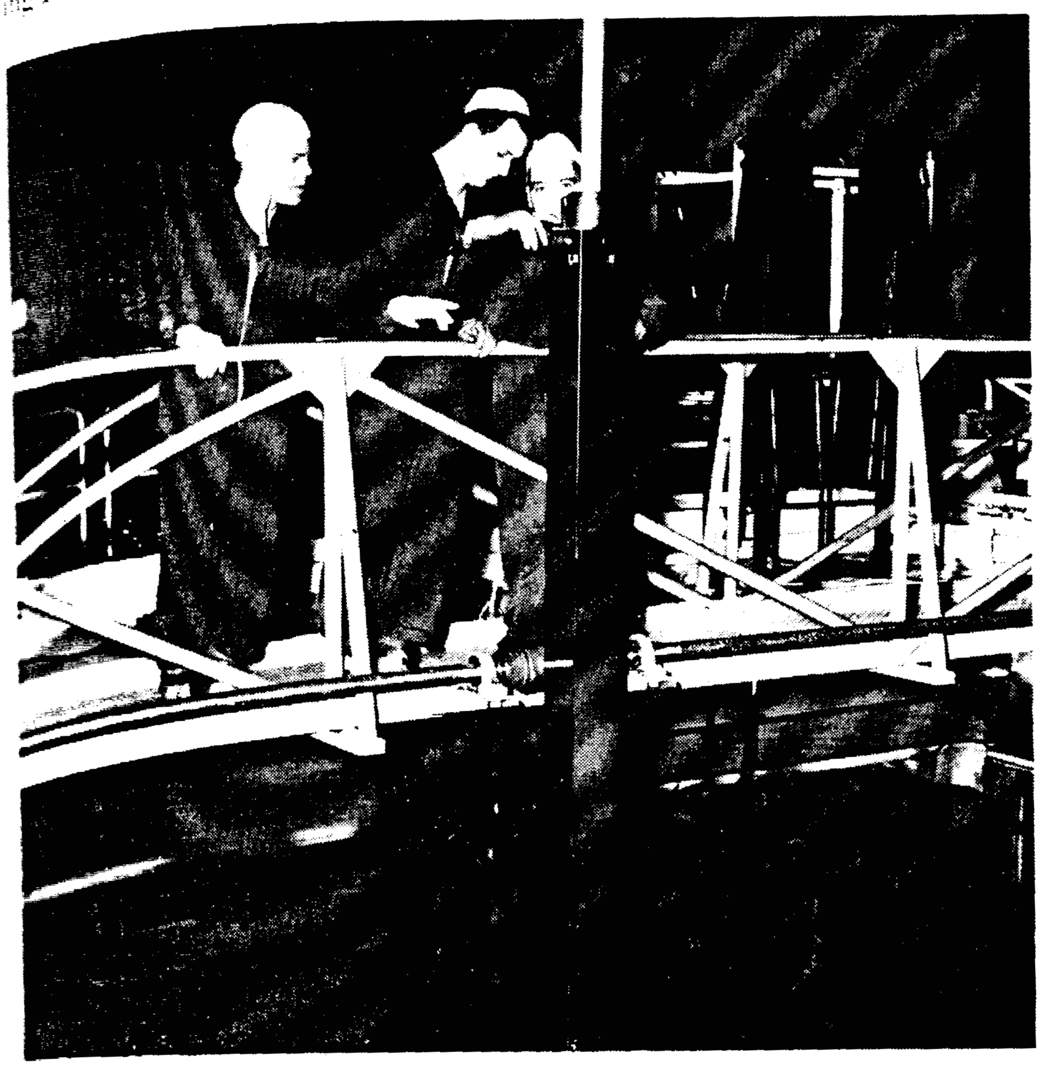
PROGRESS IN POWER REACTOR TECHNOLOGY

In this section of the report, the Commission reviews progress during 1960 for each type of reactor under development.



Shippingport Refueling. After more than 2 years of operation, the Shippingport Atomic Power Station reactor was refueled with a new type of unit during 1960. Photo shows the first of 32 "seed and blanket core" units being lowered into the reactor canal for insertion into the reactor. Refueling is accomplished under water by remote control to reduce radiation hazards.

Pressurized Water Reactors

Shippingport (Pa.) Atomic Power Station

The Shippingport Station is the first major nuclear power electrical generating plant in the United States. The 60,000 kilowatt electrical (kw) pressurized water reactor at Shippingport achieved criticality and began supplying electricity in December 1957 to the system of the

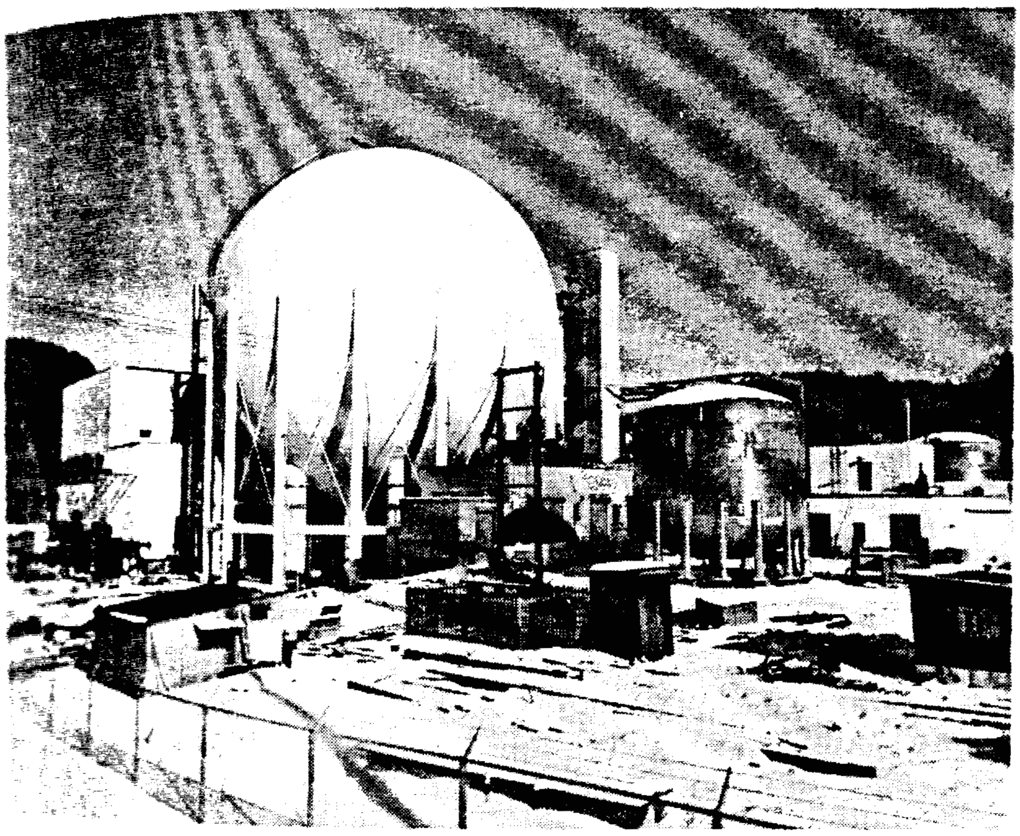
Duquesne Light Co., operator of the reactor for the Commission. In the 3 years since startup, many tests have been conducted to evaluate design and performance of the nuclear reactor, its fuel elements, and the reactor plant as a whole. The information from these tests has provided much of the technology, operation and cost data today available on large water-cooled reactors for commercial generation of electrical power.

During the past year the principal contributions resulting from operation and testing of the Shippingport Station include: achieving burnups in the uranium oxide (UO_2) fuel elements higher than in any other reactor; further confirmation of the advantages of the "seed and blanket" core concept which minimizes the investment in uranium 235 and maximizes the power obtained from natural uranium; publication and distribution of test results and evaluations covering the nuclear and thermal performance of the plant and the first refueling of the reactor; successful operation of the Shippingport reactor as part of a large public utility system.

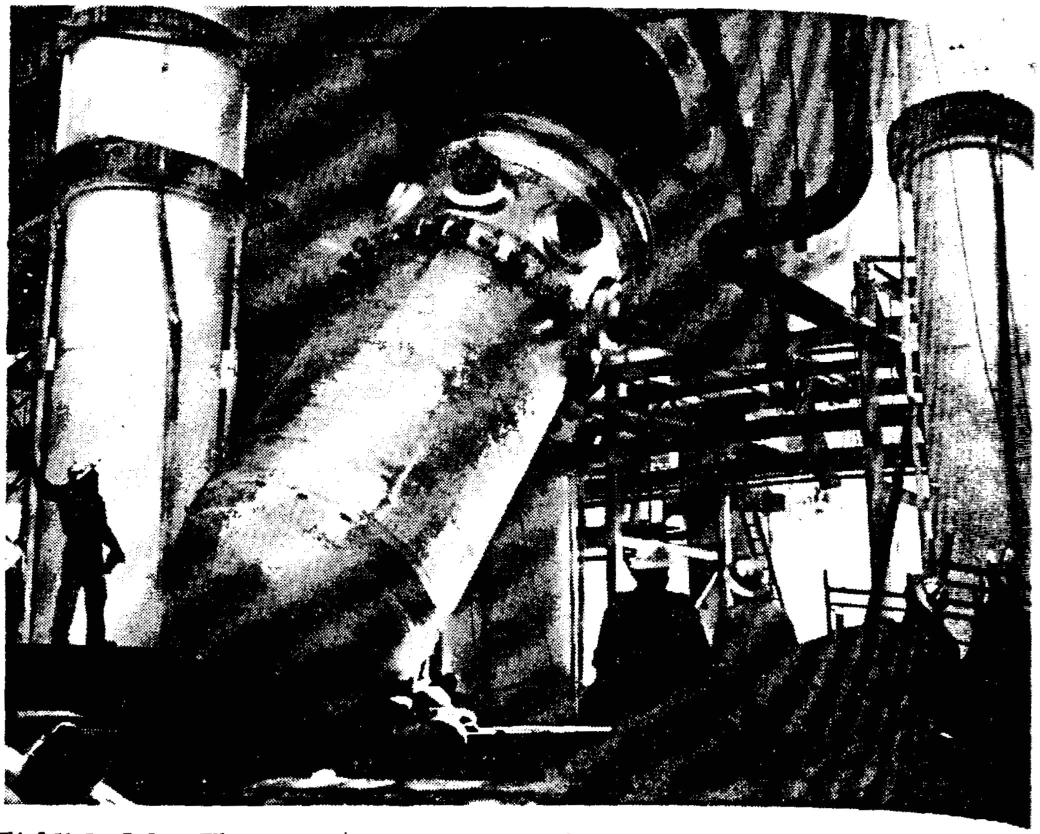
The first seed (32 enriched fuel assemblies) of the Shippingport (PWR) core was replaced after 5,808 equivalent full power hours operation which produced 388,500,000 kilowatt hours (gross) of electrical energy. This refueling was completed in March 1960 and the reactor, containing the new seed, went critical April 12. Full power operation was achieved May 7. Since May the plant has been operated most of the time at full power in order to develop information on the lifetime capabilities of the uranium dioxide blanket. Physics tests and student training also were conducted during this period. As of December 31, PWR Core 1 has generated a total of 655,000,000 kilowatt hours (gross) of electrical energy. The cumulative load factor for the second seed has been twice as great as the first seed. The average burnup in the natural uranium dioxide blanket is 3,200 megawatt days per ton, while the peak burnup is about 14,000 megawatt days per ton. This burnup represents the highest natural uranium dioxide fuel depletion achieved so far in any reactor.

Present plans are to replace the second seed of this first Shippingport core with a third seed about the middle of 1961, provided the blanket fuel elements still are performing satisfactorily. 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 the second seeding is depleted, the blanket fuel elements will have operated for approximately 12,500 equivalent full power hours. Examination of some blanket fuel elements during the second seed refueling should give an indication of the conditions of this fuel and its ability to perform satisfactorily through a third seed life.

Design and planning for a second Shippingport core of advanced design is underway with completion of the core scheduled for early 1962. This new core, PWR Core 2, will have a power capability of 150,000 ekw 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. The PWR Core 2 will utilize oxide full plates in both seed and blanket and will use fewer hafnium control rods than PWR Core 1. To dissipate the higher power which will be generated by PWR Core 2, it became necessary either to expand the present electrical generating facilities from 100,000 to 150,000 kilowatts or to provide a 50,000 kilowatt heat sink installation. Both these possibilities were investigated by the Commission and by the Duquesne Light Co.; it was concluded that a heat sink installation is economically more attractive. Use of the heat sink meets all requirements for proving out the higher power capabilities of PWR Core 2. Work on this installation is in progress and will be completed prior to installation of the second core.



Yankee Plant Completed. First joint Commission-industry nuclear power plant to be completed was the Yankee Atomic Electric Co. plant at Rowe, Mass., which is expected to begin full-power operation during January 1961. Contracts for the 110,000 ekw pressurized water facility were signed June 6, 1956—the first under the Commission's Power Reactor Demonstration Program. Photo shows the spherical containment vessel that houses the reactor.



Ticklish Job. The reactor containment shell of the Yankee plant is a sphere located well above ground. Photo shows the reactor pressure vessel being eased into the sphere through an opening that allowed only inches of clearance. The photograph was taken February 7, 1960, and 6 months later on August 19, the reactor achieved initial criticality.

Yankee Atomic Electric Co. Reactor

Construction of the 110,000 ekw Yankee Reactor at Rowe, Mass. was completed on schedule in July and initial criticality was achieved August 19. Yankee then began low-power testing of this pressurized water reactor which was built under a Commission-Yankee contract as part of the Commission's Power Demonstration Reactor Program. The Yankee plant was the first project accepted under the program initiated in January 1955, and was the first completed.

Preliminary low power tests were followed by operation at increasing power levels up to 90,000 ekw by the end of the year. It is expected that design power level of the first core (110,000 ekw) will be achieved in January. The plant is rated at 136,000 ekw and further increases in power up to this level will be based on operating information accumulated at 110,000 ekw.

Important cost information in addition to operating and maintenance experience are expected from this full-size power reactor. Re-

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Reactor design features which differ from other pressurized water reactors now in operation include the use of a stainless steel clad, slightly enriched uranium dioxide core.

Experimental Process Heat Reactor

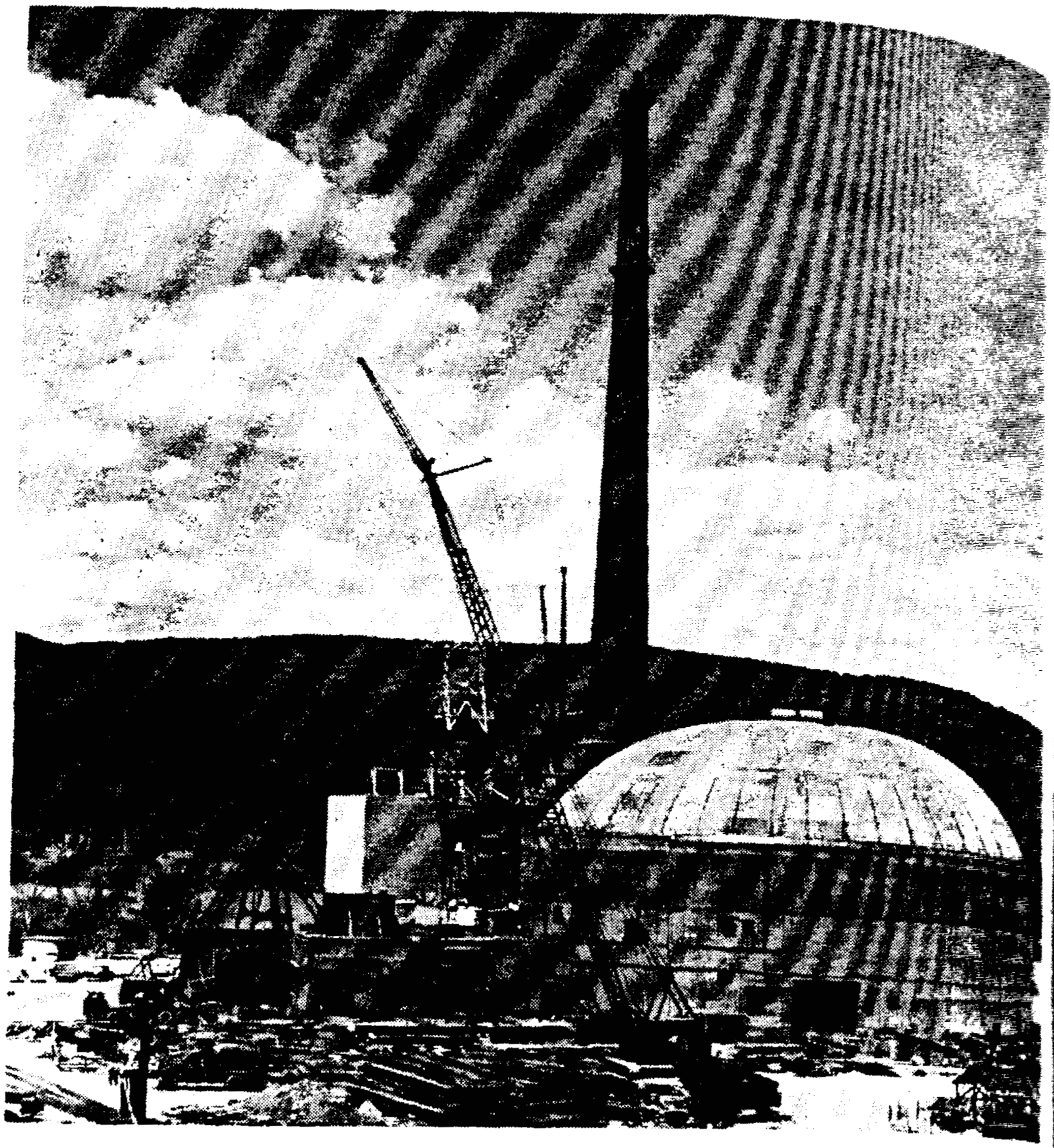
Because of difficulty in selecting a site that was both safe from the standpoint of nuclear operations and also suitable for the requirements of the Department of the Interior, the joint Commission-Interior plans to use a nuclear plant as a source of heat for conversion of salt water into drinking water were not carried out during 1960.

For this project, the Commission was to design, construct, and operate a 40,000 thermal kilowatt experimental low-temperature process heat reactor capable of producing saturated steam for the saline water conversion unit of the Department of the Interior. The proposed reactor site was at Point Loma, San Diego, Calif. However, the Commission's Advisory Committee on Reactor Safeguards (ACRS) recommended against this site. An alternate site at Point Mugu, 50 miles northwest of Los Angeles, which would probably have met safety criteria, was found by the Department of Interior not to fit its requirements. Further investigations are to be made with Department of Interior and with industry regarding this project.

Small Power Reactor

In August 1959, the Commission invited proposals from cooperative and publicly owned utilities for participation in a project under its Power Demonstration Reactor Program for a 16,500 ekw prototype pressurized water reactor, with a conventional superheater to increase the power to 22,000 ekw.

Five proposals were received and the Commission announced on April 26, that none was acceptable. Proposals submitted by the City of Jamestown, N.Y., and by the Dairyland Power Cooperative of La Crosse, Wis., are receiving further consideration. Alternate site suggestions were requested in each case for safety reasons. The alternate sites proposed by Jamestown and Dairyland were acceptable from the standpoint of safety but the proposed financial contributions for the plants had become less favorable and were not fully acceptable to the Commission. Negotiations were continued and at the end of the year the Commission was considering various courses of action regarding this project.



Completion in 1961. The 255,000 ekw Consolidated Edison Co. nuclear power plant is scheduled for completion in late 1961. The privately financed facility will use a pressurized water, thorium-fueled reactor to produce 151,000 ekw and an oil-fired superheater to increase the output to 255,000 ekw. The reactor will be housed in the dome-shaped building; the tall stack is a part of the superheater unit. The plant is located on the Hudson River at Indian Point, N.Y.

Consolidated Edison Thorium Reactor

The 255,000 ekw privately financed plant of the Consolidated Edison Co. continued under construction at Indian Point, N.Y., during 1960. The nuclear reactor will have a capacity of 151,000 ekw and will have an oil-fired superheater to increase capacity by 104,000 ekw. Criticality is scheduled for September 1961 with design power operation by the end of 1961. The Indian Point plant will provide important operating data for large water-cooled reactor systems and technical data on the use of a fuel mixture of thorium and uranium 235.

Saxton Nuclear Experime

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Saxton Nuclear Experimental Reactor

Construction began in February on the Saxton Nuclear Experimental Corp. 3,250 ekw privately financed developmental power reactor at the Saxton, Pa., site, about 20 miles south of Altoona. Westinghouse Electric Corp. is designing and building the reactor. By the end of the year, construction was about 35 percent complete. Power operation is scheduled for the first half of 1962. It is expected that this small experimental pressurized water reactor will be capable of being used for testing purposes under limited boiling water conditions.

360,000 Ekw California Plant

Southern California Edison Co. of Los Angeles announced in April that it had sent a letter of intent to negotiate contracts for design and construction of a 360,000 ekw plant to Westinghouse Electric Corp. and Bechtel Corp. The proposed closed-cycle pressurized water reactor, steam and electrical equipment, would be designed and built by Westinghouse. Bechtel would be the engineering constructor.

Completion of contract negotiations and start of construction will depend on several factors, such as granting of a permit by the Commission, approval by the California Public Utilities Commission, and selection of a specific acceptable site. Negotiations for a site on the Southern California coast now are under way.

The plant is estimated to cost about $78 million and would require about 4 years to construct.

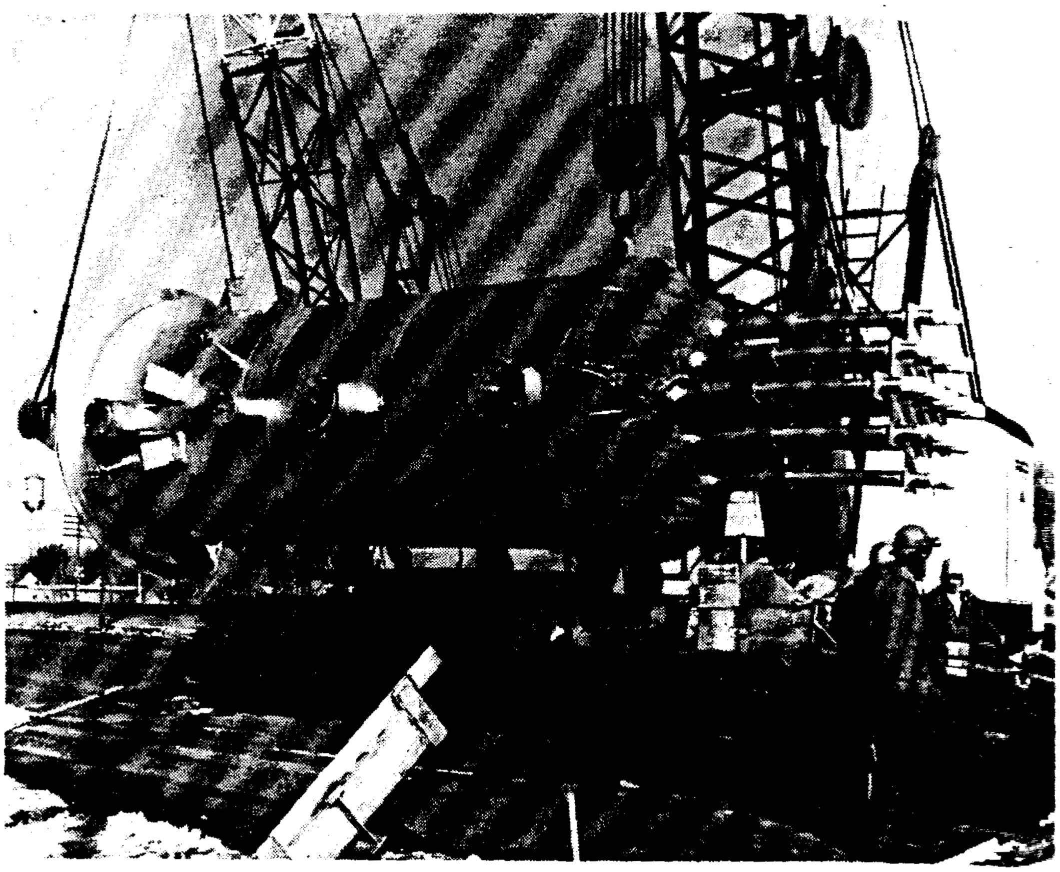
Boiling Water Reactors

Experimental Boiling Water Reactors (EBWR)

The EBWR at Argonne National Laboratory was shut down in July 1959 for modifications to increase the thermal capacity of the plant, designed originally to operate at 20 megawatts, to 100 megawatts. After delayed delivery of equipment put back the schedule, limited plant operation was resumed temporarily in the spring of 1960 with the original core while outside construction continued. Completion of the 100-megawatt modification was delayed at the end of the year when leaks were found in two primary reboilers used for the additional heat removal. Full power operation should begin early in 1961.

Operation at the higher power level will permit tests to explore the stability limits of small, natural circulation, boiling reactors with cores of greater power densities than have been used previously.

The original power generating turbine capacity—5,000 ekw—will not be increased. The excess energy will be dissipated through heat exchangers.



Elk River Reactor. The Rural Cooperative Power Association's 22,000 ekw power plant at Elk River, Minn., will be the first commercial power station to go into operation utilizing a combination of nuclear and conventional heat sources, and also the first constructed jointly by the Commission and a publicly owned power group to be completed. The photo shows the boiling water reactor pressure vessel as it arrived at Elk River during February. The reactor control rods will enter the vessel from the bottom through the pipes shown in right of photo.

Elk River Reactor

Construction of the 22,000 ekw boiling water reactor of the Commission in cooperation with the Rural Cooperative Power Association was nearing completion at Elk River, Minn., in December and criticality is expected to be achieved during the Spring of 1961. Criticality was delayed because of cracks detected in four 16-inch

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[7] See p. 47, Nineteentl

reactor vessel nozzles. Necessary repairs required approximately 6 weeks. There were also difficulties experienced in core fabrication which caused additional delays.

This reactor will provide performance and cost data on a small plant using an indirect, natural circulation, boiling water reactor coupled with a separate coal-fired superheater. Experience gained from it also will aid in evaluating certain variations in boiling water reactor design which may have application to larger plants; for example, use of mixed thorium oxide and uranium oxide fuels.

This reactor was built under the conditions of a second invitation issued by the Commission under its Power Demonstration Reactor Program[7] in September 1955 for proposals from publicly owned utilities. Under the terms of this "second round" invitation, the Commission constructs and owns the reactor, and the publicly owned utility supplies site and conventional turbogenerator equipment, operates the reactor, and purchases the steam.

Improved Cycle Boiling Water Reactor

The Commission extended an invitation in January for proposals to construct and operate a reactor with a minimum capacity of 50,000 ekw and an improved steam cycle. The two-part invitation, issued under "second round" conditions of the Power Demonstration Reactor Program, requested (*a*) proposals from publicly owned utilities to provide the site and the conventional portion of the plant, to operate the entire plant, and to purchase all steam produced; and (*b*) industrial proposals related to the design, development and construction of the reactor.

Of two proposals received from utilities before May 2 to operate the plant, the Commission selected the joint proposal of the cities of Los Angeles and Pasadena, Calif., which specified a site about 40 miles northeast of downtown Los Angeles.

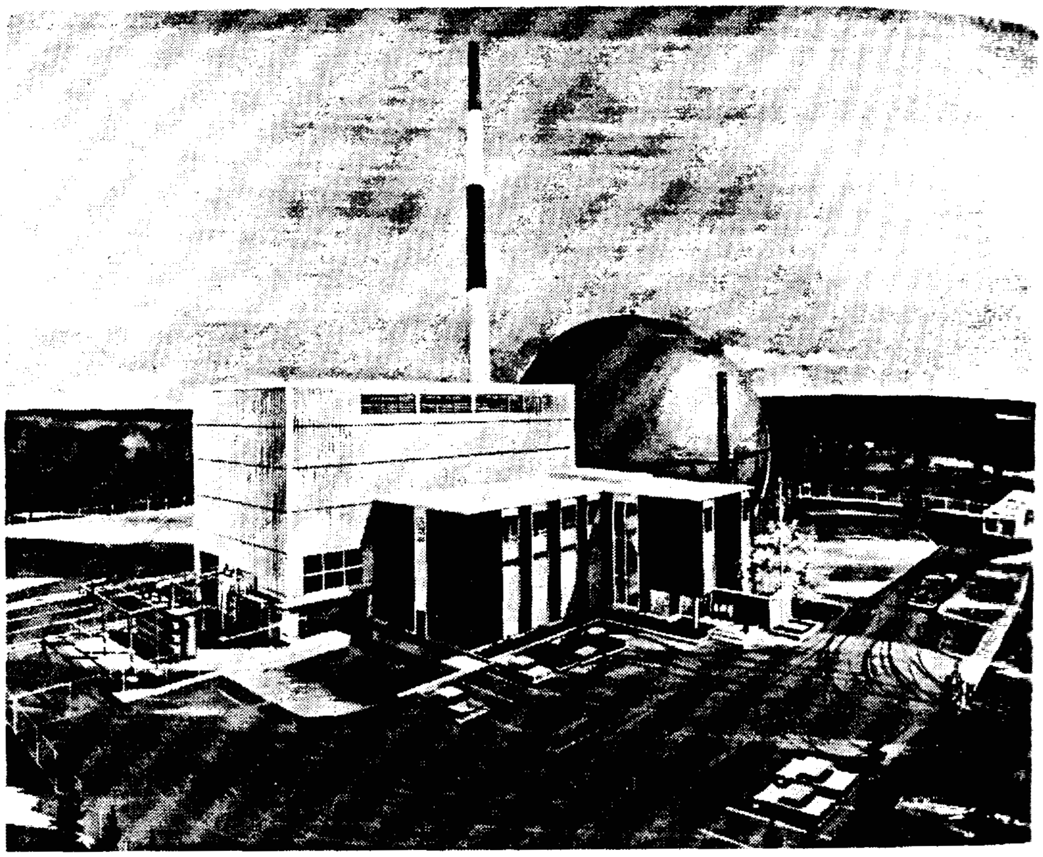
Four proposals were received from manufacturers to supply the reactor. A General Electric Co. proposal first was selected in June as the basis for contract negotiations to supply the reactor for this project, but later an error was discovered in the information upon which the Commission based its decision. After thoroughly re-evaluating all factors involved in the consideration of making a selection from the four proposals received for furnishing the reactor plant and after checking and verifying all bid data, the Commission announced November 17 that it had selected the Allis-Chalmers Manufacturing Co.

[7] See p. 47, Nineteenth Semiannual Report to Congress (July–December 1955).

proposal as the basis for negotiation of a contract to furnish the reactor. Initiation of the project is contingent upon satisfactory negotiation of the contract and satisfactory negotiation of a cooperative arrangement with the cities of Los Angeles and Pasadena.

Under the proposed arrangements, the municipally owned utilities would provide a plant site in Haskell Canyon, Los Angeles County, and the turbogenerator facilities, would operate the facility for the Commission for not less than 5 years and purchase the steam produced by the reactor.

The Allis-Chalmers Manufacturing Co. would design, fabricate, construct and test operate the reactor, furnish the first core and spare fuel elements, and provide training for operating personnel. The plant, planned for completion in early 1964, is intended as a prototype for a 300,000 kilowatt reactor incorporating features aimed at reducing power costs.



Big Rock Point Plant. Artist's conception of the 50,000 ekw boiling water reactor power station being constructed at Big Rock Point in northern Michigan by the Consumers Power Co. Completion is scheduled for 1962. The reactor is expected to lead to development of fuel assemblies with greater power densities per liter of core volume. The Commission is furnishing research and development support for the project.

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[8] See p. 55, Twenty-s

Consumers Power Co. Reactor

The Commission reached an agreement in April with Consumers Power Co. of Michigan on its joint proposal to construct a 50,000 ekw high power density boiling water reactor, and with General Electric Co. to perform associated research, under the terms of the third invitation issued by the Commission for its Power Demonstration Reactor Program.[8] Construction began in June at the Consumers site at Big Rock Point, Mich.

Under the agreement, Consumers Power Co. is responsible for the design, construction, and operation of a reactor scheduled to achieve initial criticality in the latter part of 1962. For a period of 54 months after initial criticality, Consumers will make the plant available to carry out research and development aimed at achieving higher power per unit volume of fuel.

The Commission will support research and development by General Electric before and after construction up to a maximum cost of about $3.7 million subject to escalation not to exceed 10 percent. The Commission also will waive total fuel use charges of about $1.7 million for the first 5 years of operation. Plant capital costs, including site and site preparation, are estimated at more than $27 million.

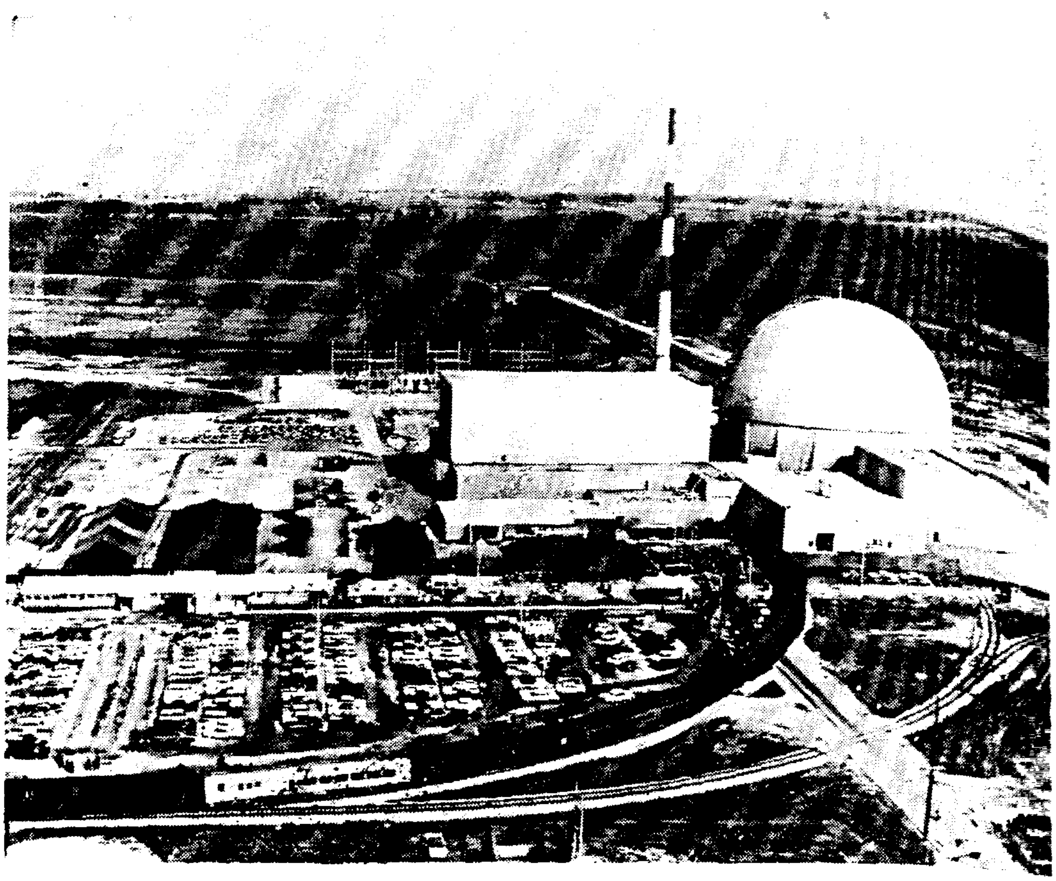
It is anticipated that this reactor's first core will have a power density of about 45 kilowatts per liter of core volume. Tests in the reactor of improved fuel assemblies to be developed are expected to provide data to permit operation of complete reactor cores with a power density of about 60 kilowatts per liter.

Vallecitos Boiling Water Reactor

The Vallecitos reactor, a privately owned 5,000 ekw reactor experiment of General Electric Co. (with Pacific Gas and Electric Co. supplying the generating equipment) was returned to operation in September 1960, after being shut down about 1 year for modifications. Modifications included installation of new circulating water pumps and piping and a new core structure to permit different fuel arrangements. Although the reactor had operated since July 1957, General Electric reported that radioactivity was not a serious problem during overhaul.

The Vallecitos reactor was initially constructed and operated to develop the fuel and reactor design for the Dresden Nuclear Power Station. It now is used for obtaining data related to advanced reactor technology such as high power density cores.

[8] See p. 55, Twenty-second Semiannual Report to Congress (January–June 1957).



Dresden Dedicated. The nation's first full-scale, privately financed atomic power facility, the Dresden Nuclear Power Station, was dedicated on October 12, 1960. Owned by the Commonwealth Edison Co., and built by the General Electric Co., the plant uses a boiling water reactor to produce 180,000 ekw, enough electricity to serve a city of 200,000 persons. Photo shows the plant site on dedication day when 2,500 persons visited the facility about 50 miles southwest of Chicago.

Dresden Nuclear Power Station

Commonwealth Edison Co. Dresden Station near Chicago was the first large privately financed nuclear power plant to go into operation in this country. The 180,000 ekw plant achieved initial criticality October 15, 1959, and went into full design power operation June 29, 1960. The plant generates 180,000 kilowatts of electricity, enough to service a city of 200,000 population.

The drive toward design power began after correction of control rod difficulties and completion of low-power experiments. The plant produced its first electricity on April 16, 1960. It then was operated at gradually increased power levels until full power was attained. After the demonstration production of full power, the reactor underwent a series of power tests with satisfactory results. The plant was then operated at low power levels and with frequent shutdowns for

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Dedication Ceremony. As a highlight of the Dresden dedication, Ralph J. Cordiner, Chairman of the Board of General Electric (left), presented Willis Gale, Chairman of Commonwealth Edison (right) with the original control switch that started Dresden's first chain reaction on October 15, 1959. In photo, Atomic Energy Commission Chairman John A. McCone (center) watches Mr. Cordiner install the new control switch. Mr. McCone was the principal speaker at the dedication.

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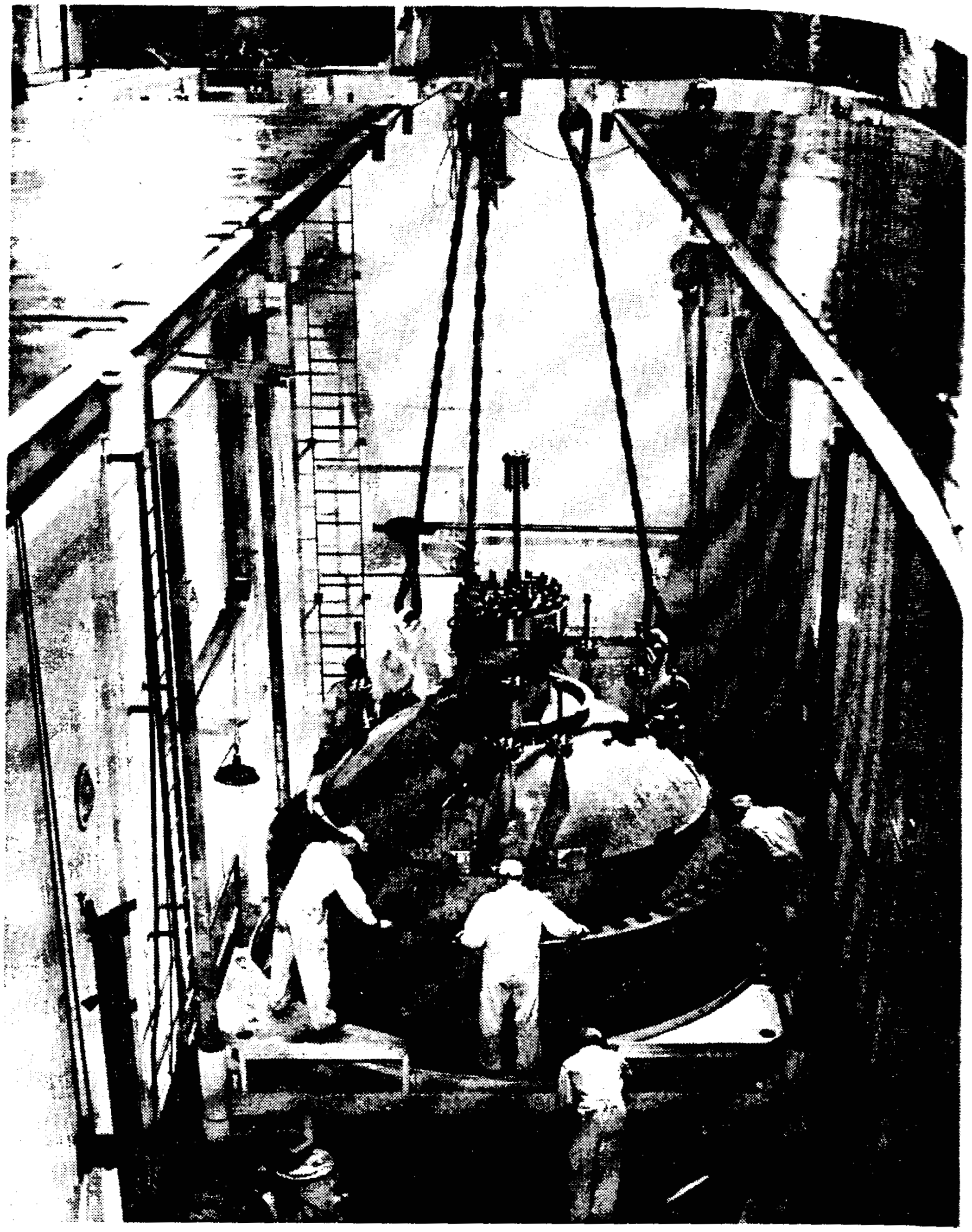

Reactor Head. Photo shows the 50-ton head of the Dresden reactor pressure vessel being emplaced. The reactor has a slightly enriched uranium core. Valued at about $15 million and weighing less than 65 tons, this initial loading of fuel is expected to last 3½ years and to produce as much electricity as would 2,000,000 tons of coal. The interior of the 300-ton reactor vessel is 41 feet high and 12 feet, 2 inches in diameter. The cylindrical walls are 5-inch carbon steel plus a ⅜-inch layer of stainless steel.

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the purpose of training Commonwealth Edison operators. During October 1960, gross electrical generation exceeded 150 million kilowatt hours. On October 12 the plant was officially turned over to Commonwealth Edison Co. by the General Electric Co., its builder.

The Dresden plant was shut down on November 15 when one of the control rods became separated from its drive. Investigation showed that the drive tube, to which the control rod is attached, had severed. A second drive tube showed evidence of cracking. It was then decided to remove the entire core and examine all drive tubes. It is expected that the plant will be shut down for a minimum of three months, during which construction cleanup work will be completed. The present control rod-problem is not related to the difficulty experienced with the control mechanism a year ago.

Humboldt Bay Power Plant

The planned April start of construction of the Pacific Gas and Electric Co. 48,500 ekw boiling water plant at Humboldt Bay, Calif. was postponed several months to allow time for tests of a pressure suppression containment system. The tests were completed, the reactor met the safety requirements of the Advisory Committee on Reactor Safeguards and site work began at Eureka, Calif. in November.

This reactor will exploit natural circulation of the coolant and will be the first to use pressure suppression containment. In this plant, vapor released by a reactor incident would be expelled through a pool of water which would reduce the vapor pressure by condensation. Design power operation of this privately owned plant is scheduled for the latter part of 1962.

Nuclear Superheat Reactors

It is expected that the production of superheated steam in reactors will have some economic advantage in comparison with water-cooled reactors which now produce saturated steam. Three boiling water reactors are now under construction which have as their primary objective the development of nuclear superheat reactor technology.

BORAX-5

Construction of this reactor, the fifth in a series of boiling reactor experiments carried out by Argonne National Laboratory, is nearing completion at the National Reactor Testing Station. It is designed primarily to demonstrate the safety aspects and feasibility of an integral boiling-superheating reactor—that is, a reactor core producing saturated steam which is subsequently superheated within the same core.

BORAX–5 will be operated initially in early 1961 with a limited number of test channels producing superheated steam, and by mid-year should attain design power of 40 megawatts (thermal) with the full boiling-superheating core.

Flexibility designed into the system will permit investigations of nuclear stability problems associated with various fuel and coolant arrangements.

Pathfinder Atomic Power Plant

Construction of the Pathfinder plant, a third-round cooperative project of the Commission and the Northern States Power Co., got under way at Sioux Falls, S. Dak., early in 1960 and by December 31 was approximately 42 percent complete. Reactor criticality is scheduled for June 1962. This 62,000 ekw reactor will provide test and operating data on an integral boiling-superheating core with a superheater centrally located within the reactor core.

Boiling Nuclear Superheat (BONUS) Reactor

Favorable results having been obtained from a preliminary design and feasibility study, the Commission signed a contract with the Puerto Rico Water Resources Authority in January for a 16,300 ekw boiling water reactor with nuclear superheat to be constructed as a second round cooperative project in northwest Puerto Rico. General Nuclear Engineering and Jackson and Moreland Inc., were selected to design the plant and Maxon Construction Co. was named construction contractor.

The proposed plant site at Punta Higuera was found satisfactory from a safety standpoint and construction was formally begun on August 23. Construction is scheduled to be completed in December 1962. This integral boiling superheat reactor will demonstrate for small reactors the practicality of nuclear superheat utilizing a superheater region located peripherally to the boiling core region.

Organic Cooled Reactors

Organic Moderated Reactor Experiment (OMRE)

The OMRE has been in operation for 3 years. During that period the reactor has operated on two core loadings accumulating over 1,800 megawatt days. The primary objective of demonstrating the feasibility of an organic cooled and moderated reactor has been accomplished. The reactor was shut down in March 1960 for evaluation of the second core fuel elements and for modification of the primary cooling system. The third core was loaded during September and criticality was achieved September 20, 1960. Low power tests are continuing.

Examination of the second core fuel elements verified the suspected surface fouling of certain fuel elements. Analysis of the material deposited on the fuel surfaces indicated the fouling material contained a large percentage of iron oxide and iron carbide as well as radiation decomposed organics. It is suspected that the fouling is the result of iron particles present in the organic coolant as a contaminant. The mechanism of fouling is believed to result from electrostatic precipitation of the particles and polymerization of the organic (which surrounds the particles) caused by intense radiation fields at the surface of the fuel plate. The special test elements in the second core loading, similar to those to be used in the City of Piqua power reactor, showed only very small deposits.

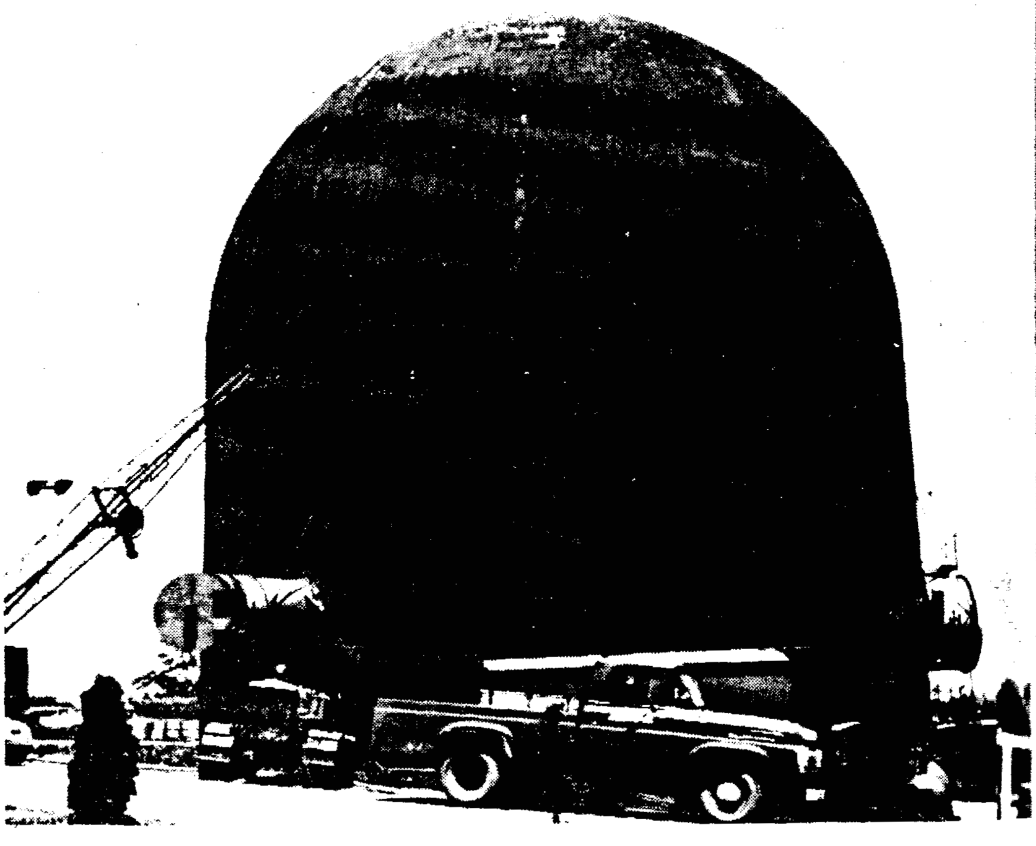
The OMRE primary loop has been modified to provide tests of devices for removal of inorganic particulate matter. The third core will be operated under controlled conditions to remove the iron particulate from the coolant system. The reactor will be further modified late in 1961 to provide more adequate fuel handling, fuel storage, and process equipment facilities. This modification is intended to extend the usefulness of the OMRE for at least the next 5 years. The OMRE will continue to be used as a fuel-testing facility, for bulk organic irradiation, for organic decomposition rates, and for heat transfer and fouling tests. The OMRE schedule will include one year's operation on low enriched metallic fuel similar to the Piqua reactor and a year on uranium oxide fuel.

Experimental Organic Cooled Reactor (EOCR)

The EOCR is being designed to supplement operating data provided by OMRE and to develop improvements for future organic reactors. The experimental reactor, to be built at the National Reactor Testing Station, will have a 40 Mwt capacity but will produce no electricity. It will have five in-pile loops for testing new coolant and fuel elements. It will also provide a facility for investigating the upper limits in operating conditions for organic cooled reactors, and the possible use of other moderators such as graphite or heavy water in organic cooled systems.

Conceptual design was prepared by Phillips Petroleum Co. Fluor Corp. was selected for architect-engineering design, with Atomics International, a division of North American Aviation, Inc., as subcontractor on nuclear design. C. F. Braun and Co. was selected as construction contractor. Phillips Petroleum was chosen as operator.

Site construction began at the National Reactor Testing Station in April and the reactor is scheduled for completion by the end of 1961. Construction was estimated to be 20 percent complete by December 31, 1960.



Piqua Reactor. The 11,400 ekw organic cooled and moderated power reactor being built by the Commission for the City of Piqua, Ohio, is scheduled for completion by late 1961. Photo shows the 70-foot high containment vessel as the project appeared in mid-1960, a year after construction started. The reactor will be the first of its type integrated into a utility system.

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Piqua Reactor

The 11,400 ekw reactor project at Piqua, Ohio, is being built under a second round cooperative arrangement between the Commission and the city of Piqua. It will have primary importance as the first operating organic reactor integrated into an electric utility station. It also will demonstrate the degree of technical and economic feasibility of a small organic reactor of this size at the present stage of technology and provide valuable data on metallic fuel element lifetime and fuel costs.

Construction started in July 1959, and plant completion is scheduled for September 1961. At the end of 1960, the plant was about 90 percent complete.

Prototype Organic Cooled Reactor

In January the Commission invited proposals from utilities for the design, construction, and operation under third round terms of the Power Demonstration Reactor Program of a prototype organic cooled and moderated reactor of 50,000 ekw capacity. The invitation stated that if no proposals were received the Commission intended to proceed with construction of the reactor.

No proposals were received from utilities by the May 2 deadline.

Before proceeding, the Commission re-evaluated current technology of organic reactors in general and more specifically (*a*) the status of the research and development effort on aluminum powder metallurgy (APM); and (*b*) the fuel element fouling problem in the OMRE. The results of aluminum powder metallurgy research and development indicated that the material has satisfactory mechanical properties and that uranium oxide fuel elements clad with this material can be fabricated. Studies of the fuel fouling problem have indicated that it can be solved through reactor modifications.

The Commission's decision to undertake a reactor of this kind was based on the need for a reactor of intermediate size to serve as prototype for a plant of 300,000 ekw capacity. A large reactor would be necessary to demonstrate achievement of economic nuclear power by 1968.

The prototype reactor will be used primarily to demonstrate (*a*) the low capital and maintenance costs associated with a plant utilizing a low-pressure coolant whose corrosive characteristics will allow use of low-cost materials of construction; (*b*) the low coolant replacement costs and acceptable heat transfer characteristics of the polyphenyl organics under forced convection and possibly nucleate boiling conditions; and (*c*) the reduced fuel cycle costs associated with the use of a high burnup fuel such as uranium oxide clad with the new aluminum materials.

In December, 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 this facility. Detailed proposals were not requested—only sufficient information related to possible sites and an indication of ability and willingness to cooperate with the Commission in the plant's operation be submitted to indicate a definite interest. The Commission has undertaken the specific research and development needed for the project and is proceeding with design of the reactor.

Fast Sodium Cooled Reactors

Reactor systems which use liquid sodium as a coolant can operate over a wide range of neutron energies from fast to thermal, depending upon specific design characteristics of the core. In fast neutron systems, sodium-cooled reactors can be made capable of breeding, that is producing more fuel than they consume. Sodium-cooled reactors offer the additional feature of being capable of supplying steam to meet modern central station steam requirements. The main reactor projects in the fast breeder category are Experimental Breeder Reactors Nos. 1 and 2 at the National Reactor Testing Station, and the Enrico Fermi Atomic Power Plant, a cooperative Commission-industry project being constructed at Monroe, Mich., by the Power Reactor Development Co.

Experimental Breeder Reactor No. 1 (EBR–1)

The EBR–1, completed in 1951, continued to operate throughout 1960 on its Mark III core. Stability experiments were performed with various core configurations.

The EBR–1 is scheduled to be shut down early in 1961 to begin modifications preliminary to installation of a plutonium alloy core. Fabrication of the plutonium fuel elements for the fourth core is underway at the Fuels Fabrication Facility at Argonne.

The reactor's Mark III core, installed in late 1957, was designed specifically to be as rigid and tight as possible in order to rule out mechanical movement as a source of the instability that was evident

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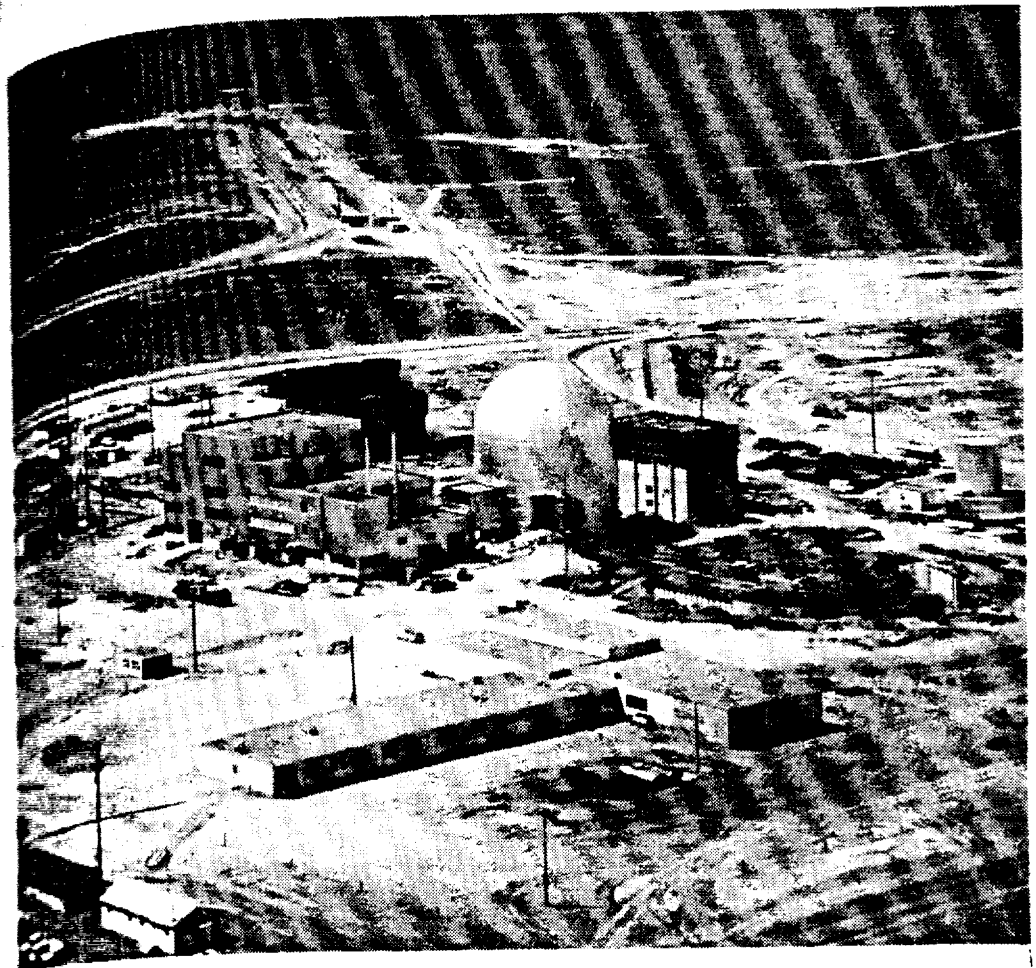

Breeder Reactor. Aerial view of the Commission's Experimental Breeder Reactor No. 2 (EBR-2) which will produce 16,500 ekw when completed in the summer of 1961 at the National Reactor Testing Station in Idaho. To the right of the reactor containment dome can be seen the foundations of the integrated fuel reprocessing building where partially-spent EBR-2 fuel elements will be re-fabricated into new fuel. The 150 ekw EBR-1, forerunner of this reactor, was the world's first nuclear reactor to produce useful electricity in December 1951.

as the previous core (Mark II). Operation of Mark III in this tight configuration demonstrated that careful design had eliminated the prompt positive power coefficient of reactivity which caused a partial meltdown of the Mark II core.[9] In early 1960 spacer ribs were removed from some of the fuel and blanket rods in order to allow them to be free to move under thermal stresses. The results of transfer function measurements carried out on the partially free core demonstrated conclusively that freeing some of the rods altered the prompt power coefficient and made it less negative. Reactor design in general aims at a negative coefficient in which excess temperature reduces reactivity.

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[9] See pp. 45–47, Twentieth Semiannual Report to Congress (January–June, 1956).

Experimental Breeder Reactor No. 2 (EBR-2)

Construction of EBR-2, designed by Argonne National Laboratory, was nearly complete at the end of December. Design power operation of 16,500 ekw is scheduled for the summer of 1961. The first core will use fuel heavily enriched in uranium 235, and the second core may use plutonium.

A primary objective of this reactor's operation will be to demonstrate the feasibility of recycling fuel. The EBR-2 complex contains an integral fuel processing and fabrication facility. The partly burned out, highly radioactive fuel will be reprocessed by pyrometallurgical methods, and the partially decontaminated fuel will be refabricated into new fuel elements. The entire procedure will be carried out by remote control in the shielded fuel cycle facility.

Enrico Fermi Atomic Power Plant

Progress on this 94,000 ekw fast breeder reactor of the Power Reactor Development Co. (PRDC) is behind schedule because of construction delays and redesign of fuel elements. The completion date now will be mid-1961 instead of September 1960. Experiments performed with the original fuel subassemblies caused the fuel elements to warp with effects on the uniformity of the sodium coolant flow. The subassemblies were redesigned to prevent warping.

The court action involving issuance of the construction permit for this reactor is reported on in Part Two, Licensing, Regulation and Indemnification.

Transient Reactor Test (TREAT)

This safety experiment facility at the National Reactor Testing Station is used to subject fuel elements to high-intensity, short-duration surges of nuclear energy without damage to the facility itself. The high-intensity surges are useful in simulating meltdown conditions which a fuel element might be subjected to under abnormal operating conditions.

The first series of meltdown experiments in the TREAT facility were performed in the fall of 1959. Since that time a large number of fuel element samples of the type to be used in the EBR-2 and the Fermi fast reactor have been exposed to high level bursts of nuclear radiation. Based on results of meltdown experiments to date, it is concluded that incipient failure could occur as a result of power

...nsients leading to maximum temperatures of fuel cladding in the ...nge of 950° to 1,120° C. Below this range there will be no failures ... cladding.

Clad temperatures of such sodium-cooled plants as EBR–2 and the ...ermi and Hallam reactors are limited by design to about 500° C, ...ll below the temperature at which failure can occur because of a ...perature transient.

Thermal Sodium Cooled Reactors

...dium Reactor Experiment (SRE)

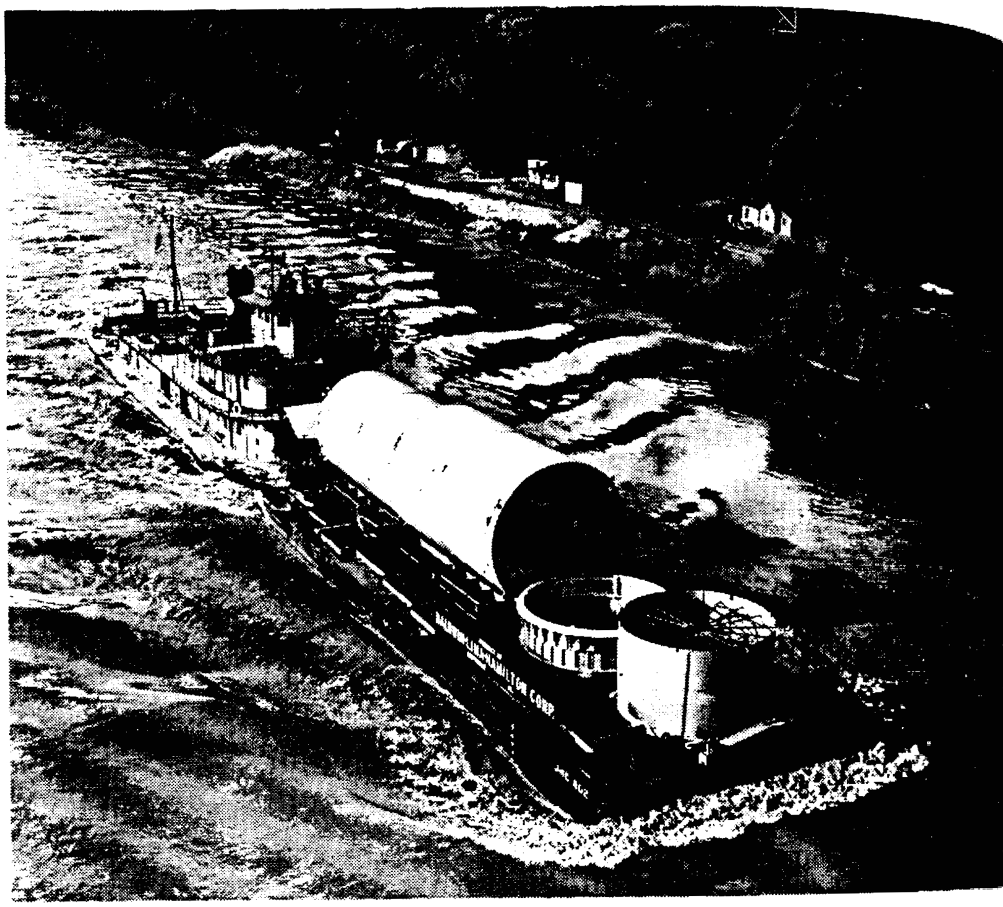
The SRE at Santa Susana, Calif., operated by Atomics Interna...nal for the Commission, is a reactor experiment originally con...ructed to prove the sodium graphite concept, and is now used to ...sist fuel element development for sodium cooled reactors. Particu...r emphasis will be placed on uranium carbide fuels for use in the Hallam Nuclear Power Facility in Nebraska.

The SRE operated for more than 2 years on the first fuel loading, ...d provided heat for generation with a 6,000 kilowatt turbogenerator ...stalled by Southern California Edison Co. of more than 15 million ...owatt hours of electricity. The reactor was shut down in July 1959 ...en plugged coolant channels caused overheating and resulted in ...ilure of fuel cladding and fuel elements. The fuel failure definitely ...sulted from blockage of coolant flow due to leakage into the primary ...dium system of the tetralin coolant from the primary pump seals. ...e of tetralin as an auxiliary coolant has been discontinued and the ...lant has been modified to eliminate the possibility of accidents of ...s type.

Criticality was attained on September 7, 1960, utilizing thorium-...anium alloy fuel. A detailed investigation of the nuclear charac...ristics of the new core loading was undertaken. At the close of 1960, ...e objective of reactor operation was attainment of a lengthy period ...f trouble-free operation to evaluate further the reliability of the ...actor and its system. A secondary objective was irradiation of fuel ...ements of advanced types.

During removal of the fuel elements, the original SRE fuel han...ling machine was jammed by one of the damaged fuel elements. ...n improved machine, designed to handle moderator elements, pumps, ...d fuel elements was devised and utilized to complete rehabilitation ... the reactor. Inspection of the cladding of individual graphite moderator units revealed that 16 units had developed leaks; the defective moderator units were replaced. The cask and moderator cladding difficulties lengthened the rehabilitation period to more than a year.

The shutdown delayed the advancement of sodium-cooled technology. However, useful information was acquired as a result of the incident. It gave evidence to confirm previous evaluations that, for example, a reactor containment sphere is unnecessary for this type of reactor. The innermost portions of the core were successfully removed and replaced without overexposure of personnel to irradiation, and important lessons were learned about design of auxiliary cooling systems, fuel and moderator handling casks, and reactor instrumentation.



Eventful Trip. A barge carrying the 75,000 ekw Hallam (Nebr.) Nuclear Power Facility's 65-ton reactor vessel and its larger containment tank, is shown being edged into a landing on the Missouri River near Plattsburg, Nebr. The reactor hardware had been barged from Eddystone, Pa., down to and across Florida, across the Gulf of Mexico, and up the Mississippi and Missouri Rivers. About 40 miles from Hallam, the 35-foot long, 22-foot diameter tank slipped off a trailer and rolled 150 yards into a field. It sustained no serious damage.

Hallam Nuclear Power Facil

During 1960 a careful rev
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Sodium Components Develo

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...lam Nuclear Power Facility

...ring 1960 a careful review was made of the design of the 75,000 ...w sodium-cooled, graphite-moderated prototype reactor under con...ction at Hallam, Nebr., to evaluate the possibility of an incident ...as the fuel element failure at SRE. As a result of this evaluation, ...e design changes were made in the Hallam reactor. This reactor ...ll supply power to the distribution system of the Consumers Public ...wer District of Nebraska, which will operate the Commission-...ned facility and buy the steam it produces. The nuclear portion ...the facility is being designed by Atomics International. Bechtel ...rp. is performing architect-engineer services, and Peter Kiewit and ...s Co. was awarded the general construction contract.

Construction of the Hallam plant began in April 1959. At the end ...f 1960 the facility was approximately 55 percent built; completion ...scheduled for early in 1962. The initial fuel loading will be a ...anium-molybdenum alloy. The Commission's work on development ...f uranium carbide fuel continues to offer promise for their material ...f the second core loading. Its use should accomplish appreciable ...duction in fuel costs because of its potential longer life in the reactor.

Construction progress was slowed somewhat because the Hallam ...actor vessel—successfully shipped by barge from the Baldwin-...ma-Hamilton Corp. in Philadelphia via the Atlantic Ocean, Gulf ...f Mexico, Mississippi and Missouri Rivers to a landing in Nebraska—...ipped off a truck-trailer about 40 miles from the Hallam site on June 22 and rolled down an incline into a field. The vessel is 22 feet ...n diameter, 35 feet tall, and weighs 65 tons. Reloading the vessel ...was difficult, but it was delivered to Hallam on July 11. A thorough ...amination revealed that the vessel sustained no serious damage and ...t was moved into place.

...dium Components Development Program

The Sodium Components Development Program, formally initiated ...n 1957, has the objective of developing within industry the capability ...for designing and manufacturing reliable and economical components ...for advanced sodium-cooled nuclear power plants capable of operating ...t steam conditions of 1,050° F. and 2,200 pounds per square inch. ...mponents under development include superheat steam generators, ...ermediate heat exchangers, flow controllers, and sodium system in...truments. Investigations are underway on the physical properties of ...aterials exposed to sodium, and on the mass transfer characteristics of materials used in sodium systems. These investigations will pro-vide better data for designing sodium components and systems for high temperature service. Work is continuing on instruments to measure impurities in sodium.

In 1960 a site at Santa Susana, Calif., near the SRE was selected for a large nonnuclear facility required to test large prototype heat exchange equipment. Design and procurement for the facility were undertaken and operation is scheduled for 1962.

Gas Cooled Reactors

Experimental Gas Cooled Reactor (EGCR)

Plant construction of the 22,300 ekw EGCR at Oak Ridge was begun in August 1959 and by the end of December 1960 was about 20 percent complete.

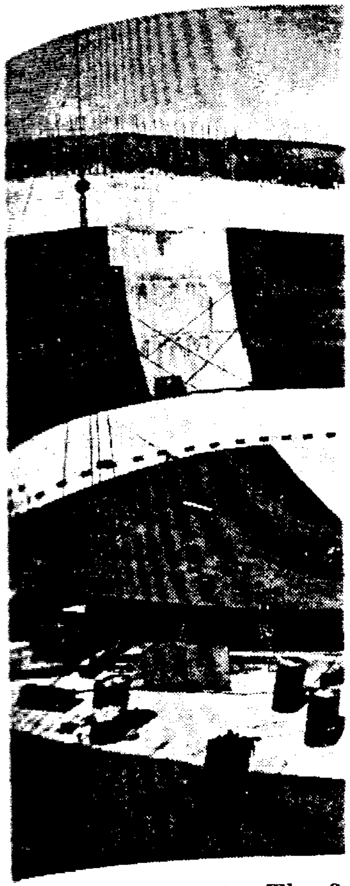
In late 1960 the Commission determined that the total cost of the EGCR would be about $40 million instead of the $30 million originally estimated. This increase resulted mainly from higher than anticipated costs for engineering and purchase of major components such as the pressure vessel and charge and service machinery.

When finished in October 1962, this reactor will be the first civilian gas-cooled nuclear power plant in this country. Work on military and marine gas-cooled concepts is reported in other sections. Power produced by the EGCR will be fed into the electrical system supplying the Commission's Oak Ridge facilities.

Experimental facilities within the reactor will be of two types: those involving experimental loops and those involving fuel channels. Separate heat exchangers and pumping equipment will be provided so that each loop can operate as a completely independent unit. Design changes were made late in 1960 when it was decided that installation of some test loops would be deferred until after some operating experience with the reactor. In the reactor core, fuel channels are readily accessible for inserting experimental fuel assemblies. The varied and flexible experimental capabilities of the EGCR will be useful not only in the initial development of fuel assemblies, but also in pilot operation of fuel elements for large-scale plants.

High Temperature Gas Cooled Reactor (HTGR)

Research and development work continued during the year on the High Temperature Gas Cooled Reactor proposed by Philadelphia



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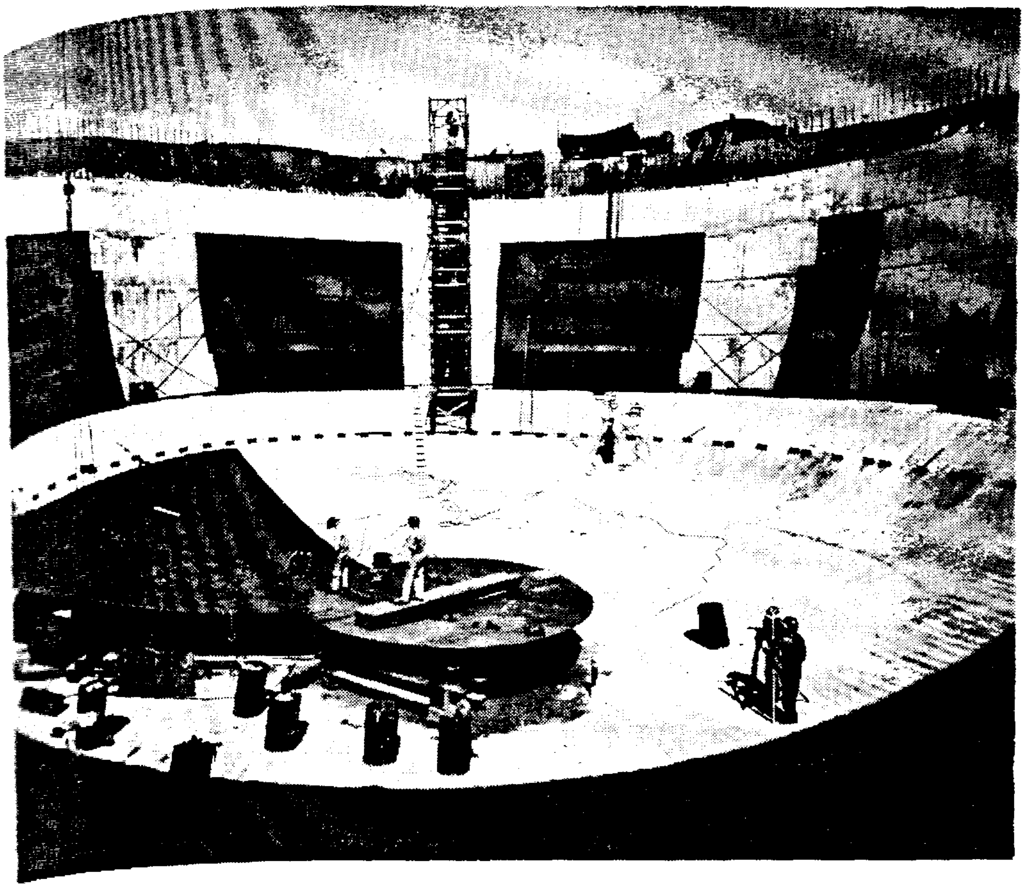

…ruction Start. The first section of the 150-foot high containment shell that … house the 22,300 ekw Experimental Gas Cooled Reactor (EGCR) is shown … attached to the foundation base plate. The EGCR, under construction at … Ridge, Tenn., will be the nation's first gas-cooled reactor to produce com…al electricity. The facility is scheduled for completion in October 1962. … will be operated by the Tennessee Valley Authority under contract to … Commission.

…tric Co. and General Dynamics Corp. under the Power Demon…ation Reactor Program. The proposed site for the reactor is at … Bottom, Pa., about 20 miles south of Lancaster, and construc…on is scheduled to start in April 1961 with completion by September … The ultimate goal in developing the HTGR is to combine in one …tor the high temperature potentialities of gas cooling with high …er density and a fuel capable of high burnup.

…ign has reached a point that will permit placing orders for … components by the beginning of 1961. Based on favorable re…s of research and development work and commercial availability … high permeability graphite, General Atomic Division of General …mics recommended, and the Commission approved, revising the … for the first core loading from the use of metal-clad fuel elements … the immediate use of graphite-matrix elements which had originally been planned for subsequent cores. This decision will make possible the design of a first core compatible with the overall plant design capacity of 40,000 ekw whereas a capability of only 28,500 ekw would be possible with metal-clad fuel.

The General Atomic recommendation was based on research and development work dealing with the feasibility of graphite-clad fuel elements for the first core loading. Full scale fuel elements of the HTGR design were fabricated from normal commercial graphite and subjected to mechanical tests which demonstrated the fabrication technique and mechanical integrity of the elements. Irradiation tests indicated that impermeable graphite of the type to be used for the fuel element cans and sleeves can be expected to stand up under the environmental conditions of the reactor core for the anticipated core lifetime. General Atomic began operation of an HTGR critical experiment facility in July.

The HTGR preliminary hazards report was reviewed by the Advisory Committee on Reactor Safeguards (ACRS) during December in connection with Philadelphia Electric's application for a construction permit. The ACRS reported that, based on the status of reactor development, it could not go beyond its statement of March that the proposed site is satisfactory for a reactor of this general design and power level. This ACRS action probably will result in some delay in issuance of a construction permit and could result in delaying the project schedule.

Florida West Coast Reactor

Research and development work continued on the gas-cooled, heavy-water-moderated 50,500 ekw reactor proposed by the East Central and Florida West Coast Nuclear Groups in the Power Demonstration Reactor Program. In August, the Commission announced plans to develop beryllium-clad fuel instead of stainless steel-clad fuel for the first core loading. Future plans for the reactor depend on the success of the research and development program which will require about 2 years.

A major advantage of gas-cooled, heavy-water reactors is the fact that, in large sizes, they can use natural, unenriched uranium as fuel. Natural uranium fuel, however, requires use of a cladding material that absorbs few neutrons such as beryllium.

The plant, if constructed, would be located at Pierce, Polk County, Fla., about 35 miles east of Tampa. The 50,000 ekw reactor, fueled with slightly enriched uranium, is designed as a prototype for a similar 300,000 ekw plant fueled with natural uranium.

Exchange Agreement on Gas-Cooled Reactors

An exchange of information agreement was completed in late 1959 between this country and the United Kingdom regarding the EGCR at Oak Ridge and Britain's Advanced Gas-Cooled Reactor. The exchange of technical information on these two projects was supplemented in early 1960 by an agreement to exchange information on the HTGR and the DRAGON project, which is a high temperature, gas-cooled reactor to be built in England (see section of this report on International Activities).

Heavy Water Reactors

Carolinas Virginia Tube Reactor (CVTR)

Site clearance, excavation, and other preparations for construction of the 17,000 ekw (of which 1,500 ekw is conventional superheat) heavy water moderated and cooled, pressure tube reactor began at Parr, S.C., in June. Construction of this cooperative project by the Carolinas Virginia Nuclear Power Associates, Inc. was to start in April but delays in fuel fabrication set back completion of a prerequisite critical experiment by Westinghouse Electric Corp. By the end of December, construction was 10 percent complete. This CVTR represents the first time that private companies have invested in a reactor that will use heavy water for cooling and moderating.

The new reactor also will eliminate the large pressure vessel which has been the main component in previous pressurized water reactors. In place of the heavy steel vessel which houses the entire core and its structural support under a high pressure, the Carolinas Virginia reactor will accomplish the same function with 42 pressure tubes installed in a low pressure tank. This type of reactor is expected to be more flexible because fuel elements can be more easily inspected and replaced.

A critical facility for the reactor, the LRX at Waltz Mill, Pa., will be used in determining physics parameters, essential to completion of prerequisite research and development. The facility went critical in July. Irradiation experiments in the Westinghouse test reactor of the CVTR fuel bundle to determine effects of radiation are pending.

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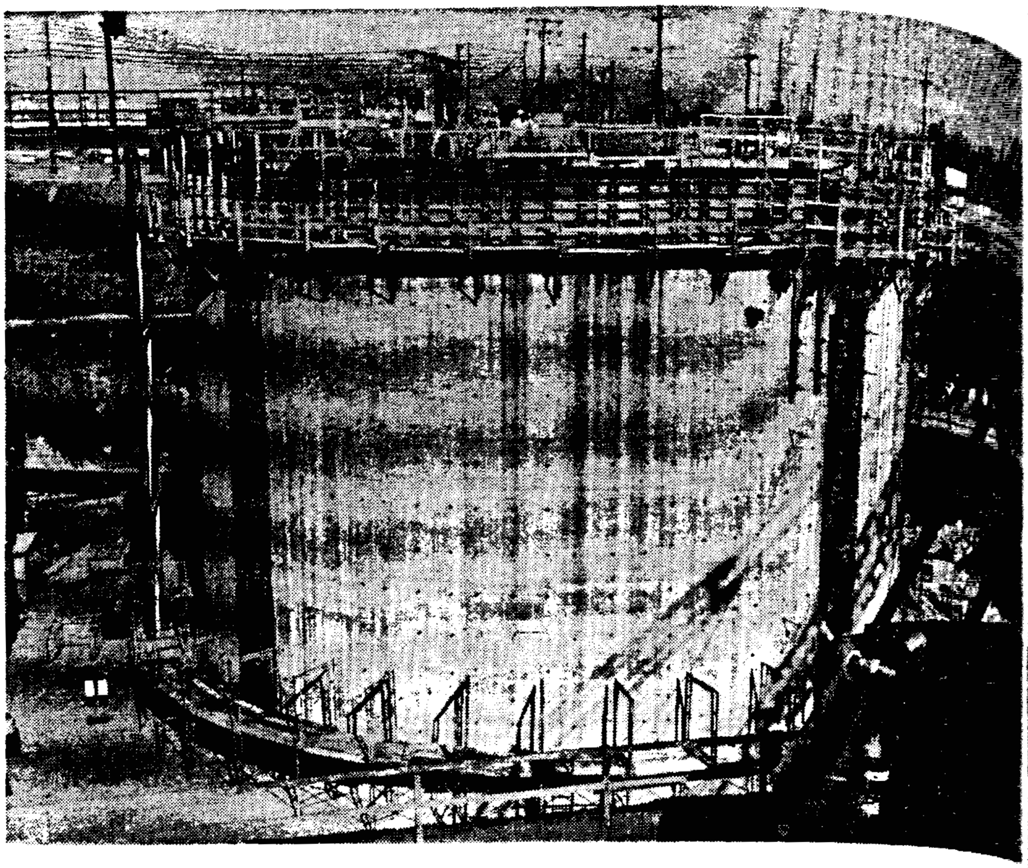

Reactor Foundation. Initial operation of the Heavy Water Components Test Reactor (HWCTR), now under construction at the Commission's Savannah River, S.C., plant, has been re-scheduled for late 1961. This early 1960 photo shows the concrete foundation of the containment shell. The reactor has been designed to permit simultaneous test irradiation of up to 12 full-sized natural uranium fuel elements at temperatures, pressures, and power densities similar to those encountered in operating power reactors.

Heavy Water Components Test Reactor (HWCTR)

Construction of the HWCTR, started at Savannah River, S.C., in April 1959, was approximately 45 percent complete at the end of 1960. Construction progress on this project was slowed by the labor-management disputes in the steel industry in late 1959. The reactor vessel is expected to be delivered in May 1961, about 10 months behind the previous schedule. The delay was caused by the inability to obtain steel for the reactor vessel and welding difficulties encountered in the fabrication of this unit. Initial operation is now set for the fall of 1961.

This 61 Mw (thermal) test reactor will yield operating information on a heavy water-moderated system under conditions similar to those for power production. It will irradiate fuel elements and test other heavy water reactor components.

Cooperative Program

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Cooperative Program with Canada

The Commission and Atomic Energy of Canada, Ltd., signed a memorandum of understanding in mid-year providing for an expanded program of cooperation in development of heavy water-moderated power reactors.

The program includes: exchange of information on heavy water reactor projects under construction or design; close cooperation in research and development work including mutual use of pertinent research and development facilities and provision for transfer of certain materials; and exchange of personnel. In the United States, the Commission is undertaking research and development work at a maximum cost of $5 million during the next 5 years. This work will be specifically directed toward heavy water reactors to be constructed in Canada. The program covered by the memorandum of understanding will continue at least 5 years beyond the date of initial operation of Canada's 200,000 ekw CANDU heavy water power reactor.

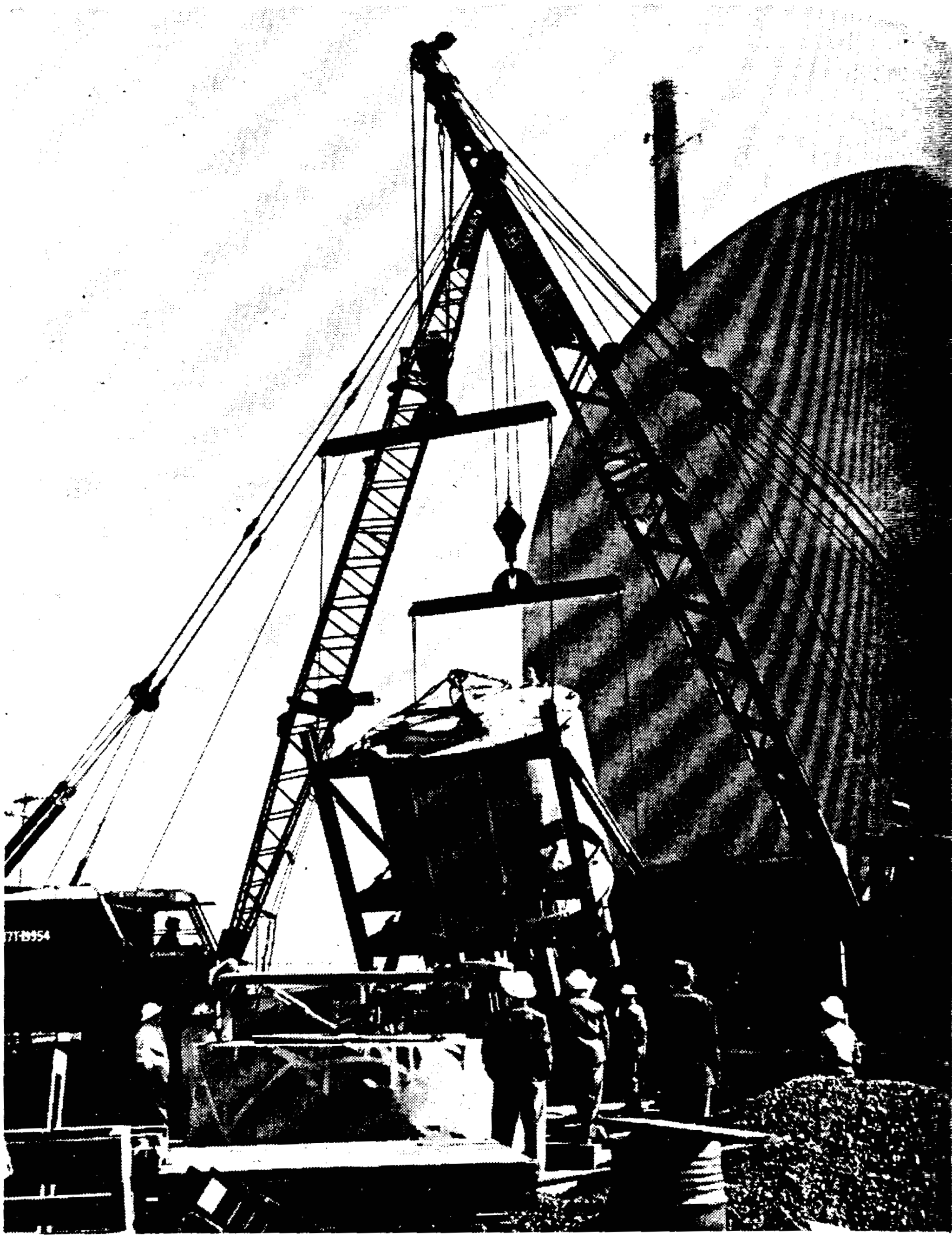
A joint technical board was established to review progress of the cooperative program and to establish future requirements to meet its objectives.

Plutonium Recycle Program

Plutonium Recycle Test Reactor (PRTR)

The PRTR at Hanford, Wash., attained initial criticality on November 21. Design power of 70,000 Mw (thermal) is expected early in 1961. Construction of the full PRTR plant and associated facilities is scheduled for completion by June 1961. Critical tests are underway and reactor operation meets expectation.

This experimental test reactor will be used to investigate and demonstrate the economic feasibility of recycling plutonium, and to develop the technology for using plutonium as an alternative, or a supplement, for uranium 235 in power reactor fuels. The primary focus of the program is on thermal reactor fuels, which commonly contain low concentrations of fissionable materials as contrasted to fast-neutron breeder reactor fuels which generally involve higher concentrations of fissionable materials. About one-third of the first core loading of fuel elements contains plutonium in the form of an aluminum alloy with 1.8 percent plutonium; the remainder of the elements are natural uranium oxide rods clad with zircaloy. Mixed plutonium-uranium oxides are to be used later.



Plutonium Test Reactor. The "heart" of the Plutonium Recycle Test Reactor (PRTR) is shown as it was swung off its delivery truck and rigged for movement into the containment vessel (background) at the Commission's Hanford, Wash. plant. Made of aluminum, the reactor calandria will contain the heavy water coolant and moderator of the reactor which has been designed for flexibility in irradiation of plutonium-bearing fuel and investigation of the operating characteristics of plutonium re-cycle systems.

Plutonium Processing. ... with extreme caution. ... glove-box production l ... ford, Wash. The use ... of a negative pressure ... than outside) prevents ... tion of plutonium-bear

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Plutonium Processing. Because plutonium is highly toxic it must be handled with extreme caution. Photo shows the mixing of plutonium oxide powders in a glove-box production line at the new Plutonium Fabrication Pilot Plant at Hanford, Wash. The use of gloves sealed into the plexiglass sides and maintenance of a negative pressure within the chamber (air pressure is lower inside the box than outside) prevents the escape of plutonium-contaminated air during fabrication of plutonium-bearing fuel elements for the Plutonium Recycle Test Reactor.

The PRTR is a pressure-tube reactor, using heavy water as a coolant and moderator, and operating at power-reactor temperatures, will be an important source of additional power reactor information and technology.

Essentially full-scale operation of the *plutonium fabrication pilot plant* at Hanford started in August following the installation of almost all major equipment items. This facility, which fabricated the plutonium-containing fuel elements for the first core loading of the PRTR, supports the development of advanced, semi-remote processes for fabrication of plutonium-bearing fuels preparatory to their evaluation and test.

Fluid Fuel Reactors

The Commission's research and development program on reactors that would utilize fluid fuels includes the aqueous homogeneous concept which first came under study during 1954, and the newer molten salt and molten plutonium approaches.

Aqueous Homogeneous Reactors

Detailed evaluation studies were conducted during the year on aqueous homogeneous reactors which tended to confirm their potential as thermal breeders. Preliminary results of the study indicate such reactors would breed each year 16 percent more fuel than consumed at a fuel cycle cost of 1.2 mills per kilowatt hour.

The aqueous homogeneous reactor concept incorporates solution fuel, continuous fission product removal and freedom from mechanical control and safety rods. The program objective is to solve the problems of the corrosiveness of the fuel solution, the instability of the fuel at very high temperatures, and the maintenance of a highly radioactive loop. When these problems are solved, the simple fuel cycle together with the potential of breeding can be balanced against the disadvantage of limited thermal efficiency.

The General Advisory Committee of the Commission[10] reviewed the development program and made an evaluation of the potential of the aqueous homogeneous concept. It recommended early in the year that laboratory work should continue on this system, and that the work should include studies of other aqueous uranium solutions and alternative core tank materials in an attempt to find a combination in which corrosion will be less severe and the permissible operating temperature higher than in previous experimental reactors. The Committee also recommended that the second homogeneous reactor experiment be operated with reverse flow of the aqueous fuel in the hope that this would shed light on the difficulties of operating the aqueous uranyl sulfate system in the Homogeneous Reactor Experiment No. 2 (HRE–2).

Further work on the aqueous system would be necessary to determine whether the advantages inherent in the simplicity and low cost of the fuel cycle, and in the breeding capability, might outweigh low steam efficiencies resulting from temperature limitations and the technical complexities of the system.

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[10] See Appendix 2.

After 105 days of continuous operation, the HRE–2 was shut down January 22 to investigate a marked increase in fuel concentration in the blanket region of the reactor. Inspection of the reactor core revealed that corrosion had eaten a second hole between the core region and the blanket region. The new hole, measuring about ½ inch by 1½ inches, was about the same size as the one found in the core tank in the autumn of 1958. Examination of a sample cut from the edge of the hole indicated melting due to a heat source other than metal-water reaction with the temperature excursion lasting not more than 2 seconds. Other shallower pits appeared in the lower half of the core wall, but the upper half appeared to be in generally good condition.

Major modifications were made in the HRE–2 during the period from February through October, including patching the holes, removing the diffuser screens, and brush-cleaning the core interior. All these operations were carried out in the 32-inch-diameter core through a 2-inch opening in the top of the core fuel pipe. This required development of greatly improved remote maintenance techniques and the perfection of remote methods for detailed inspection of the core interior.

In addition, several components were replaced and the direction of flow was reversed. Mockup tests have shown that, with reversed flow, local stagnation in the reactor is reduced and uranium-bearing solids are swept out of the core rather than allowed to settle on the lower half of the core wall where they can cause local overheating.

Operation of the reactor was resumed in November. The immediate objective is to determine whether the revisions made in the reactor circuit will allow it to be operated stably under the original design conditions. The reactor is being operated at gradually increasing power levels and system performance is monitored at each step in an attempt to determine precisely the nature of any instabilities and the conditions under which they occur.

The HRE–2 is scheduled to be operated at full power in January 1961 to establish its performance characteristics with reversed flow. The remainder of fiscal year 1961 will be used to close out the aqueous homogeneous program, including operation of the HRE–2, in favor of increased development of the molten salt concept.

Molten Salt Reactor

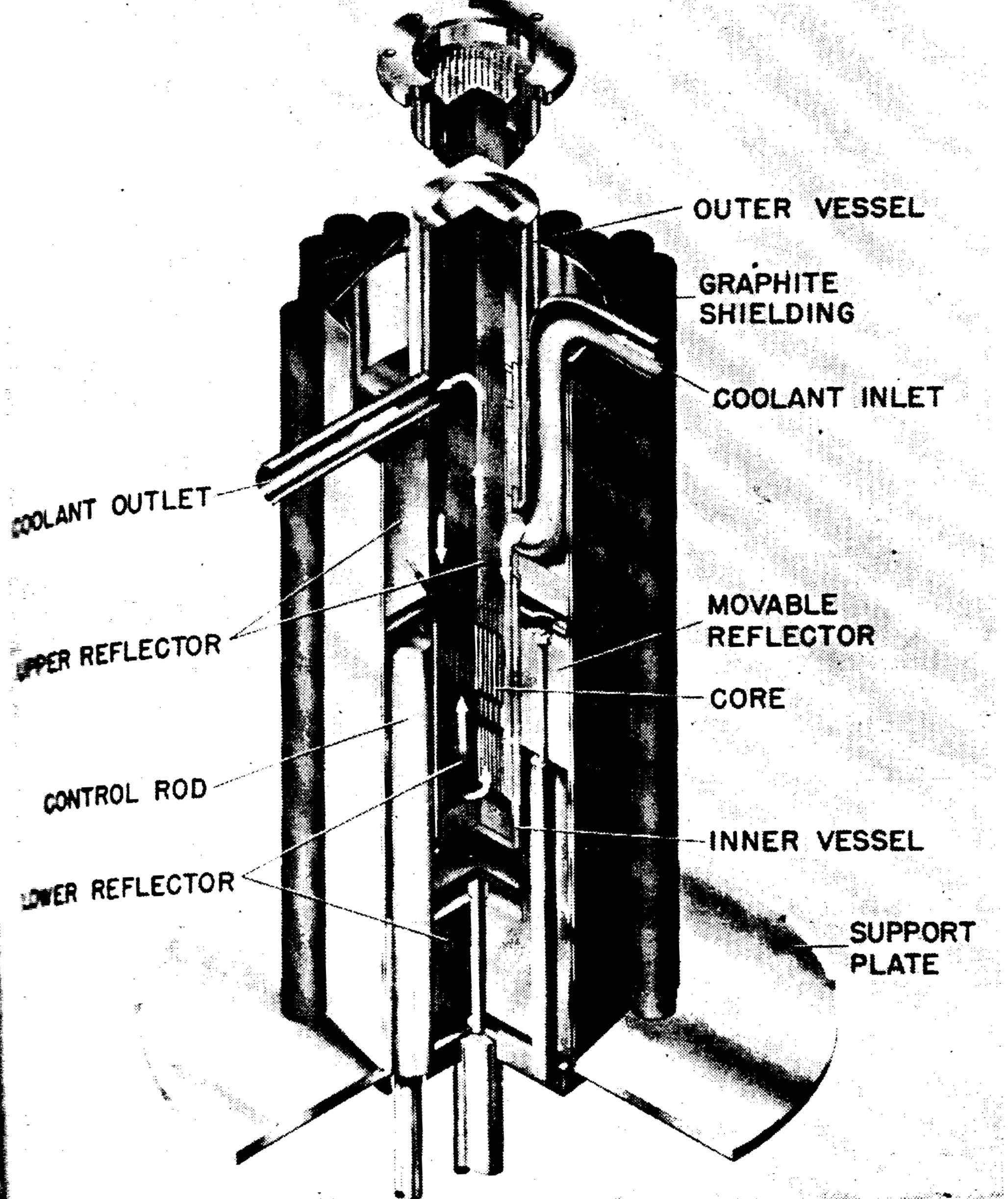
Favorable evaluation of the molten salt concept by the Commission's General Advisory Committee and other study groups resulted in a decision to continue the research and development program. The evaluations cited a number of practical advantages of this reactor type.

The Committee stated that the slightly lower breeding ratio as compared with the aqueous homogeneous reactor, is not a serious disadvantage at present U-233 prices, and recommended that the research program be pursued vigorously, including construction and operation of a reactor experiment. Evaluation studies indicated that the molten salt reactor has potentially low fuel cycle costs and has a somewhat better breeding potential than was anticipated. Preliminary results indicated a maximum annual fuel yield of 8 percent and a probable fuel cycle cost of 1.0 mill per kilowatt hour.

Conceptual design of a 10 Mw (thermal) molten salt reactor experiment (MSRE) was completed by Oak Ridge National Laboratory in September and the Commission decided in October to authorize construction. The proposed reactor has a cylindrical, single region graphite-moderated core about 4½ feet in diameter and height. The graphite core is made up of graphite columns pierced by vertical channels for fuel flow. The fuel, a molten mixture of beryllium, lithium, zirconium, uranium and thorium fluorides, would discharge its heat to a molten salt of the same type, but containing no uranium in the primary heat exchanger. In the experiment, heat from the secondary loop is discharged to the atmosphere through a secondary air blast heat exchanger.

The major objectives of the MSRE are to demonstrate the dependability, serviceability, and safety of the molten salt concept for civilian power purposes, and to provide confirmation of earlier experimental work and information on components needed for a larger reactor. The molten salt reactor concept offers the potential economic advantages of improved steam conditions and high efficiency through operation at very high temperatures and power density. As the fuel is in solution, no fabrication of fuel elements is necessary and continuous removal of fission poisons is possible as in the aqueous homogeneous reactors, thereby providing greater continuous neutron economy.

Construction of the MSRE will begin early in 1961 at Oak Ridge in an existing building previously used for the Aircraft Reactor Experiment, a reactor of the molten salt type which was dismantled after operation in November 1954 as part of the Commission's Aircraft Nuclear Propulsion Program. Much of the research and development work earlier carried out in connection with aircraft reactor systems is applicable to MSRE work. Tentative completion date of



Plutonium Experiment. Although built as a short-term experimental device, the Los Alamos Molten Plutonium Reactor Experiment (LAMPRE) is being used in the loug-range project of developing fuel suitable for breeder reactors in which uranium 238 or thorium can be converted into fuel. Above is a diagram of the main components of the LAMPRE.

the reactor is May 1963; the estimated cost, exclusive of supporting research and development, is about $4.2 million.

Los Alamos Molten Plutonium Reactor Experiment (*LAMPRE*)

This small reactor experiment of 1,000 thermal kilowatts was built as a short-term experiment primarily to explore use of a fuel of

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melted plutonium alloy containing 10 percent iron. A tantalum-tungsten alloy is being tested as a container material for molten plutonium. A dry critical experiment was conducted with LAMPRE in November 1959. Sodium was circulated at operating temperature late in 1960, and hot criticality tests are expected to start early in 1961.

When the reactor has demonstrated stable operating performance and suitable characteristics, it will be used to test other fast fuel materials under development at Los Alamos, including ternary plutonium alloys.

Results of LAMPRE tests will permit design of a core for test in a higher power facility.

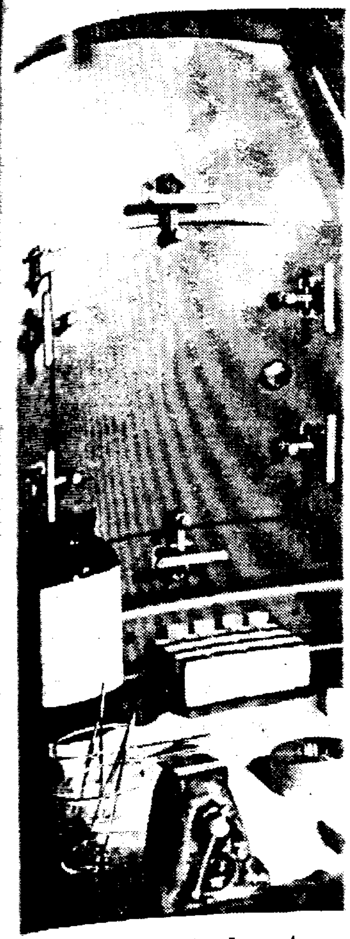
New Reactor Projects

Research and development was continued during 1960 on a number of new reactor concepts, each of which offers one or more improvements over existing reactor designs. None is sufficiently developed at current stages of their respective technologies to permit plant design, construction and operation. Each concept is subjected to continuing evaluation and development is continued to the point where a decision can be reached on whether to build an experiment or to terminate the work. In 1960, development work on one of the advanced concepts, the Molten Salt reactor, had reached a point where a decision was made to construct a reactor experiment.

Three Evaluated Concepts

Three of these advanced concepts so far have survived preliminary evaluation: the liquid fluidized bed, advanced epithermal thorium and pebble-bed, gas-cooled reactors.

Fluidized bed reactor. The Martin Co., under Commission contract to investigate and develop the fluidized bed reactor concept, constructed a critical experiment for such a reactor at the Martin Nuclear Division site near Baltimore. Experiments will begin early in 1961. The idea of this reactor type is to maintain a bed of fissionable and fertile material in a fluidized state under turbulent flow conditions. Water or organic liquids are considered as possible fluidizers and coolants. High power density, ease of charging and discharging fuel and uniform fuel burnup are potential advantages of this system. It also may offer the possibility of reactor control without control rods.



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…minary *Work.* An Atomics International scientist prepares a wafer of …active uranium dioxide for an experiment in connection with the Advanced …thermal Thorium Reactor which has been proposed as a privately financed …ect by Southwest Atomic Energy Associates. Preliminary studies are being …ducted on the nuclear characteristics of uranium-thorium core configurations …ich might be used in the reactor. The work is being done in a critical experi…nt facility at Santa Susana, Calif.

…anced *epithermal thorium reactor.* This reactor, which would … a uranium 233-thorium fuel cycle, operates with neutron energies …ove the thermal range—the high epithermal neutron energy …gion—and be cooled with sodium, is sponsored by the Southwest …omic Energy Associates, a group of privately owned electric com…nies in the southwest area of the United States. In order to obtain …actor physics information on this reactor concept, Atomics Interna…onal completed construction of a critical facility at Santa Susana, …lif., late in 1960 and operation was begun using part of 25 kilograms … uranium 233 provided by the Commission. It is expected that this …pe of reactor would have high operating temperatures, which pro…de good steam conditions and high thermal efficiency; low reactor …essure, minimizing the difficulty of vessel manufacture; compactness and high power density, with resultant low investment per unit of power in the reactor structure.

Pebble Bed Gas Cooled Reactor. Work on the pebble bed concept was being performed during the year by Oak Ridge National Laboratory and by Sanderson and Porter, Inc., under Commission contract. A feasibility study and conceptual design of a reactor experiment was being completed at the year's end to help determine whether or not an experimental reactor should be undertaken. In this concept, a stationary bed of spherical balls or pebbles of graphite containing uranium fuel is cooled by helium gas. Because of the nature of the structure, coolant, and fuel, the reactor can produce steam at temperatures high enough for use with modern generating equipment. The fuel also is amenable to simple handling techniques in loading and unloading.

A new type of fuel material has been developed and tested under this program. It consists of small particles of uranium oxide or uranium carbide coated with a high temperature ceramic as described in the later section on Fuels Development.

Other Concepts

Other reactor concepts in earlier stages of development include the *mercury cooled fast reactor;* the *variable moderator reactor;* the *supercritical water reactor* studied for application to aircraft and maritime propulsion and now being considered for a central station plant; and the *moderator control or spectral shift reactor* in which heavy water is added and subtracted from the light water coolant.

Section 111 of the Authorization Bill for fiscal year 1961 authorizes the Commission to carry out a design and engineering study of *steam cooled power reactors* for a report to the Joint Committee on Atomic Energy by April 1, 1961. Ten different variations of the steam-cooled concept are being considered.

Work on an advanced fluid concept using *boiling sulphur* as coolant was terminated in mid-year by the contractor, Aerojet General Nucleonics. The study of boiling sulphur, interesting because of its potential in a direct-cycle reactor for obtaining a high thermal efficiency, was limited to corrosion and heat transfer measurements. The corrosion studies indicated that gross out-of-pile corrosion rate for the metal alloys most promising for reactor use were of the order of 10 to 20 mills per year, which was considered excessive.

Unsolicited New Reactor Concepts Proposals

The Commission announced on March 23 a revision of its procedures for evaluation of unsolicited proposals received from industrial companies for studies of new reactor concepts. Previously, unsolicited proposals were reviewed twice each year in March and September, although proposals could be submitted at any time. Under revised procedures, proposals may be submitted at any time and will be reviewed by Commission staff as received. The New Reactor Concepts Board, previous evaluator of unsolicited proposals, was abolished.

Twelve proposals asking Commission support were submitted by 10 companies between September 1, 1959 and March 1, 1960. The Commission accepted the proposal on a mercury-cooled fast reactor, and rejected all other requests for Commission support.

Reactor Safety

The Commission's intensive experimental and theoretical program to increase reactor safety and to reduce safety costs includes five facilities designed for reactor tests as well as research and development in containment of reactor systems, and in chemical aspects of reactor safety.

Work with Facilities

Three facilities at the National Reactor Testing Station are exclusively devoted to safety tests. They are known as Special Power Excursion Reactor Tests (SPERT) 1, 2, and 3. A fourth facility SPERT-4 will be completed by May 1961. A fifth facility is the Kinetic Experiment on Water Boilers (KEWB) at Santa Susana, Calif., which is an aqueous homogeneous type.

SPERT-1, an open vessel reactor, has been used for kinetic testing of various cores since 1955. During early 1960, tests were run on an extremely fast integral control system. Results showed that the control system is capable of limiting nuclear excursions having periods as short as 3 milliseconds.

Following these tests, a program of capsule experiments was started to investigate, on a limited scale, the details of void behavior and other effects that contribute to reactor self-shutdown during a power excursion. The SPERT-1 program has been extended to include a study of the behavior of cores, such as oxide cores that are assuming importance, but for which overall kinetic and safety aspects have been previously studied. During the last quarter of 1960, a low enrichment oxide core was installed in the reactor for a series of reactor behavior studies. This low enrichment core, fabricated from N.S. *Savannah* type of fuel, is representative of cores being used in power reactors where high fuel burnup is important for economic or military reasons.

SPERT–2, a medium pressure reactor (375 psig, 400° F.) is designed to study the comparative kinetic behavior of cores using various moderators and reflectors. Initial criticality with light water moderator was achieved in March 1960 followed by static measurements in light water. Criticality with heavy water was achieved in August and was followed by static measurements in heavy water. The transient program with these cores was started before the end of the year.

SPERT–3 can operate at temperatures up to 668° F, pressures up to 2,500 pounds per square inch (gauge), and with flow up to 20,000 gallons per minute, and is able to simulate either boiling water or pressurized water conditions. This reactor completed measurements of static physics parameters in the spring of 1960, and a test program was initiated at ambient temperature to investigate the effects of pressure and flow on transient behavior. Preliminary results indicate that the SPERT–3 reactor can safely withstand a 10 millisecond transient while operating with a system pressure of 2,500 psi, an initial coolant temperature of 70° F, and a coolant flow of 20,000 gallons per minute.

SPERT–4, now under construction, is designed to investigate the kinetics of pool reactors which are commonly used for university research and training, as well as to further investigate the instabilities observed in the SPERT–1 experiments. Completion of this pool-type reactor is scheduled for mid-year of 1961.

The Kinetic Experiment on Water Boilers (*KEWB*) was designed to obtain data on the dynamics of simple homogeneous reactors. After experiments were completed with a spherical core in 1959, a cylindrical core was installed, and achieved criticality in March 1960. On May 10, this reactor underwent the shortest period nondestructive transient power burst ever recorded in a thermal reactor. An instantaneous power of 2,300,000 kilowatts was reached on a 0.90 millisecond period. The total energy released was about 8,600 kilowatt-seconds. Investigations are underway to determine the usefulness of the KEWB reactor for studies of fuel processing accidents.

Research and Development

Brookhaven National Laboratory started a study to determine the chemical and physical identity of biologically hazardous fission products that might be released should a reactor accident occur. This knowledge can be used to design filter systems, washout systems and containment systems more accurately and cheaply.

Oak Ridge National Laboratory completed the design and fabrication of the first in-pile loop to measure fission product release under realistically simulated reactor accident conditions.

At Argonne National Laboratory, metal-water reaction rates of zirconium and uranium were measured at atmospheric pressure at temperatures up to 3600° C. A series of in-pile measurements were also made in the TREAT reactor in order to correlate the laboratory findings. Work is continuing at higher pressures and on other important reactor materials such as aluminum and stainless steel.

Studies of ignition of pyrophoric metals discovered that halogenated hydrocarbons drastically inhibit the ignition of zirconium and uranium. This may provide a means of assisting safe handling of these highly pyrophoric metals.

A survey and analysis was completed of criticality hazards in processing uranium hexafluoride into uranium oxide or uranium metal—the first of a series of studies to cover each step in the fuel cycle.

In studies of reactor containment, the leak rates of components for buildings to contain low overpressures that might result from a reactor incident were measured to determine the usefulness of this type of building for low enthalpy (heat content) coolant systems. Methods of reducing the initial leak rates of some components by a factor of ten have been determined. In another study, an equation has been developed and experimentally verified to describe the velocity of sound in boiling water with various void fractions. This equation makes possible more accurate calculations of the transmittal of shock during a violent reactor excursion.

During October contractual negotiations were started for design of a new test facility to model and examine loss of coolant accidents occurring as a result of the rupture of primary coolant circuits in water reactors. Construction will begin early in 1961. This facility will aid in the test and evaluation of new containment concepts eventually leading to the reduced cost of containment.

MARITIME REACTORS

The Maritime Reactors Program has as its goals the demonstration of the safety and reliability of nuclear merchant ships, and the reduction of capital and operating costs to encourage the construction of privately owned nuclear vessels. To achieve these objectives, the Commission and the Maritime Administration are engaged in a joint research and development program. On the nuclear phase of the program, the Commission has determined that emphasis should be placed on the development for maritime use of pressurized water reactors as in the N.S. *Savannah*, and of gas-cooled reactors.

N.S. Savannah

Construction of the N.S. *Savannah*, the first nuclear powered merchant ship, was essentially completed at the Camden, N.J., yard of the New York Shipbuilding Corp. at the end of December. Initial criticality of the ship's pressurized water propulsion plant is scheduled for early 1961. Startup was delayed by ship construction problems, and by extension of precritical testing and analysis.

During the past year The Babcock & Wilcox Co. and Ebasco Services, Inc., carried forward design reviews to identify any potential difficulties that might impede future operation of the nuclear plant and to provide a basis for developing improved components. The reviews did not find any need for major changes, but some minor modifications were undertaken to improve reliability. Additional changes may be made at the first refueling. Future effort will be pointed toward improving components for the nuclear plant. The Commission will hold a public hearing early in 1961 on nuclear safety aspects of the *Savannah*.

Yorktown, Va., has been selected as the base from which the *Savannah* will undertake her sea trials. It is expected that the ship will be taken from the shipyard to the Yorktown base in the early spring of 1961.

After sea trials are completed, the *Savannah* is to be operated as an experimental vessel for two to three years. Toward the end of this period, the vessel will enter limited commercial service and visit major world ports. Operation under commercial conditions will contribute to resolution of legal and regulatory problems.

Negotiations were conducted during the year both with U.S. port authorities and with foreign governments regarding the *Savannah's*

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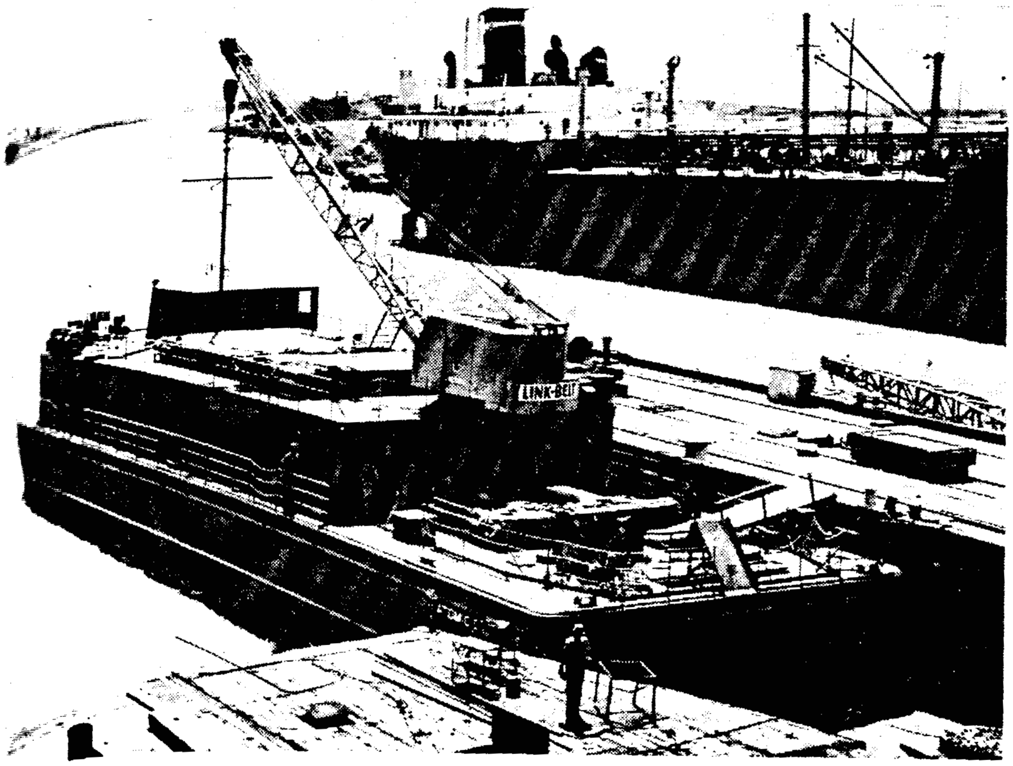

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...he engineering and deck officers for the *Savannah*, trained at dif... Commission sites in reactor operation, management and regu... aspects, reported in early summer to Camden to learn physical ... and procedures of the *Savannah.*

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Nuclear Tanker Studies

Commission evaluation was completed, and a summary report submitted in April to the Joint Committee on Atomic Energy of the Congress, on design studies to determine the type of reactor which has the greatest potential for early use in a tanker under existing conditions. Studies on direct cycle boiling water, advanced pressurized water, and indirect cycle boiling water concepts were performed by General Electric Co., Combustion Engineering, Inc., and Westinghouse Electric Corp., respectively.

Although tanker use was emphasized, the studies undertook to identify a prototype nuclear propulsion plant suitable for relatively broad application in merchant ships. The studies accordingly provide additional evaluative data for continuing investigations and analyses of various reactor-ship combinations.

Maritime Gas Cooled Reactor (MGCR)

The gas cooled reactor shows considerable promise as a propulsion system for merchant vessels. The Commission also determined that this basic reactor concept possesses promise for use in stationary power plants.

Development of the MGCR, which has been carried out since February, 1958, for the Commission by the General Atomic Division of General Dynamics Corp. has been directed primarily toward solving basic problems of metal-clad fuel elements, materials, controls, and reactor physics associated with early construction and test operation of a 30,000 shaft horse-power gas-cooled beryllium oxide (BeO)-moderated plant. As this basic concept shows promise for merchant ship propulsion as well as for stationary power plants, and since no facility existed to test a gas-cooled BeO-moderated core at suitably high temperatures and pressures, the Commission has approved development of a flexible gas-cooled, BeO-moderated reactor experiment, to be known as BORE. Development of the MGCR prototype will be deferred for the present. BORE, which will have a thermal capacity of about 10 megawatts, will be constructed at the National Reactor Testing Station. The current estimated cost of this project, including research and development, is about $8 million. The plant is scheduled for completion in June 1962.

Construction of an MGCR beryllium-oxide critical experiment was completed in July at the San Diego site of General Atomic, and experiments were begun in August. Irradiation tests of reactor mate-als were conducted during the year in a high temperature gas loop at Hanford, and in the Materials Testing Reactor, the Engineering Test Reactor, and the reactor of the Battelle Memorial Institute.

SPACE PROPULSION REACTORS

The objective of the nuclear rocket propulsion effort, designated Project ROVER, is to develop reactors and related nuclear technology for the propulsion of space vehicles.

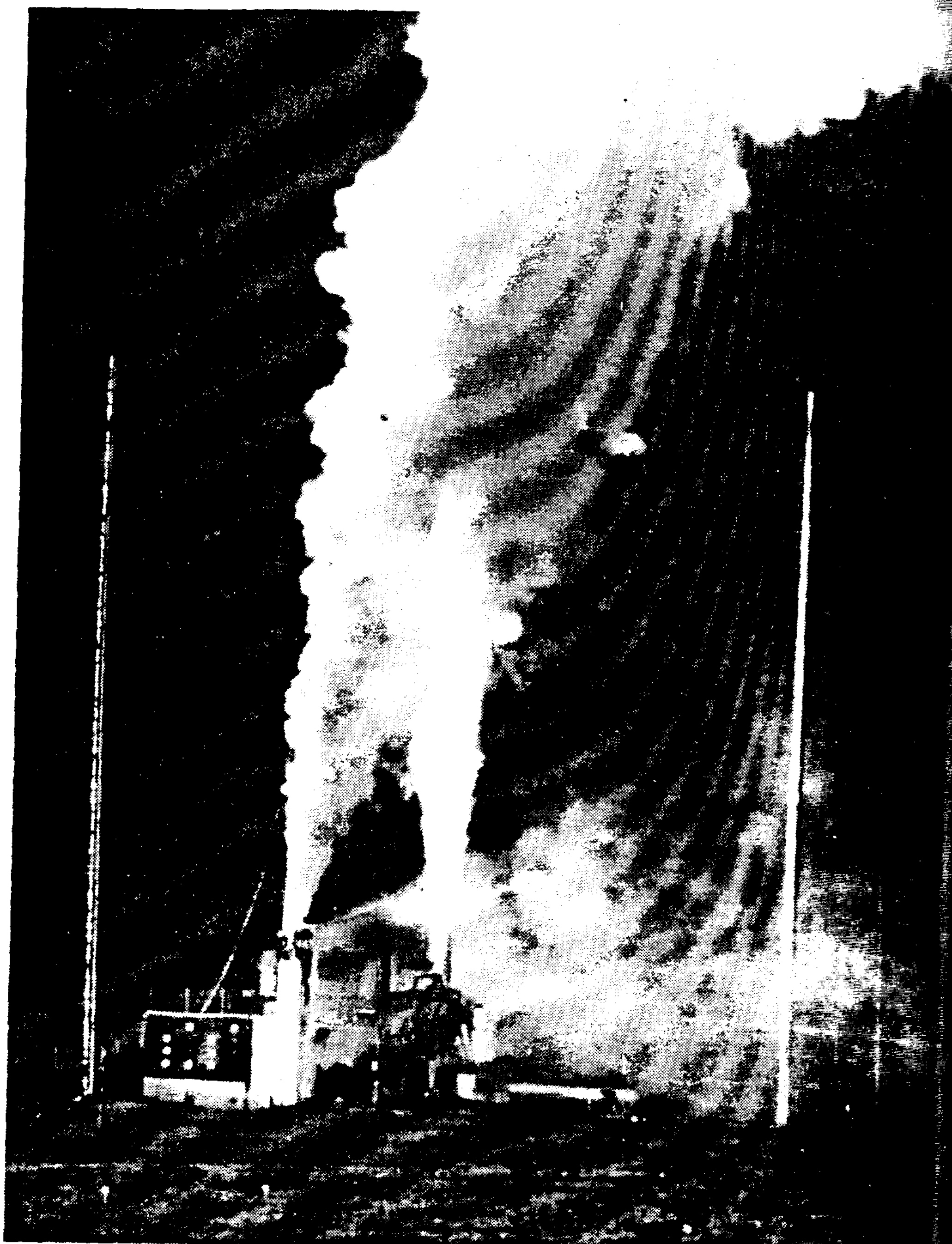
The major ROVER effort during the year consisted of the development of a series of nonflyable experimental reactors—designated Kiwi after the flightless Australian bird. A basic complex of test facilities was constructed at the Commission's Nevada Test Site which would be suitable for assembly, test, disassembly, and limited post-mortem examination of these reactors. This work is conducted under the technical direction of the Los Alamos Scientific Laboratory, operated for the Commission by the University of California.

The first of the planned series of reactor experiments in Project ROVER was completed in July 1959. The primary objective of the Kiwi-A test was to operate the reactor at high power at a predetermined temperature level and a duration representative of an operational cycle. The attainment of high power was successful on the first attempt, and the Kiwi-A test objectives were satisfactorily met. The reactor was disassembled using remote manipulator equipment. An elaborate and well planned post-mortem examination and diagnostic analysis of internal components was conducted and yielded valuable information for later reactor designs.

The experiments continued during 1960 with the successful test of Kiwi-A Prime in July and Kiwi-A3 in October. Both reactors were similar to Kiwi-A, using high pressure hydrogen gas as propellant, but contained modifications and design improvements for increased performance. The Kiwi-A3 test was the most successful in the initial experiment series. All performance goals were achieved or exceeded. On-site radiation levels were extremely low. There was no measurable off-site radiation, although traces were detected at a few points at the site perimeter.

Improved procedures resulted in completion of Kiwi-A3 reactor disassembly in less than 6 days, a considerable reduction from the time required for the Kiwi-A Prime reactor.

These tests concluded the Kiwi-A series and work is now underway on construction of new and enlarged test facilities preparatory to conduct of an advanced series of reactor experiments in 1961. The



Nuclear Space Propulsion. As a part of the Commission-NASA develop- program of a nuclear rocket, a third experimental reactor engine was succ- fully tested during October 1960. The KIWI–A3 reactor (called Kiwi after t- flightless bird) is shown in action in above photo. The white exhaust com- from the nozzle of the reactor (right of photo) is burning hydrogen gas which h- been heated to a high temperature by fissioning uranium inside the reactor. Th- plume on the left is a chemical smoke released to enable sampling aircraft t- follow the hydrogen cloud.

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new Kiwi-B reactor series will involve the use of liquid, rather than gaseous, hydrogen as the coolant-propellant. This is a requirement in a flyable system. A vigorous research program to develop fuel element materials for higher power density, lighter weight reactors is being pursued concurrently.

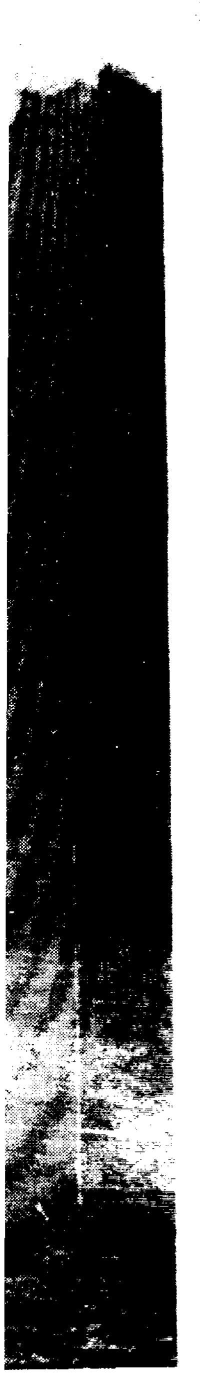
Joint AEC-NASA Office

On August 31, a joint AEC–NASA Nuclear Propulsion Office was formally established to develop nuclear space propulsion systems. This Office now integrates the respective agency efforts previously carried out by the Commission in its Aircraft Reactors program and in NASA's Office of Launch Vehicles. Concurrently, a Memorandum of Understanding was signed by the Commission Chairman and NASA Administrator outlining the broad division of agency responsibilities.

In accordance with the statutory responsibilities of both agencies, the Commission will have primary responsibility for development of all reactors and their components, including those for flight missions specified by NASA. NASA will have primary responsibility for research and development of nonnuclear components and integration of the nuclear components in engines and vehicles of rocket systems.

Pursuant to a joint agreement between the Commission and the National Aeronautics and Space Administration (NASA) made early in 1960, the Commission, within the broad framework of NASA guidance, would retain prime program management responsibility and would fund for operations and facilities through the ground feasibility demonstration phase. In support of the Commission, NASA would provide liquid hydrogen and other fluids at the test sites and would fund for the development of nonnuclear engine components. NASA would assume prime program management responsibility and would fund for flight engine and flight test system development and operation including the construction of necessary facilities. The AEC would support the flight system development by providing the reactors.

On November 1 it was announced that a request for proposals would be sent to a number of qualified manufacturers for research and development of a nuclear rocket engine. Consideration had been given to contracting for a six-month preliminary design study, but after a careful evaluation of program requirements, it was decided that the interest of Project ROVER would best be served by an early selec-



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SUPPORTING ENGINEERING AND DEVELOPMENT

In addition to specific work on individual power reactor projects, the Commission develops broadly based technology applicable generally to nuclear reactor systems and operation. The objectives of the nuclear technology program of reactor development are to provide data on reactor fuels, cycles and processes, reactor materials, reactor physics, reactor components and associated equipment, to carry out engineering development of a general and fundamental nature, to investigate the feasibility and potential of new methods for improving reactors, and to provide tools, such as test and research reactors and remote handling devices, for use in reactor research and development. The increasing emphasis which the Commission places on this work and the broadening of the effort, is reflected in increased expenditures, some $40 million in the fiscal year ended June 30, 1960, which was 50 percent more than the 1959 outlay.

Developments in this area may help to lower the cost of power generation through improvements in reactors and through reductions in the cost of fuel cycles. Interim results obtained during the year from contract work showed encouraging progress in development of new fuel combinations, cladding techniques, and fabrication methods. Related work conducted during 1960 included development of techniques for irradiated fuel which will lower costs for current reactor fuels or permit reprocessing future fuels not susceptible to existing practices. Environmental investigations continued in development of practical systems for safe handling and disposal of a wide variety of radioactive wastes.

Reactor Physics

Reactor core studies using critical and subcritical assemblies and involving different fuels and moderators were conducted at a number of installations during 1960. The technical data and information obtained from these studies are used for design purposes by reactor engineers in determining critical size of reactors, the degree of fuel enrichment needed, and the lifetime of core reactivity.

A cooperative program of critical experiments was completed by The Babcock & Wilcox Co. and Argonne National Laboratory on reactor lattices (fuel arrangements in core) fueled with oxide mixtures of thorium and uranium 235 in light water-moderated and heavy water-moderated systems. The fuel used was from the Argonne thorium-uranium development program and the Babcock & Wilcox-Consolidated Edison Co. critical experiment program. The program generated highly useful reactor physics information while avoiding expensive fabrication of oxide fuel. This physics information is needed for the design of power reactors using the above fuels and moderators.

A program of reactor lattice physics studies, including exponential experiments on low enrichment uranium rods in heavy water, was started at Massachusetts Institute of Technology. Varying uranium enrichment will be tested. Arrangements are being made through the International Atomic Energy Agency to lend low enrichment fuels to Norway for use in reactor lattice physics studies planned to start in 1962.

A critical experiment facility approved for construction at Brookhaven National Laboratory will provide a tank in which measurements can be made at high temperature and high pressure.

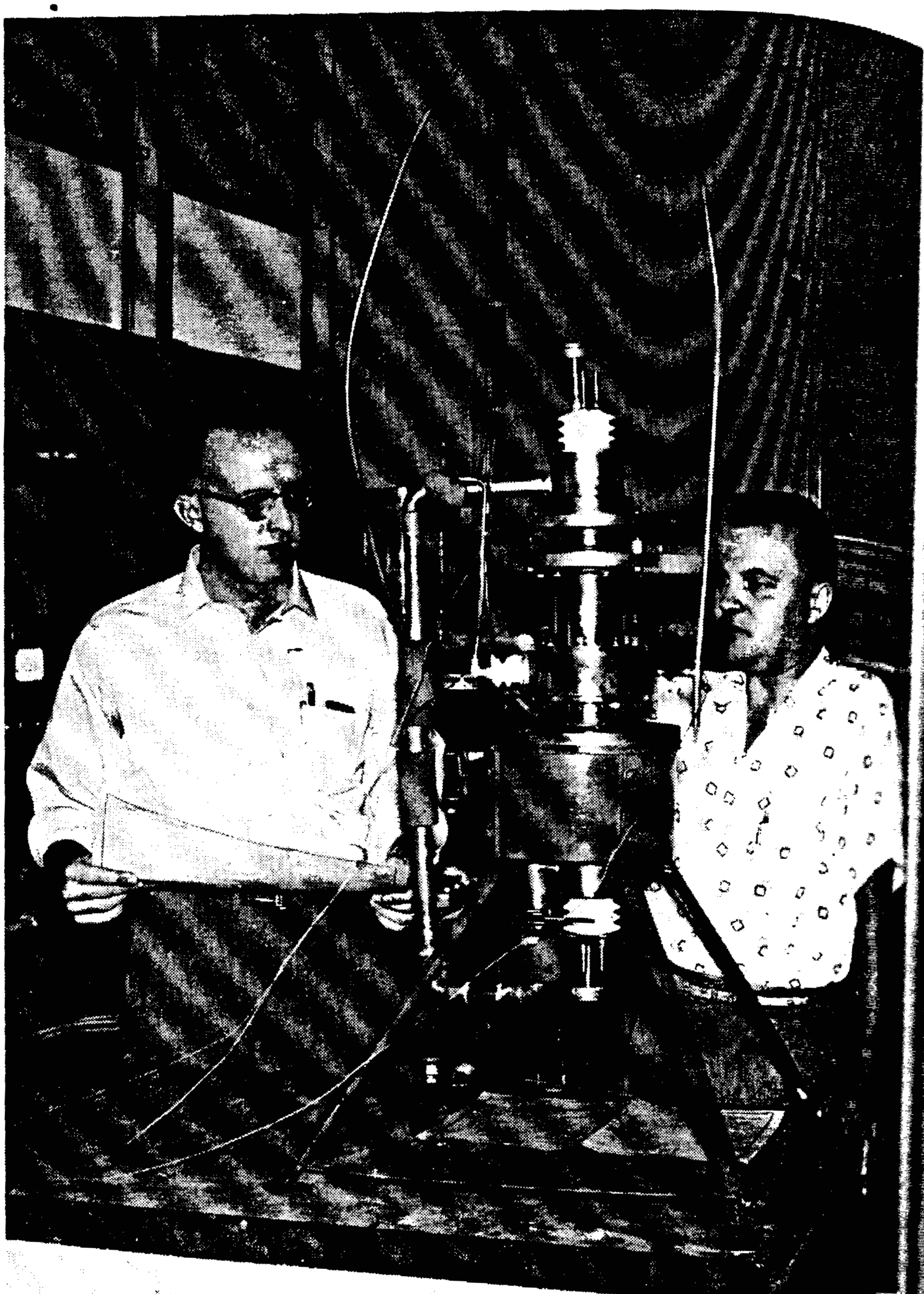
Advanced Reactivity Measurement Facility

Construction of an Advanced Reactivity Measurement Facility was completed at the National Reactor Testing Station in August, the second facility of this type at that site. The other is the Reactivity Measurement Facility which has been in continuous use since 1955. Studies at these facilities are part of the Commission's program to achieve more efficient reactor fuel utilization, prolong core lives, and to provide basic data of general value for designing and evaluating advanced reactors and concepts.

The new facility will permit very precise reactivity measurements with a sensitivity 10 times that of the older facility which up to now has been the most sensitive in the world. Studies of reactivity changes as a function of fuel burnup, and of resonance integral measurements, can be expanded by the use of both facilities.

Neutron Thermalization

A program of studies on neutron thermalization—direct measurement by time-of-flight techniques of neutron spectra resulting from the various moderators and reactor lattices—is being carried out



Plasma Thermocouple. As part of the Commission's program of developing means of direct conversion of nuclear heat into electricity, a plasma thermocouple (shown above) has been developed at Los Alamos Scientific Laboratory. The device transforms heat, generated by fissioning of zirconium carbide-uranium carbide mixtures, directly into electricity without use of any moving parts.

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for the Commission by General Atomic Division of General Dynamics Corp. utilizing a pulsed linear accelerator as a neutron source. Measurements have been completed in water, polyethylene, and zirconium hydride with various degrees of rare earth or boron poisoning.

Thermal Inelastic Scattering of Neutrons

In order to study the interaction with moderators of monoenergetic neutrons near thermal energies, Phillips Petroleum Co. has developed a double rotor neutron velocity selector and has made direct scattering measurements on beryllium, water, and several organic gases such as propane, ethane, methane, and normal butane. Data are taken as a function of both scattering angles and the incident and emergent energy of the neutrons. These measurements are useful in developing neutron scattering theory and serve to evaluate the importance of the vibrational and rotational energy levels of molecules in reactor materials.

Direct Conversion

Programs on direct conversion of heat from nuclear fission to electrical energy—the thermoelectric reaction—continued at Los Alamos Scientific Laboratory and Westinghouse Atomic Power Division. The work at Los Alamos consists of research and development on the thermionic vapor diode, a plasma thermocouple in which electrons emitted from a high temperature cathode are collected on an anode at lower temperature. The high temperature required is developed by causing fission in zirconium carbide-uranium carbide cathode material.

A thermoelectric nuclear fuel element in which thermoelectric materials as an integral part of the fuel element would convert the fission heat directly to electricity is the goal of the Westinghouse program. Recent results indicate that thermoelectric materials may be found which are suitable in the intense radiation fields of a nuclear reactor.

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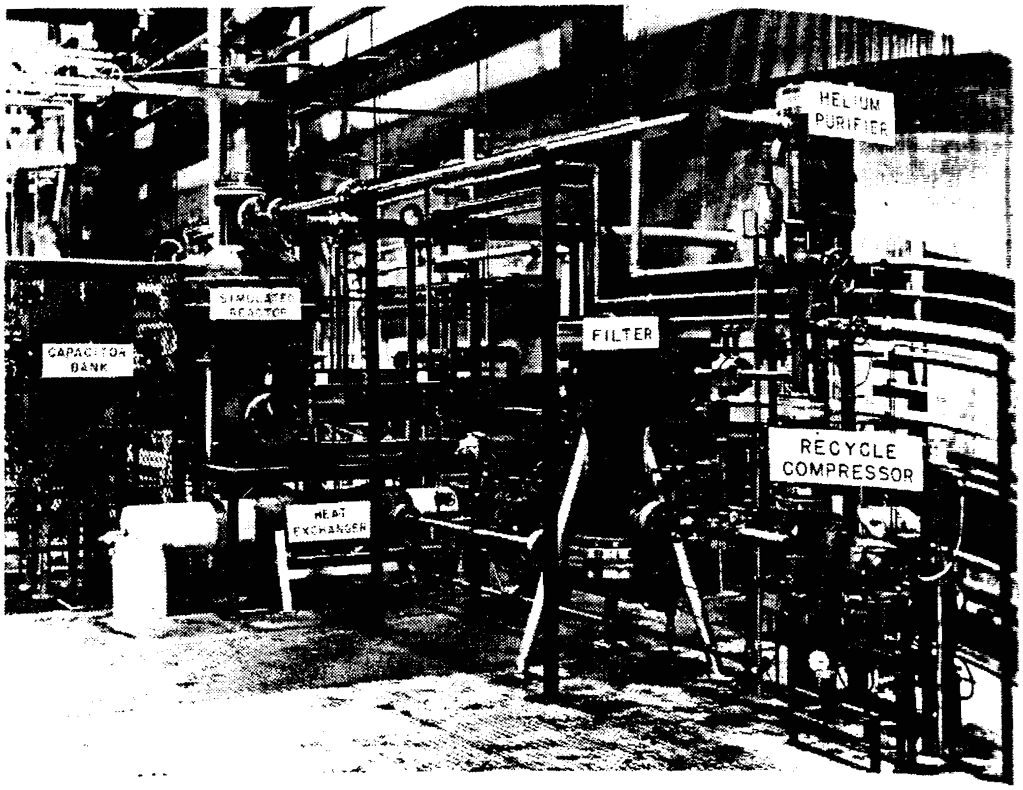
High Temperature Work

Achievement of high temperature operation of power reactors is important to achieving lower cost power since there is a direct relationship between high temperature and heat-conversion efficiency in power plants.



High-Temperature Facility. Use of high-temperature nuclear heat for industrial processes—including the gasification of coal—is the goal of work being done with a Commission-Bureau of Mines high-temperature test facility at Morgantown, W. Va. The helium gas recycle system is powered by electrical induction heaters which simulate a high-temperature nuclear reactor. During September and October the test facility was operated continuously for more than 1,000 hours at a gas temperature of 2,500° F. and under 250 pounds per square inch. Photo shows the experimental facility with its major components labeled.

High Temperature Reactor Facilities

A pioneer effort to develop advanced technology for reactor systems operating at temperatures far in excess of limitations imposed by current technology has been the helium-cooled Induction Simulated Reactor facility operated for several years at Morgantown, W. Va. as a joint Commission-Bureau of Mines project. The ISR contains all the components of a reactor system except fissionable fuel. On October 22, it completed a test of 1,000 hours of continuous operation

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rated conditions of 2,500° F gas temperature and 250 pounds per square inch pressure. This is believed to be the first time that the feasibility of operating a reactor system for sustained periods at these severe conditions has been demonstrated.

The high temperature gas-cooled Turret reactor experiment planned for construction at Los Alamos Scientific Laboratory, was to carry forward development of technology applicable to very high temperatures, including possible industrial process heat. It has been determined that unclad fuel performance and problems of radioactive circulating coolant gas can be investigated in existing reactors. Therefore, the Commission does not propose to proceed with construction of this reactor experiment at this time. Basic studies of high temperature, high burnup, power reactor systems employing unclad fuel will continue.

High Temperature Instrumentation

Successful operation of reactors at high temperatures will depend in great measure on devising means for accurate and reliable measurement of the many physical operating variables of the system. Development work on techniques and instruments has produced several new instruments during the past year.

One instrument is a new type of neutron sensor, employing microwave absorption techniques and utilizing a waveguide filled with helium 3. This instrument can be used to measure neutron flux in an environment up to 3,000° F without requiring the use of special high temperature electric cables.

Another instrument has been developed for rapid quantitative determination of oxidizing impurities in inert high temperature gas coolants such as helium.

A liquid level sensor also has been developed for use in liquid-cooled reactors operating at temperatures up to 950–1,000° F. This instrument employs no moving parts and operates on the principle of ultrasonics. It can be sealed permanently into a system and will provide remote indication and control.

High Temperature Reactor Components

Mechanical equipment that will operate satisfactorily with helium in high temperature reactor systems also is being developed.

The past year has seen successful design and long-term operation of a helium compressor operating at a gas inlet temperature of 1,000° F—

a substantially more severe operating condition than any component has met previously in reactor service.

Encouraging results were achieved in development of an electrostatic precipitator for removing particulate matter, specifically fuel element erosion products, from high temperature gas coolants. Tests to date have indicated efficiencies of 95 to 99 percent in removal of particles less than 9 to 10 microns in size from gas streams at temperatures up to 1,200° F.

High Temperature Heat Transfer

In order to predict performance of gas-cooled reactors more accurately, thermodynamic properties and heat transfer data are required for higher temperatures and pressures of specific gases than heretofore have been available. Tables of thermal properties for helium and molecular nitrogen have been extended to temperatures of 4,000° F and pressures to 2,500 psia. Heat transfer and pressure drop data have been obtained for helium at temperatures to 2,500° F. The results of these studies confirm the classical relationships of forced convection. This work is being continued for helium to temperatures approaching 4,000° F.

Nuclear Fuels and Materials Development

Development of new and improved fuels and materials is essential to achievement of economic nuclear power. In addition to work on specific individual power and military reactors, the Commission conducts comprehensive fuels and materials development under its nuclear technology program. In this effort, specific projects develop, design, fabricate, and test prototype fuels and fuel elements aimed at advancing and improving nuclear reactor efficiency, output, and life.

The program supplies data on physical and mechanical properties of metals, alloys, and materials, required by reactor designers, and improves current technology by utilizing advanced concepts to provide novel combinations and configurations of materials for efficient reactor use. Work in this program is carried out at the Commission's laboratories and in private industrial and research institutions under contract to the Commission. Many of these contracts now are at the midway point and encouraging progress has been shown.

Fuels Development

A recent successful effort in the fuels area is the development of coated fuel particles as mentioned earlier in the discussion of the

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ble bed gas-cooled reactor concept. Programs at Nuclear Materials d Equipment Corp. and at Battelle Memorial Institute have shown e feasibility of coating techniques and have indicated that fission roduct leakage can be materially reduced. In this process, small ains of fissionable material—comparable in size to common table lt—are individually coated with a dense refractory material by a gas composition technique using fluidized-bed procedures. The coating ll both protect the fuel from damage by chemical reaction with the olant at the high temperatures of the nuclear reactor and also pre- nt escape of the fission gas produced by the fuel. Alumina coating uranium oxide has worked well in early tests conducted at Battelle work related to the pebble-bed reactor concept. In using this ma- rial as a fuel, the individually coated fuel particles are evenly dis- rsed in a matrix material such as graphite, and the dispersion can be nveniently and economically shaped into reactor fuel elements by mple mass production techniques. Such a fuel appears particularly tractive for the high temperature operation required for gas-cooled actor systems by eliminating the need for temperature-limited metal- cladding.

It has been demonstrated by the Oak Ridge National Laboratory ORNL) that reductions in cost may be achieved in fuel elements aluminum plate. These elements use uranium enriched to 20 per- nt in uranium 235, the type used by many foreign countries. tisfactory and economical elements result from the use of disper- ons of U_3O_8 rather than a more conventional high-uranium alloy. ith this fuel element, it is estimated that a reduction of about ,000 may be achieved in each core loading for a pool reactor.

A timely conclusion of the Argonne National Laboratory's study of urania-calcia-zirconia as a ceramic fuel for water reactors led to immediate application in the Experimental Boiling Water Reactor. Studies of synthesis and fabrication of uranium monocarbide have progressed to the point where this material is ready for in-reactor aluation in a variety of configurations. This material can be cast pressed and sintered to achieve a high density. Development of table claddings is continuing to allow its use in high temperature actor applications.

dding and Container Materials

Research with beryllium has confirmed the existence at tempera- s above 1,260° C of a body-centered cubic phase of metallic struc- e. This structure may prove more ductile than the normal agonal close-packed beryllium structure. An alloy containing up to 8 percent nickel showed this structure at a temperature of approximately 1,060° C.

A recent study at Oak Ridge National Laboratory indicated that potassium is one of the more attractive molten metals for reactor turbine-generator power sources for space vehicles. In order to investigate the compatabilities of various container materials with boiling potassium, a testing program has been initiated.

Ames Laboratory has found that ultra-high purity yttrium exhibits high resistance to high temperature oxidation, and that the oxidation resistance appears to increase as the purity increases.

The program on properties and characteristics of pressure vessel materials has shown an unexpected result. It was found that the vast amount of data on materials which are currently available is of direct value for structures used for nonnuclear applications whose load and temperature histories are quite different from those encountered by nuclear pressure equipment. The type of materials data needed are those to be acquired under test conditions simulating the pressure equipment's actual service environment. The program is being expanded to obtain these data.

Control Materials

A comprehensive research and development program on control rod materials is underway at the Vallecitos Atomic Laboratory of General Electric.

Experimentation is leading to improved understanding of the neutron current flow into control rods. Samples of all known important reactor control materials are being irradiated in a high flux test reactor. These measurements are providing useful information on the alterations in control value of these materials to be expected over the long-term in power reactor service.

The need for these measurements arises from the incompleteness of basic neutron cross-section data. For example, it has been found that dysprosium apparently will have a useful lifetime in a reactor that is approximately twice the value given by the best estimates based on cross-section data .

Moderator Materials

Studies at Brookhaven National Laboratory on graphite absorption of xenon 135, a fission product gas with a high cross-section for neutron capture, have shown that 99 percent of the gas found in

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Non-Destructive Testing

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reactor graphite at elevated temperatures is held in the void volume of graphite pores, and only 1 percent is adsorbed on surfaces. Procedures for annealing irradiated graphite have been developed and oxidation of graphite has been evaluated.

It has been determined that even under unfavorable conditions, the temperature range in which graphite reactions become troublesome is about 600° C, which is well above the operating temperatures for the type of fuel elements used in air-cooled reactors.

A program has been initiated at Hanford to develop a graphite that is dimensionally stable under high-temperature neutron irradiation, and to develop manufacturing processes for producing this graphite in quantities.

Fabrication Technology

Gas pressure bonding techniques were developed by Battelle Memorial Institute for producing fuel elements containing 60 to 90 volume percent of uranium dioxide dispersed in matrices of stainless steel, molybdenum, niobium, or chromium. Dispersions of this type make possible high loadings with uranium dioxide and thermal conductivities 3 to 10 times more favorable than bulk uranium dioxide.

Fuel elements clad in aluminum, stainless steel, and zircaloy have been fabricated at Hanford by vibrational compaction of uranium oxide. Tubular fuel elements and fuel rods of various diameters have been fabricated using stainless steel cladding as thin as 0.005 inch in some instances. Remarkably good performance has been demonstrated with fuel elements up to eight feet long in irradiation tests involving core temperatures to 5,000° F and exposures up to 3,000 megawatt days per ton. This development shows considerable economic promise and further studies are in progress.

Gladding, McBean and Co. is perfecting a unique method of fabricating flat plates of nuclear grade urania by rolling urania powder into strips. Work to date indicates that the rolling process provides a method of rapid production of high quality, uniform, dense urania parts of precision dimensions, available in a wide variety of complex configurations valuable for use in fuel elements. These urania parts can be made with length-to-thickness ratios that cannot easily be achieved by any other process.

Non-Destructive Testing

Outstanding programs are in progress at Oak Ridge, Argonne, and Hanford on non-destructive test techniques for evaluation of reactor fuels and materials. Excellent methods have been devised for determining presence of defects, thickness of cladding, location of core positions in fuel plates, and for identifying metal composition. As one example, Oak Ridge National Laboratory performed several series of measurements on the wall thickness of the zircaloy 2 core vessel of Homogeneous Reactor Experiment Nos. 2 during shutdown. These tests were performed remotely and did not require disassembly of the core vessel.

Chemical Processing Development

Significant progress has been made in developing methods for chemical reprocessing of spent fuels from nuclear reactors. This work may be more specifically defined as the conversion of irradiated 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 reprocessing is justified whenever material can be recovered for a credit greater than the cost of reprocessing. The three general approaches being followed are (a) aqueous processes with single or multiple dissolution facilities; (b) uranium hexafluoride volatility processes; and (c) integrated 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 because of experience gained in uranium and plutonium production programs. For this reason, they are being applied to reprocessing civilian reactor fuels. The basic concept involved in aqueous processes is the reduction of solid fuel elements to an aqueous solution, followed by solvent separation of contained fissionable materials from each other and from dissolved fission products and structural materials.

Long experience with solvent extraction techniques for aluminum-clad uranium and uranium-aluminum fuels has been gained at Hanford, Savannah River, Oak Ridge, and the Idaho Chemical Processing Plant. With the extreme diversity of fuel compositions (e.g., zirconium, niobium, chromium, nickel, molybdenum, graphite, carbides, etc.) being developed or considered for power reactors, the aqueous nitrate systems previously used do not alone suffice. This resulted in the need for multiple dissolution facilities wherein fuels could be combined into groups having similar dissolution chemistries, the di-

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During 1960, several aqueous processes particularly suitable for the uranium and stainless steel clad oxide fuels were explored successfully in the laboratory and are ready for pilot plant demonstration with irradiated fuels. Processes for the more advanced fuels such as the cermets and those containing carbides, graphite, and beryllium are under continuing investigation.

An alternate to a centrally located, large-scale reprocessing plant capable of handling a variety of fuels is a small-scale plant located at a reactor site to process the fuel load from a single reactor complex. Phillips Petroleum Co. completed a study at the Idaho Chemical Processing Plant of the technical and economic feasibility of such a plant for a typical civilian power reactor site. The study, which included a conceptual plant design, hazards evaluation, and cost analysis, indicated that this approach has considerable promise.

Volatility Processing

In volatility processing, uranium fuels are fluorinated to produce uranium hexafluoride and the fluorides of the fission products and alloying metals. Uranium hexafluoride, being much more volatile than the other fluorides, can be readily separated by fractional distillation or adsorption-desorption processes. Potential cost advantages of volatility over aqueous techniques result from the reduced number of process steps, and an approximate 30-fold reduction in the volume of high level wastes.

At Argonne National Laboratory, studies are being conducted to apply to civilian power fuels the fluoride volatility process used for military reactor fuels. Before a practical reprocessing method can be devised, considerable knowledge must be acquired about the conditions of formation of volatile plutonium hexafluoride, its reactions with construction materials, and the general problems of handling and storing this species which is highly reactive chemically.

Pyrometallurgical Processes

In the pyrometallurgical or low decontamination processes, also called 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

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decontamination of irradiated fuels, followed by manual refabrication of fuel elements, may not be as applicable to civilian power fuels as in the military program from which it was derived. The closed cycle concept presents technical difficulties. Unless reasonable economics 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.

The first successful demonstration of pyro-processing of non-metallic fuels was completed in 1960 by Atomics International. In this demonstration, a stainless steel-clad uranium dioxide fuel sample irradiated to 7,000 megawatt days per metric ton of uranium was declad through oxidation, reprocessed in three oxidation-reduction cycles, and prepared for the first of five additional successive re-irradiations.

A pyrometallurgical facility is integrated with the Experimental Breeder Reactor No. 2.

Environmental and Sanitary Engineering

The Commission long has recognized radioactive waste management as an important factor in the over-all health and safety program of the nuclear industry. Accordingly, the Commission has pursued a vigorous program which is aimed at developing methods of minimizing the release of radioactive contaminants to the environment.

Environmental Studies on Wastes

Cooperative studies are being carried out at national laboratories and other Federal and private institutions on specific ground, air, and water environments which may receive limited radioactive discharges of low-activity and intermediate-activity radioactive wastes from nuclear power operations. The waste disposal problem at each nuclear energy operation must be evaluated on an individual basis to fit variations in sites and inherent differences in nuclear facilities.

A comprehensive field investigation of the Clinch River below Oak Ridge National Laboratory was initiated during 1960. The purpose of the study is to obtain fundamental information on the physical, chemical, and biological dynamics of a flowing, freshwater ecosystem which is receiving large volumes of low-level radioactive wastes. The U.S. Public Health Service, the U.S. Geological Survey, the Tennessee Valley Authority, and the Tennessee Stream Pollution Control Board are actively participating in the program. Routine monitoring

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continues to indicate that releases of radioactivity to the Clinch River are well below permissible limits. This study will determine the fate of specific radionuclides released and will develop a better understanding of the mechanisms of stream dispersion.

A project is being carried out jointly by the California Institute of Technology and Scripps Institute of Oceanography which involves studies on the origin, effects and fate of radioactivity introduced into a municipal sewerage system. Last year, techniques were developed and a limited number of analyses made of cesium and cobalt activity concentrations in the Los Angeles sewage treatment plant. Beta emitters such as strontium 90 and other isotopes are being studied in approximately 10 sewage treatment plants around the United States, as well as in the Los Angeles plant, not only to determine the fate and behavior of the materials in sewage treatment plants, but also to assist in evaluating the effectiveness of the Commission's waste release criteria applied to licensed operations.

Sea Disposal

The Cleveland Pneumatic Industries is completing a study of the environment of two sea disposal sites off the California coast. This work entails collection and analysis of biological, geological and chemical samples, measurement of water currents, photography of the deep ocean bottom, and testing a deep water buoy marking system. Initial results of these comprehensive studies have indicated that no radioactivity attributable to waste disposal operations can be detected.

The Chesapeake Bay Institute of the Johns Hopkins University is developing a complete understanding of the New York Harbor system from West Point, N.Y., to the mouth of the harbor. This study involves investigation of a mathematical model which can be used to predict the fate of any radioactivity introduced at any point in the system. The work involves an analysis of tide, current, temperature, and salinity information collected by the Coast Guard and collation of the data for use in a computer. As part of this study, the Chesapeake Bay Institute has developed a chemostat which reproduces in a laboratory elemental biological systems and makes it possible to predict the fate of activity.

The Commission has initiated an evaluation of all types of containers currently used in sea disposal operations. One phase involves testing at sea some 150 actual disposal containers with waste materials selected at random from waste packagers. The other phase involves a series of laboratory tests being conducted at the Southwest Research Institute to measure the effects of pressure and impact forces on various variables of containers such as concrete thickness, contained compressible space, amount and spacing of reinforcement steel and pressure relief vents.

Field investigations related to the feasibility of disposal in inshore locations off the North Atlantic coast were completed early this year. The study was carried out through the cooperation and participation of the U.S. Coast & Geodetic Survey, U.S. Public Health Service, University of Connecticut, and U.S. Fish and Wildlife Service. Included was a survey of a site in Massachusetts Bay formerly used for disposal of limited quantities of packaged wastes. This survey did not reveal any radioactivity attributable to disposal operations. Although the investigations indicated that the locations studied could safely receive up to 250 curies per year of strontium 90 or its equivalent, Commission policy continues to require that solid packaged wastes be disposed in water at least 6,000 feet deep.

A later section of Part One reports on Commission policy on interim land burial of wastes.

High Level Wastes

At present the primary means of handling highly radioactive liquid fuel reprocessing wastes at the few locations where they are produced is to provide special underground storage tank facilities and appropriate monitoring. Approximately 15 years' experience has shown that these systems provide a safe and practical means of interim containment. However, because of the nature of this particular category of wastes, including their long effective life (measured in hundreds of years), and volume (estimated at a total accumulation of approximately 65 million gallons in 1959), and the comparatively shorter life of the physical structures containing the wastes, it is possible to envision a potential hazard in this method of handling over the long-term.

Recognizing this potential problem, the Commission is directing current research and development along the lines of transforming these wastes to solid form for long-term storage or disposal, or placing the wastes in a geological environment which would serve as a safe, perpetual tank farm.

Laboratory tests over the past several years have indicated the technical feasibility of storing high level radioactive liquid wastes in such geological formations as salt. Field tests to verify the laboratory results and to establish engineering feasibility are required. Such tests are presently being conducted in a mined-out portion of the Carey Salt Mine near Hutchinson, Kans. In this program, both

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Salt Disposal Experiment. To determine the feasibility of storing high-level radioactive wastes in abandoned salt mines, the Commission is conducting a series of experiments in a salt formation near Hutchinson, Kans. Heated nonradioactive materials are used as simulative wastes. The experiments are being conducted to determine whether there would be movement of the wastes within the formation and what chemical or other changes the rock salt might undergo. Photo shows one of the underground test cavities (foreground).

...ed and neutralized 2-year-old nonradioactive simulated Purex waste is stored in two 7.5 x 7.5 x 10 foot deep cavities and the various parameters are monitored.

The temperatures in the system have reached equilibrium and have followed the pattern predicted by laboratory research and subsequent theoretical calculations. Parameters still to be verified include migration of the cavities themselves, and salt deformation. On the assumption that the results of the field test will continue to be favorable, radio ...er tests and experiments are being contemplated at another site.

Fixation of radioisotopes in a solid form not only would decrease the ... volume of high level wastes generated but also would make them relatively immobile. Immobility facilitates management of the waste, and decreases the hazard. It is presently contemplated that wastes ... in solid form would be stored in an impervious environment such as a salt mine under continuous monitoring.

At the National Reactor Testing Station (NRTS), a hot pilot fluidized bed plant to demonstrate and evaluate the feasibility of calcination to dry solids of aqueous aluminum nitrate waste is nearing completion and is scheduled for cold runs in the first half of 1961. This program will require the resolution of some severe problems concerning heat removal, encapsulation, and treatment of off-gases from fluidized bed operations. Though by no means insurmountable, these problems can be resolved only by engineering scale experiments utilizing actual wastes.

Preliminary studies have been initiated also to evaluate the feasibility of utilizing the fluidized bed technique to process wastes from zirconium and stainless steel fuels. It is expected that similar handling problems will be encountered that are similar to those of the aluminum nitrate process.

In the radiant heat spray calcination method used at Hanford, simulated Purex waste is mixed and atomized with steam and introduced into the top of a tower. The walls of the tower are heated to a high temperature. The atomized liquid, in the form of small droplets, passes through zones of radiant heat where the suspension achieves increased degrees of dryness. The configuration of the spray must be such that the atomized waste is completely dry before it hits the walls of the tower in order to preclude deposition of calcined solids on the walls and to eliminate operational interference.

The solid wastes could be in the form of a fine powder or, if utilized with a fluxing agent, in the form of a larger coagulated solid. The solids and gases are separated at the bottom of the column in filters with the gases scrubbed with caustic and exhausted to the building vacuum system. Though only assessed on a laboratory scale, the preliminary results indicate the system's adaptability to changes in waste composition. Further studies are required on corrosion, feed rates, effect of additives, and ruthenium and cesium behavior.

Studies have been underway at Oak Ridge on transforming liquid radioactive wastes through use of a pot calciner to thermally stable solid materials more suitable for ultimate disposal. The contents are heated to dryness, and the stainless steel cylinder serves for a final storage container. Laboratory experiments have been conducted with waste containers 8 inches in diameter and 78 inches long. Current research and development is being conducted on the off-gas and aerosol problems of this method of calcination.

Intermediate Level Wastes

At present, some intermediate level wastes are being dispersed into the ground at Hanford, Oak Ridge, and Savannah River. However, this operation is carefully controlled and monitored by the extensive use of monitoring wells in the area. Concentrations of radioisotopes which appear in surface waters are, on the average, several orders of magnitude below acceptable levels. Research and development continues to evolve methods of handling these wastes which may make it unnecessary to dispose of them into the ground.

Current research which has had encouraging results is a method called "hydrofracking" being investigated at Oak Ridge National Laboratory. In this process, the intermediate level waste is mixed with cement to form a grout. The mixture then is injected into a specially prepared well under high pressure. The chosen geologic strata is fractured at the predetermined elevation by the high hydrostatic pressure maintained on the grout. The grout continues the fracturing of the stratum until the entire volume of waste has been "consumed." Pressure is maintained on the system until the grout solidifies, fixing the waste in an impervious geologic stratum. To date, approximately [illegible],000 gallons of simulated waste containing radioactive tracers have been experimentally disposed of by this means. The geologic formation is currently being probed in an effort to evaluate this method in order to predict the results of future tests.

Low Level Wastes

Low level wastes are released to the environment either directly or after primary treatment. Research conducted at Oak Ridge National Laboratory which utilizes a lime-soda treatment for precipitating the dissolved radionuclides. Inclusion of clays in this process makes it possible to obtain up to 95 percent removal of cesium and strontium. In an effort to accomplish still greater decontamination, research and development efforts are exploring the use of specific natural and synthetic resins. Results obtained to date are encouraging. Similar programs are conducted at Hanford to evaluate ion exchange capabilities for specific waste. In addition, various Commission installations and contractors are engaged in basic ion exchange research in an effort to gain better understanding of this phenomenon and to predict operational characteristics.

Gaseous Effluent Studies

Studies directed toward new and improved systems for control of radioactive gaseous discharges and particulates in gaseous wastes are mainly on such problems as improved high capacity filters for iodine removal and equipment for filtration of particulates at high temperatures (above 1,000° F).

Meteorological research by the U.S. Weather Bureau at several Commission sites is centered around obtaining a better understanding of the ability of the lower atmosphere to disperse pollutants—an ability affected by topography, temperature conditions, and the flow of air as determined by barometric conditions.

In the air cleaning program, fundamental development work is continuing on aerosols and filtration devices which will operate with lower resistance to air flow, and with high efficiency at lower capital costs. A simple electrostatic fluidized bed for cleaning supply air is being developed based on work at the University of Illinois and Harvard University.

The Harvard Air Cleaning Laboratory evaluation of an incinerator developed for burning solid combustible radioactive waste material has been completed with analyses of its combustion characteristics and air cleaning system. The device will burn about 20 pounds of mixed waste an hour. The next step is to develop and construct a commercial prototype for field testing. During the past year, effort has been concentrated on developing the air cleaning system.

RESEARCH AND TEST REACTORS

Test Irradiation Services

New and untried reactor fuel materials as well as reactor structural materials, moderators and coolants, must be tested under conditions of radiation and temperature which simulate those experienced in operating reactors. Such characteristics as corrosion resistance, mechanical strength, and good thermal conductivity while exposed to radiation must be determined. The ability of a proposed fuel material to resist undesirable irradiation-induced changes, as tested in a reactor, will almost invariably form the final basis for its acceptance or rejection.

Most fuel and material irradiation tests in the United States have been conducted in the Materials Testing Reactor (MTR), which went critical in 1952, and the Engineering Test Reactor (ETR), which began operation in late 1957. These two test reactors, both at the National Reactor Testing Station in Idaho, have performed irradiation services for military as well as civilian reactor projects. Both are high neutron flux reactors, although the larger and more advanced ETR has a greater variety of fluxes than the MTR. (Neutron flux is the intensity of neutrons in a given region of a reactor to which components and materials may be subjected. This region provides environmental conditions similar to conditions in reactors for which the components and materials are intended.) The ETR provides large test volumes within the reactor fuel core, a feature not included in the MTR.

Both MTR and ETR, which have fluxes up to about 5×10^{14} neutrons per square centimeter per second, operate on established schedules calling for regular shutdowns to insert or remove experiments and related equipment, and to replenish or rearrange fuel loadings. The principal objective is to provide the most intense neutron flux for the highest percentage of operating time. With some materials, three weeks exposure in the high flux MTR or ETR is equal to two or more years in an actual power reactor, which generally operates in the low or medium flux ranges.

In October 1958,[11] the Commission invited industry to submit proposals for performance of test irradiation services in addition to those carried out in the MTR and ETR. From the 11 proposals received, the Commission selected in July 1959 the proposal of The Babcock & Wilcox Co., as a basis for contract negotiations. A portion of the company's proposed reactor space was to provide the Commission with test irradiation services in the low and mid-flux ranges. Anticipated industrial requirements, as estimated earlier by industry for test reactor space, failed to materialize, and the negotiations were mutually terminated by the Commission and Babcock & Wilcox on July 8, 1960. The Commission's needs for test irradiation space, materially unchanged since the start of negotiations, will be met in existing and planned Commission reactors and in two privately owned test reactors now in operation. They are the Westinghouse Test Reactor at Waltz Mill, Pa., and the General Electric Test Reactor at Pleasanton, Calif. Expected industry demand for space in private reactors has not materialized and this situation makes additional space available to the Commission.

In response to the 1958 public invitation, industry made no proposals for building a test reactor capable of producing neutron fluxes of greater intensity than those in the MTR and ETR. The Commission's needs for high-flux irradiation space will be met by a Government-built advanced test reactor authorized by the Congress. The conceptual design study for this test reactor was done by Phillips Petroleum Co. The new reactor will be known as the Advanced Test Reactor (ATR)—a 250 Mw (thermal) reactor with a ribbon of fuel elements in a four-leaf clover configuration. An experimental loop facility, running vertically parallel to the fuel region, is provided in each of nine flux concentration zones, providing an even greater

[11] See p. 82, Annual Report to Congress for 1959.

variety of fluxes up to 10^{15}. The new reactor will be located adjacent to the MTR–ETR complex at the National Reactor Testing Station.

Phillips Petroleum is responsible for conceptual design; Ebasco Services Inc. was awarded the contract for architect-engineering services; Babcock & Wilcox wil be subcontractor to provide assistance in designing the nuclear portion. Construction is scheduled to start by March 1961 and to be completed in 3 years.

Other high flux reactors. Research and development work continued on an Argonne High Flux Reactor planned for Argonne National Laboratory and on a High Flux Isotope Reactor (HFIR) to be built at Oak Ridge National Laboratory. A site for the HFIR in the Melton Valley at Oak Ridge was approved in August from the standpoint of safety by the Advisory Committee on Reactor Safeguards. Construction of this 100 MW reactor is expected to start late in 1961.

Programs In Support Of Industry

The Commission during 1960 reaffirmed its policy of using commercial facilities for needed services and supplies wherever practical, and of curtailing its services or supplies to industry whenever commercial sources become reasonably available. The Commission improved and increased its information services to industry, declassified further broad areas of information, and simplified its access permit program. A manpower survey conducted for the Commission counted 185,000 persons employed in atomic energy activities and estimated some future needs. These developments, recent activities in the commercial field and added Commission assistance to industry, are summarized in this portion of the report.

All Commission activities, except those directly related to weapons, have the potential of contributing to industrial progress. This is especially true of the broad research programs in the life and physical sciences—this year the subject of a special report to the Congress[12]—which help expand the basic knowledge on which the industry and its safe operation are founded.

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[12] "Atomic Energy Research in the Life and Physical Sciences"—1960, Superintendent of Documents, Government Printing Office, Washington 25, D.C., $1.25.

The program developments in the effort to achieve economic production of nuclear power have been described in the preceding chapter. In Part Two of this report, separate sections deal with civil uses of nuclear explosives and radioisotope and radiation applications.

Highlights of 1960 included the following actions and developments:

- The Commission again reduced prices on two key radioisotopes, some 26 percent on carbon 14 and from 30 to 70 percent on cobalt 60. The Commission also proposed to alter its regulations to permit use of tritium in self-luminous instrument dials under general license. A major price reduction for the stable isotope helium 3 also was announced.
- A program was established to test and demonstrate the technical and practical feasibility of extending the shelf life of certain refrigerated foods by irradiating the foods.
- The Commission plans to use space in two privately owned testing reactors to complete its requirements for low and intermediate neutron flux irradiation.
- Three experiments with nonnuclear high explosives were carried out to increase knowledge of crater formation in planning for possible future civil uses of nuclear explosives.
- Small business' share of Commission subcontracts increased from [illegible] percent in the fiscal year ended June 30, 1959, to 42.1 percent in the following fiscal year.
- Preliminary steps were completed looking toward take-over by various States of responsibility for licensing and inspecting certain categories of atomic energy activities.
- A total of 584 personnel of the Commission and its contractors was available to respond to local calls in assigned areas whenever help was requested in accidents believed to involve radiation.
- The Commission inaugurated a program to develop techniques for nondestructive analysis of fuel materials for reactors to assist in compliance with the requirements for maintaining safeguards against diversion of fissionable materials from peaceful uses.
- Seminars were held to inform public carriers on the transportation characteristics of atomic energy materials and products.

POLICY ON COMMERCIAL SERVICES

In carrying out its statutory responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise, the Commission has maintained a firm policy to procure goods and services from private industry wherever practical.[13] The Commission redeclared this policy in February 1960, when it responded to inquiries from the Chamber of Commerce of the United States, the National Association of Manufacturers, and the Manufacturing Chemists' Association concerning the Commission's application in its operations of Bureau of the Budget Bulletin 60-2 on "Commercial-Industrial Activities of the Government Providing Products or Services for Governmental Use." [14]

The Commission has consistently maintained two broad policies: one, that it will supply with its own facilities materials and services needed by industry only to the extent that they are not available commercially at reasonable costs, and two, that in meeting its own needs, it will procure goods and services from private industry wherever practical.

The first policy has been in effect since the Atomic Energy Act of 1954 made possible the participation of private industry in the development of nuclear power. As private industrial capacity has come into being, the Commission has withdrawn from providing a number of supplies and services, as announced publicly from time to time and described in the Semiannual and Annual Reports to the Congress.

In 1958 the Commission issued a listing of materials and services which it would no longer provide, since they were then available from private industry.[15] As early as 1956 the Commission announced that it would permit the use of Commission-owned test reactors for non-Government purposes only if privately owned facilities were not available for the irradiation services required. With industrial irradiation facilities [16] becoming available in 1960, the Commission, in July 1960, reaffirmed its policy of not performing irradiation services for commercial firms if privately owned facilities are reasonably available. The announcement also extended this policy to foreign requirements.

The Commission policy of utilizing to the fullest practical extent the services of private business enterprise in carrying out its various programs has been fundamental since passage of the Atomic Energy Act of 1946. At its inception the Commission turned to private industry to construct and operate its major facilities. Government ownership of these facilities was essential, since no reasonable way could

[13] See pp. 153–55, Twenty-third Semiannual Report to Congress (July–December 1957); pp. 61–63, Twenty-fourth Semiannual Report to Congress (January–June 1958).

[14] See Appendix 18 for text.

[15] See p. 14, Twenty-fifth Semiannual Report to Congress, (July–December 1958).

[16] The General Electric Test Reactor at Vallecitos, Calif. and the Westinghouse Test Reactor at Waltz Mill, Pa. The Commission also is obtaining irradiation services from these reactors.

found to provide adequate incentives for private investment in them.

Passage of the Atomic Energy Act of 1954 opened new opportunities for industrial participation in the nuclear field. Specific responsibility for identifying industrial activities, including those performed by the Commission, which lend themselves to performance by private industry, was centralizd within the Commission the following year. Since then, coincident with the development of private capability, the Commission has taken a number of steps directed toward enlarging the area of commercial participation in Government financed programs.

Although the continued use of existing Government facilities is clearly necessary in the public interest for the production of fissionable materials, the assembly of weapons, and the conduct of most advanced research and development, 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 national objectives. However, care will be exercised in discontinuing a specific government activity to assure that related activities which are closely integrated do not unduly suffer in development, cost or efficiency by reason of the procurement.

In the nuclear industry, the tempo of technological developments in many instances does not permit establishing precise specifications to assure a volume of repeat orders necessary to attract investment of private capital in the specialized facilities, equipment, and personnel required. Consequently, there still remain areas of the Commission's work where it is premature to expect that such work can be procured from private industry on a competitive basis. Nonetheless, as the atomic energy industry grows, there will be areas of activity appropriate for transfer from Government to private operation.

The Commission has directed its field offices and operating contractors to follow this policy. In implementing the policy, decisions to procure materials or services from commercial sources rather than from Government-owned plants will be made whenever it is reasonable under the policy to do so.

COMMERCIAL ACTIVITIES

Industrial Laboratories' Contracts

Reactor development work conducted for the Commission by private industrial organizations largely in their own facilities has con-

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tinued to increase. In the fiscal year ended June 30, 1960 it represented 26 percent of the $361.7 million spent by the Commission for such work and an increase, from $75.9 million to $94.1 million, or 24 percent, over the amount so spent in the previous fiscal year. The distribution of these funds for the past three fiscal years is shown in the following table:

DISTRIBUTION OF AEC REACTOR DEVELOPMENT FUNDS

Type of organization	Fiscal year (millions of dollars)		
	1958	1959	1960
Industrial	$49.1	$75.9	[illegible]
AEC laboratories	237.3	246.0	[illegible]
Universities	0.8	1.3	[illegible]
Other nonprofit	1.8	1.3	[illegible]
Other Government	1.2	1.7	[illegible]
Total[a]	$290.2	$326.2	[illegible]

[a] These totals do not include depreciation on AEC-owned facilities or special nuclear materials consumed. Such costs are included in costs reported for reactor development work in the Annual Financial Report, Appendix 21.

Commercial Processing of Fuel

Orders placed by the Commission and its principal contractors with commercial sources for the conversion of uranium hexaflouride to materials suitable for fuel elements, and for the fabrication of fuel elements, rose from $41.4 million in the year ended June 30, 1959 to $52.4 million in the year ended June 30, 1960, an increase of 26 percent.

These amounts represent, in large part, orders for cores of naval reactors. The Department of the Navy transfers funds to the Commission for procurement of all shipboard reactor cores. Excluding the orders for naval purposes, the awards totaled $2.8 million for fiscal year 1959 and $3.8 million for fiscal year 1960, an increase of 36 percent.

An indication of the extent to which procurement from commercial sources has increased also is given in the following table which shows enriched uranium furnished in the form of uranium hexaflouride compared with that furnished in a form requiring processing in Commission facilities:

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ENRICHED URANIUM FURNISHED TO ALL SOURCES

Excluding the Weapons Production Chain

	Fiscal Years (kilograms of uranium)				
	1956	*1957*	*1958*	*1959*	*1960*
Furnished as UF_6	0	6,000	24,000	110,300	86,200
Furnished in forms other than UF_6	2,400	4,000	21,000	6,300	3,400
Total	2,400	10,000	45,000	116,600	89,600

Thus, although all enriched uranium furnished in 1956 required processing beyond the uranium hexafluoride stage in Commission facilities, in 1960, 96 percent was processed beyond this stage in commercial plants—86,200 kilograms out of a total of 89,600.

Chemical Processing of Fuel

During 1960 a chemical company in cooperation with five utilities completed an independent study leading to the conclusion that the available technology necessary to process the irradiated fuel under consideration is adequate for design and operation of a privately owned plant. At least two other companies are studying the desirability of entering this field.

Although services of this kind now are offered to reactor owners by the Commission, suitable privately owned facilities are a key requirement for a self-sufficient nuclear power industry.

Toward the end of the year the Industrial Reprocessing Group (Davison Chemical Co. and five utilities) were in Phase II of their study, to determine the economic feasibility of their plan.

Plutonium Fabrication

The first license covering fabrication of plutonium was issued in December 1960 to Nuclear Materials and Equipment Corp., Apollo, Pa. The license also covers the manufacture of plutonium-beryllium neutron sources, all of which heretofore have come from Commission-owned plants.

At the end of 1960 the Commission, through its New York Operations Office, was surveying industry capability and interest in the recovery of plutonium from nonirradiated scrap with a view toward developing industrial participation in this aspect of the Commission's work.

Two other private organizations, Battelle Memorial Institute, and Nuclear Development Corp. of America, also have fabricated plutonium under Commission contracts which did not require a license.

Changes in Reactor Status

As a result of the reorientation of the Aircraft Nuclear Propulsion manned aircraft program, the Georgia Nuclear Laboratory facility, an unshielded reactor operated for the Air Force by Lockheed at Dawsonville, Ga., no longer was required in support of the program. The facility remains operational but on a limited standby basis. Under these arrangements, Lockheed has applied for a Commission license to operate the facility for both Government and commercial purposes.

Two other facilities, the Air Force Nuclear Engineering Test Facility at Wright-Patterson Air Force Base, and the Curtiss-Wright reactor at Quehanna, Pa., were built in anticipation of required support of various proposed nuclear powered systems. Since developments have not progressed as rapidly as forecast, the need for these facilities has been deferred. The Air Force-Nuclear Engineering Test Reactor will be placed in a standby status after initial startup and checkout for proper operation. The Quehanna reactor has been donated by Curtiss-Wright to Pennsylvania State University, about 25 miles away. Curtiss-Wright activities in the reactor and isotopes fields, formerly located at Quehanna, have been transferred to the Princeton, N.J., Division.

COMMISSION ACTIVITIES

Standard Lease Agreement

On March 1, 1960, the Commission put into effect a new standard lease agreement covering all special nuclear material distributed to licensees. Except with respect to material in neutron standards distributed by the National Bureau of Standards. At the same time the Commission modified procedures followed in the leasing of material. These actions were intended to improve and clarify those functions of a business nature which the Commission must carry out in distributing and accounting for special nuclear material.

The new lease does not alter or affect the rights or obligations of any Commission licensee under its license or construction permit. A standard provision of the new form is an expiration date of June 30, 1963. The uniform expiration date was established to provide a rea-

reasonably early re-evaluation of the Commission's terms and conditions for distributing special nuclear material in the light of changing technology and circumstances in a new industry. At the uniform expiration date the Commission intends either to renew existing agreements or to offer lessees an appropriately amended agreement.

By the end of 1960, about 95 percent of material with licensees valued at $86 million was brought under the new agreement, and the remainder was expected to be brought under it shortly.

The new agreement is expected to facilitate lessees' dealings with the Government not only by standardizing lease arrangements but also by clarifying responsibilities and establishing procedures in more detail than had been available previously. Administrative functions relating to the lease of special nuclear materials have been centralized in the Oak Ridge Operations Office.

In a related action in April 1960, the Commission published in the *Federal Register* base charges, special charges, specifications, and packaging information for uranium hexafluoride. Although the base charges heretofore had appeared in public releases, the specifications, special charges and packaging information, referred to in the standard lease agreement, had not been published previously.

Regulation and Indemnification

The Commission adopted two revisions to Part 50 of its regulations—"Licensing of Production and Utilization Facilities"—which clarified and simplified procedures to be followed in obtaining licenses for nuclear reactors.

The first revision made clear the extent of construction work permissible prior to issuance of a construction permit. It allowed preparation of the site for construction of the facility, including construction of roadways and utility lines, procurement and manufacture of components of the facility, construction of nonnuclear facilities and temporary buildings, and construction of buildings to be used for activities other than operation of a reactor even though they may also house a medical or research reactor.

The second revision provided for issuance of a provisional operating license under circumstances where a final operating license cannot be issued because construction has not been completed, or limited operating experience at limited power levels is necessary to test certain features, components or characteristics of the facility.

A third revision to Part 50 proposed by the Commission would make clear that it is Commission policy to issue provisional construction permits, even though there may exist at the time of issuance unresolved safety questions relating to important design features, provided that a research and development program will be conducted which is reasonably designed to resolve the safety questions. The intent of this proposed revision is to prevent unreasonable delays, which could total 1 to 3 years in construction of most developmental reactor projects, pending resolution of all substantial safety questions. However, no action has been taken toward issuing this third revision of Part 50 pending a final court decision in the case of the construction permit issued to the Power Reactor Development Co. which now is in litigation.

The Commission continued work on two studies directed toward establishing safety criteria for reactors which would provide advance guidance for organizations in designing reactors or in choosing sites for them. Both studies were nearing completion at the year's end. The central problem is to determine whether development of reactor technology has reached a point that would permit delineating specific safety requirements either for design or for sites. Specific criteria could have both advantages and disadvantages. Knowing in advance the specific safety criteria which the Commission would apply would enable reactor-building organizations to plan with more assurance and with a firmer estimate of costs. At the same time, fixed criteria during a period of rapidly evolving technology could place obstacles in the way of innovations in reactors that might accomplish needed economies in construction and operation. Establishment of criteria would in no way relax the Commission's requirements that its health and safety standards be met.

During the year the Commission also notified applicants for facility licenses of specific procedural steps to be taken in licensing actions and their relation to project schedules. The Commission established, after consultation with the applicants, tentative schedules for regulatory actions designed to prevent necessary procedures from causing delays in reactor construction and startup schedules.

A complete revision of Part 140, Financial Protection Requirements and Indemnity Agreements, was issued effective May 7, 1960. In issuing the revision the Commission made it clear that those sections of the regulation relating to financial protection required of those licensed to construct and operate reactors would be re-evaluated in consultation with licensees and the insurance syndicates concerned. A conference for this purpose was held October 11, 1960, and at the end of the year the Commission was considering recommendations on the regulation.

Land Burial of Wastes

In January 1960, the Commission announced a policy for land disposal of radioactive wastes. It provides for permanent land-burial of low-level packaged radioactive wastes only on Government-owned land, under long-term Government control, to assure adequate protection of public health and safety throughout the period of any potential hazard. Interim sites initially selected, pending possible later designation of permanent land-burial sites to serve various areas of the country, are on Federal reservations at the National Reactor Testing Station in Idaho and the Oak Ridge National Laboratory grounds in Tennessee. The new policy is not expected to affect commercial sea disposal activities being carried out under Commission licenses, except as convenience or economic factors may influence sea disposal firms to use land burial facilities.

When growth of the atomic energy industry establishes the need for new sites, the Commission expects that State governments may wish to establish and control sites for the benefit and convenience of their citizens.

The low-level wastes to which the policy applies include broken glassware, rags, paper, laboratory paraphernalia, and the like. Such solid wastes, packaged to meet the Interstate Commerce Commission regulations will be acceptable for burial at the two designated sites. Licensees will pay transportation costs. Charges for burial will be at a rate of 70 cents per cubic foot with a minimum charge of $21 for 30 cubic feet or less of packaged wastes. Details regarding this service are available from the Manager of Operations at either the Oak Ridge or Idaho Operations Office.

High-level wastes from the chemical processing of irradiated fuels will continue to be stored in specially designed underground storage tanks at Commission sites where these elements are processed.

A related amendment to Part 20 of the Commission's regulations permits Commission licensees to continue past practices in burial of their own very low-level wastes, but prohibits issuance of licenses to receive wastes from others for disposal on land not owned by the Federal or State governments (see later section on "Waste Disposal Licensing").

INFORMATION FOR INDUSTRY

Through further declassification of technical information, publication of increased numbers of reports, abstracts, books, translations and technical films, and revision of access permit categories, the Commission continued during 1960 to enlarge and improve the availability of technological material to the atomic energy industry. These activities are detailed in Part Two of this report; only highlights are summarized in this section.

The new Classification Policy Guide, issued in January, opened up entire areas of information previously classified—for example, all chemical engineering activity relating to atomic energy. The 37 categories of classified information previously requiring access permits for interested industry were reduced to 2. Some 5,000 additional documents were declassified.

Four new technical books were published, and six others were in press. Engineering drawings of atomic energy equipment were made available through a commercial source. Some 300 foreign language, chiefly Russian, documents were translated and placed on sale. Ten new professional-level films were prepared. More than 4,000 copies of classified reports, and 150,000 unclassified reports were sold, and more than 5,000 new unclassified reports were placed on sale.

Gas Centrifuge Information

The Commission initiated late in 1960 a revision of its regulation on access permits (10 CFR 25) to allow private industry to work in the classified area of gas centrifuge separation of heavy isotopes. This action was taken after industry informed the Commission that it believed there was substantial commercial potential in using gas centrifuges to provide enriched fuels (enriched in uranium 235) for reactors.

Under the proposed amended regulation permitting industrial access, industry could use its own funds for development work in this field, and, under appropriate safeguards, retain the benefits of its achievements. The amendment is a necessary first step toward establishing a basis for a commercial service to provide enrichment of fuels—a service now provided only by Commission plants.

The gas centrifuge was one of the methods investigated during the war-time program for producing weapons-grade uranium 235 concentrations. When development work at that time indicated this method was not ready for use in producing the required quantities and grades of uranium 235, work on this process was discontinued temporarily, and the present gaseous diffusion process was emphasized. Work on the gas centrifuge method was resumed in 1953 in the United States and has been expanded gradually as the technology advanced.

Scientists in other western countries also have been engaged in developmental work on gas centrifuge separation for many years. A major goal is to find a cheaper way to produce uranium 235 for the relatively low enrichments required for most types of nuclear power reactors and to expand the sources of fuel supply. The gas centrifuge method also could find use in separating plutonium isotopes, uranium 233-uranium 235 mixtures, and other stable isotopes now made available only in small quantities by electromagnetic separation. Scientific effort aimed at lowering the cost of nuclear fuels also could develop the capacity for producing highly enriched uranium 235 for use in nuclear weapons. It is impossible, however, to fix a precise time schedule when this might be possible by the gas centrifuge method because of the early stage of development and uncertainties in the pace of technology.

The technology of gas centrifuge separation is not now developed to a point where this process can produce uranium 235 at a cost competitive with the product from the gaseous diffusion plants. However, projections of possible gains in the gas centrifuge process indicate the possibility that the process may become attractive from the economic standpoint in the future. This would come only after very substantial further advances in centrifuge technology. For the United States, the gaseous diffusion method remains the most economical process for large-scale production of uranium 235 at this time.

(The Commission's research and development program on the gas centrifuge system is described in Part Two under Production of Special Nuclear Materials. A statement by Chairman John A. McCone on the gas centrifuge, and a Commission report on the current status of gas centrifuge technology, made public in December 1960, are included as appendix 20.)

Two possible advantages of the gas centrifuge method are its low requirement for electrical power and its requirement for fewer units in series in order to produce the necessary enrichment. The United States has kept abreast of advances in the gas centrifuge field outside its own program. Because of its potential significance to production of weapons materials, the United States program is classified.

Access to advanced industrial and technical resources would be required in order to develop and build within the span of a few years, a gas centrifuge plant able to produce enough enriched uranium for an initial atomic weapon. To achieve such a production capability, it would be necessary to install large numbers of centrifuges in a complex arrangement.

Scientists in West Germany and the Netherlands have worked to develop the potential of the gas centrifuge process for its interesting scientific and commercial possibilities. They have been particularly interested in the potential of the centrifuge for the production of low enriched uranium for civilian research and power reactors.

In July 1960, representatives of the Department of State and of the Atomic Energy Commission discussed centrifuge technology with the West German and Netherlands governments in connection with general discussions on the peaceful uses of atomic energy.

The United States asked that Germany and the Netherlands give consideration to the control of gas centrifuge technology. The governments of these two countries shared our concern over the implication of the centrifuge process for weapons development.

The United States also has discussed the gas centrifuge question with the United Kingdom. Both the United Kingdom and Canada follow classification criteria similar to those of the United States on the gas centrifuge process.

The West German Government announced late in 1960 that it had taken steps to control the dissemination of information on the gas centrifuge process. The United States understands that the Netherlands Government is actively studying the question of applying controls to its work.

Many of the civil reactors planned or in operation throughout the world will produce materials which can be used in nuclear weapons. The United States has supported broad international action to insure that nuclear material used in civil programs is not diverted to military use.

The General Conference of the International Atomic Energy Agency, which met in Vienna in September, endorsed proposed safeguards to apply to reactors and special nuclear materials that will be subjected to IAEA controls. The principles of these safeguards can be extended to apply to the gas centrifuge.

Reactor Physics Data Centers

As a means of providing a centralized source of information on neutron cross section data needed by reactor engineers, designers, and physicists, the Commission has established a Cross Section Evaluation Center at the Brookhaven National Laboratory. Information generated at the center will be available to the nuclear industry.

The basic working unit at the center will be the recently-formed Neutron Cross Section Evaluation Group, which will evaluate cross section measurements and make theoretical extrapolations of the data. The services of the group will also be available in determining the completeness of measurements in various areas and knowledge of planned experiments to improve and broaden measurements knowledge.

The information processed by the group will be obtained from Commission laboratories and other facilities engaged in neutron cross section measurement studies.

The Commission's Advisory Committee on Reactor Physics will serve as a consultant body and assist in establishing priority assignments for critical evaluations and theoretical assessments. Contractual arrangements have been made with the Nuclear Development Corp. of America for consultant services.

Other reactor physics data centers include the Neutron Cross Section Compilation Center, also located at Brookhaven, which compiles and publishes all seemingly reliable results of neutron cross section measurements; and the Reactor Physics Constants Center at Argonne National Laboratory, which compiles, evaluates, and publishes determinations of quantities other than cross section, quantities exemplified by the number and energy of neutrons emitted in fission, values of resonance integrals, neutron age in reactor materials, and the types of fission products resulting from fission.

Patents

In keeping with the Commission's practice of securing United States and foreign patents on worthy inventions originating under Commission sponsored work, 230 additional United States patents issued during calendar 1960. The Commission today has a portfolio of some 2,499 United States patents available for royalty-free licensing. As of December 1, 1960, 801 licenses within this group had been granted.

The Commission's portfolio of foreign patents on December 31, 1960, numbered some 505, an increase of about 215 during the year. The Commission, under a policy adopted in December, will license Commission-owned foreign patents for royalties to nationals of those countries charging royalties of the U.S. Government or its citizens. No royalty charges are made in those countries extending free royalty licensing to United States citizens. Where a foreign government has no policy, Commission decision on charges will be made on a case basis. Licenses or foreign patents granted by the Commission may be exclusive or nonexclusive for a period of 3 to 5 years.

The Commission adopted a new policy in December of authorizing contractors to file for foreign patents and retain substantive rights under specified terms and conditions. The policy applies to inventions derived from work performed in privately owned or operated facilities, and is retroactive to include existing contracts.

In order to secure the foreign patent rights, the contractor is to file the United States application which would serve as a basis for the foreign application. The Commission acquires the rights in the United States application but the contractor would retain all rights in the foreign applications subject to receipt by the U.S. Government of a nonexclusive, irrevocable license to the U.S. Government for U.S. 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, nonexclusive, royalty-free licenses to United States citizens and agrees to grant to foreign users and purchasers of a product of a United States licensee, a license at a reasonable nondiscriminatory royalty. If after 5 years of 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 patent, the contractor or its assignee shall, at the request of the Commission, grant licenses on any such foreign patents at reasonable royalties.

MANPOWER FOR ATOMIC ENERGY

The Commission began during 1960 an annual collection and analysis of statistics on total employment[17] in atomic energy activities throughout the United States. As of January 1960, total employment including private, Federal contract, and direct Federal employment exclusive of members of the Armed Forces was estimated at approximately 185,000 of which only 10,000 represent direct Federal employment.

Detailed figures for 1960 cover about two-thirds of total employment; the survey for 1961 will be expanded to include the remaining third which, this year, is estimated on the basis of data collected for other purposes.

The two-thirds of the work force surveyed this year by the Bureau of Labor Statistics, Department of Labor, at the request of the Com-

[17] 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 reactors, (transmission and consumption of electricity are excluded) nuclear ship operation, industrial, medical, and pharmaceutical applications, etc.

mission,[18] is employed by 158 establishments operated by 130 prime contractors of the Commission. These establishments have reported total employment in their atomic energy activities, including both those working full-time on Commission contracts and also those who devote part or full-time to private research or industrial atomic energy operations. Among the 130 prime contractors, 29 operate 38 Government-owned facilities which employ about 70 percent of the total work force of the prime contractors.

The 158 establishments operated under prime contracts with the Commission employ a total of 125,921 (see Table 1). In addition, the Government's direct employment is estimated at 10,000 (excluding the Armed Forces, but including the Commission), and industrial and educational organizations that do not hold prime contracts with the Commission employ an estimated 48,900 (see Table 2).

Among the establishments under Commission prime contracts, scientists and engineers made up 20 percent of all employees as of January 1960. Skilled workers made up 19 percent of the total, and technicians and other technical personnel 15 percent (see Table 3). The high percentage of skilled workers results from the complexity of products, precise tolerances required, and the custom manufacture of many products required.

Distribution of Manpower

Of ten major segments of the atomic energy field,[19] laboratories and research facilities employed 33 percent of the 126,000 workers included in the survey, and defense production facilities—the production of uranium 235, plutonium and weapons—employed 28 percent, production of feed materials an additional 9 percent of the total. Reactor design and manufacturing accounted for another 9 percent. The remaining 21 percent was distributed among 6 other major segments, and one small miscellaneous category.

The largest number of employees in single occupation was 4,400 mechanical engineers. Other occupations with substantial employment were maintenance mechanic, 3,100; chemist, 3,100; and electrical

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[18] Employment in the Atomic Energy Field, Results of a 1960 Survey, Bureau of Labor Statistics, Department of Labor, January 1960, Superintendent of Documents, Government Printing Office, Washington 25, D.C.

[19] The 10 major segments are: (1) Commission laboratory and research facilities, (2) atomic energy defense production facilities, (3) reactor and reactor component design and manufacturing, (4) production of feed materials, (5) design, engineering, and construction of nuclear facilities, (6) private research laboratories and centers engaged in atomic energy work, (7) production of special materials for use in reactors, (8) uranium milling, (9) fuel element fabrication, and (10) power reactor operation and maintenance, plus a small miscellaneous category.

or electronic engineer, 3,000. It is of interest to note that a number of persons are employed in occupations peculiar to atomic energy—for example 372 Health Physicists, 720 Health Physics Technicians, and 881 Reactor Operators.

1961 Requirements

As of January 1960, when the survey was made, need for an increase of 4,000 employees by January 1961 was forecast by Commission prime contractors (see Table 1). Commission-owned laboratories expected to need 1,800 additional employees, defense production facilities 1,400. Requirements included 1,000 engineers and 850 scientists.

The 1961 round-up of atomic energy employment will include a survey of industrial employment by the Bureau of Labor Statistics, a survey of Federal employment by the Civil Service Commission, and a survey of employment in universities and colleges by the Office of Education, Department of Health, Education, and Welfare.

The Commission participates in the Government-wide effort designed to increase the pool of professionally and technically competent workers available in the United States, and in other countries of the free world. These various programs are described, as appropriate, in sections of this report on International Activities, Radioisotope and Radiation Development, Education and Training, and Health and Safety.

TABLE 1.—EMPLOYMENT IN THE ATOMIC ENERGY FIELD, 158 AEC PRIME CONTRACTORS

Type of Activity	January 1959		January 1960		January 1961 (anticipated)	
	Number	Percent	Number	Percent	Number	Percent
Atomic Energy Commission laboratories	40,531	32.81	42,172	33.49	43,951	[illegible]
Atomic energy defense production facilities	35,627	28.84	35,590	28.26	36,945	[illegible]
Reactor design and manufacturing	12,049	9.75	11,760	9.34	12,149	[illegible]
Production of feed materials	12,003	9.72	11,717	9.31	11,631	[illegible]
Construction of nuclear facilities	6,319	5.12	6,575	5.22	6,320	[illegible]
Private research laboratories	4,832	3.91	5,295	4.21	5,725	[illegible]
Production of special materials	3,222	2.61	3,584	2.85	3,855	[illegible]
Uranium milling	3,261	2.64	3,432	2.73	3,506	[illegible]
Fuel element fabrication	2,924	2.37	2,903	2.31	3,021	[illegible]
Power reactor operation	235	.19	366	.29	531	[illegible]
Miscellaneous	2,527	2.05	2,527	2.01	2,373	[illegible]
Total, all activities	123,530	100.00	125,921	100.00	130,007	[illegible]

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 2. EMPLOYMENT IN ATOMIC ENERGY FIELD, EXCLUSIVE OF AEC PRIME CONTRACTORS

Field	*Number Employed*
Uranium mining	4,100
Research at universities with AEC contracts other than those covered in the survey and including supporting personnel	15,000
Other university research and teaching, including supporting personnel	11,400
Research and development in private (other than universities) laboratories not under contract with AEC	1,300
Nuclear instrument manufacturing, radioactive waste disposal and other service and manufacturing establishments not under contract to AEC	2,200
Government (exclusive of military)	10,000
Construction of nuclear facilities	15,000
Total	59,000

TABLE 3.—EMPLOYMENT IN THE ATOMIC ENERGY FIELD, 158 AEC PRIME CONTRACTORS, BY MAJOR OCCUPATIONAL GROUP

Occupational Group	January 1960		January 1961 (anticipated)	
	Number	Percent	Number	Percent
Scientists	9,488	7.53	10,333	7.95
Engineers	15,112	12.00	16,154	12.43
Technicians	14,612	11.60	15,393	11.84
Other technical personnel	3,744	2.97	4,017	3.09
Managerial, administrative, and other professional personnel	12,417	9.86	12,599	9.69
Clerical and other office personnel	18,537	14.72	18,413	14.16
Skilled trades	23,881	18.97	24,383	18.76
Other production, maintenance, and construction workers	17,495	13.89	17,933	13.79
Service workers	9,754	7.75	9,824	7.56
Nuclear reactor operators	881	.70	958	.74
Total, all employees	125,921	100.00	130,007	100.00

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

Part Two

Major Activities in Atomic Energy Programs

January–December 1960

Raw Materials

Receipts of domestic uranium oxide, plus imports, totaled 33,500 tons of uranium oxide (U_3O_8) during 1960, of which 17,730 tons were from domestic suppliers, 11,310 tons from Canada, and 4,460 tons from overseas.

Progress was made during the year in stretching out uranium deliveries to bring supply more nearly in line with projected current requirements. Under agreements negotiated with Canada, approximately 9,300 tons of U_3O_8 in Canadian concentrates scheduled for earlier delivery have been deferred until after April 1, 1962. Similarly, 5,050 tons scheduled for earlier delivery from domestic producers have been deferred and will be delivered in the 1962–1966 period. Negotiations with other domestic producers are continuing. The Commission program for bonus payments upon initial ore deliveries from new domestic mines expired on March 31, 1960.

Shipments totaling about 400 tons were received through September from the Congo, completing deliveries under this long standing contract. Uranium concentrate deliveries under long term Combined Development Agency contracts with Australia, Portugal, and South Africa were continued at a normal rate during the year.

The Commission has virtually completed negotiations of all proposals submitted in accordance with the program announced April 2, 1958, of limited expansion of milling facilities to provide a market for ores developed prior to November 1, 1957, in those areas where milling capacity was inadequate. The Commission also worked toward completion of arrangements with mine operators and milling companies pursuant to its modified purchase program for the 1962–66 period announced November 24, 1958.[1] Property holders seeking to qualify under this program have submitted statements claiming ore reserves developed prior to November 24, 1958. Agreements on these reserves have been reached with the owners of most large deposits, but a number of small properties remain to be examined.

DOMESTIC ACTIVITIES

Production

The United States maintained its position as the world's leading producer of uranium. Uranium ore production in the United States

[1] See pp. 5–6 and 353–365, Twenty-fourth Semiannual Report to Congress (January–June 1958), p. 8, Twenty-fifth Semiannual Report to Congress (June–December 1958), and pp. 56–57, Annual Report to Congress (January–December 1959).

totaled 8.0 million dry tons during 1960, as compared to 6.9 million tons in the previous 12 months. Production of uranium oxide (U_3O_8) in concentrates for the year totaled 17,730 tons.

Ore Reserves

Preliminary estimates of domestic uranium ore reserves totaled 82.0 million tons containing 0.28 percent U_3O_8 as of December 31, 1960, a decrease of only about 4.0 million tons from the previous year-end estimate despite the fact that 8.0 million tons were mined during 1960. In addition, approximately 1.3 million tons of ore were in Government and private stockpiles at the end of 1960.

Only a portion of the estimated ore reserves in a number of large deposits will be mined to meet deliveries to the Commission under existing contracts extending through 1966. Notwithstanding the reduced level of exploration that followed the placing of limitations on purchases, and the absence of important new discoveries during the past two years, substantial domestic ore reserves will still be available in 1967. The estimate is that the equivalent of between 45 and 50 million tons of average grade ore (0.25 percent U_3O_8) from present reserves will remain. Additional reserves routinely developed during the course of mining may add several million tons.

These reserves, although not large in terms of the long-range requirements of a major atomic power program, would provide a firm base for the domestic mining industry and they could be augmented by renewed exploration as demand increases.

1962–1966 Purchase Program

Under a November 24, 1958, announcement, the Commission limited its purchase of domestic uranium concentrates during the period April 1, 1962–December 31, 1966, to appropriate quantities of concentrates derived from ore reserves developed prior to November 24, 1958. Producers wishing to qualify under the 1962–66 procurement program were given until October 1, 1959, to file statements and supporting data showing ore reserves developed as of November 24, 1958. The Commission received statements covering claimed reserves on approximately 2,650 properties involving many thousands of mining claims. The November 1958 ore reserves contained in most of the larger deposits have been calculated, and agreements reached as to production allocations with the operators. A number of small properties remain to be examined.

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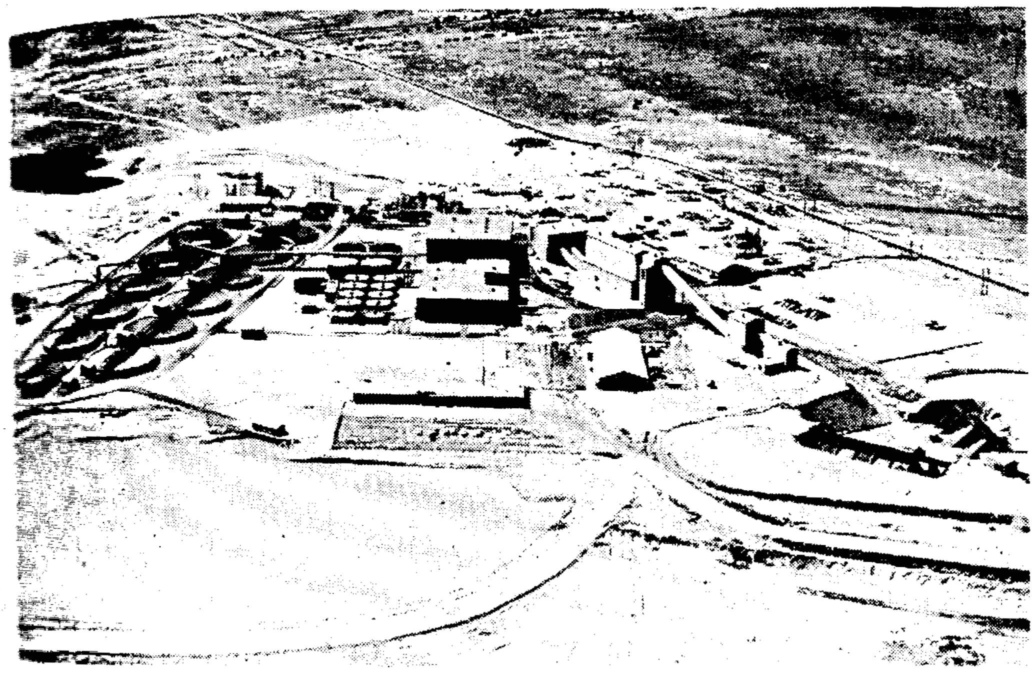
In accordance with the 1962–66 uranium purchase program, a number of contracts with ore processing mills have been modified and extended to provide an appropriate market in the post-1962 period for uranium concentrates produced from reserves developed prior to November 24, 1958. In addition, a contract was executed with the Petrotomics Co. which provides that the company may, at its option, build its own mill to produce concentrates in the 1962–66 period from ores located in the Shirley Basin, Carbon County, Wyo., qualifying under the November 24, 1958, announcement, or arrange for treatment of its ores at some existing plant. Of 25 mills now operating, 13 have contracts extending through 1966, and two have contracts which terminate in 1965 by reason of a limited eligible ore supply. Extensions of other milling contracts will be considered in the light of eligible ore reserves tributary to the mills. The major features of each of the contracts are in Appendix 19.

Milling Operations

With the exception of final action on a contract for the purchase of uranium from the lignite area of North Dakota-South Dakota, the



Largest Mill. Twenty-five domestic mills are currently processing uranium ore for the Commission at the rate of 22,100 tons of ore per day, and three more mills now under construction or planned will increase production by approximately 1,000 tons. Shown in this aerial photo is the largest of the mills in operation, the Nuclear Fuels Corp. uranium mill at Grants, N. Mex., which processes [illegible] tons of ore a day. The ore is primarily from the Ambrosia Lake district which is the nation's largest known body of uranium ore reserves.

Commission has completed its contracting of limited expansion of milling facilities in accordance with the program announced April 2, 1958,[2] in areas where milling capacity was inadequate for ores developed prior to November 1, 1957. In the lignite area, completion of a contract with International Resources Corp., involving the purchase of U_3O_8 produced from uraniferous lignite, is pending. Reassessment of ore supply by milling companies resulted in a reduction in the total amount of additional mill capacity as estimated in April 1958.

Increases in capacity resulting from contracts involving new facilities and expansion of existing mills are as follows:

	Tons per day	
	Contemplated in April 2, 1958 announcement	Provided to date
Southeast Texas	600	a 2[illegible]
North Dakota-South Dakota (lignites)	600	(b)
Wyoming (Gas Hills-Crooks Gap)	1,700	1,[illegible]
Colorado Front Range	200	3[illegible]
Nevada (Austin)	200	...
	3,300	1,[illegible]

a Mill under construction.
b Pending contract would provide for plant having initial capacity of 200 T/day with proposed increase to 600 T/day after April 1, 1962.

Southeast Texas. The April 2, 1958, announcement provided for a 600-ton-per-day mill in Southeast Texas, based upon ore deposits located in Duval and Karnes Counties. Several companies investigated the feasibility of such an operation, but their studies led to the conclusion that a greater portion of the Duval deposits could not be mined economically and that a milling operation would depend largely on the ores in Karnes County. Susquehanna-Western, Inc., in July 1960, signed a contract with the Commission to supply uranium concentrates from a 200-ton-a-day processing plant to be built 10 miles southwest of Falls City, Tex.; it will draw its major ore supply from Karnes County.

North Dakota-South Dakota. Negotiations with International Resources Corporation, which may result in the construction of a plant in this area to process uraniferous lignites, have been concluded. Execution of the contract is waiting completion of financial and management arrangements.

The Company originally planned a 600-ton-per-day mill but the pending contract calls for construction of a plant to process 200 tons

[2] See Appendix 11, p. 352, Twenty-fourth Semiannual Report to Congress (January–June 1958).

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lignite a day with a provision for increasing the capacity to 600 tons per day after March 31, 1962.

Wyoming. The additional capacity of 1,560 tons of ore per day provided for Wyoming was attained through construction of two new mills, one by Globe Mining Co., and one by Federal-Radorock-Gas Hills Partners; and by additions to the capacity of two existing mills, one operated by Western Nuclear, Inc., and one by Utah Construction and Mining Co. (formerly Lucky Mc Uranium Corp.). The original program for this area provided also for expansion of Susquehanna-Western's mill at Riverton, Wyo., but this expansion was dropped because the production rate of eligible ores did not require expansion in plant capacity.

Colorado Front Range. The 200-ton-per-day mill indicated for this area was provided for by expansion to 200-tons-per-day capacity of the 50-tons-per-day Cotter Corp. pilot plant at Canon City, Colo.

Austin, Nevada. Ore from the principal property near Austin is being marketed at existing mills in other areas, and no proposals are under consideration for a Nevada mill.

A list of operating mills, and those under construction as of December 31, 1960, is given in Table 1.

Bonus Payments

The Commission's program of bonus payments for initial production from new domestic sources of uranium ores expired on March 31, 1960. Between March 1, 1951, when the program began,[3] and termination, total bonuses of approximately $17.7 million were paid for initial production of about 5.4 million pounds of U_3O_8. The bonus program, which was established when domestic reserves and production appeared small, encouraged uranium prospecting and exploration and assisted miners during early development of new ore bodies.

Vanadium Sales

In April, the Commission's Grand Junction Operations Office issued a public invitation for bids on approximately 1.5 million pounds of vanadium pentoxide. The Vanadium Corp. of America was the successful bidder and purchased the entire quantity at $1 a pound.

[3] See p. 9, and pp. 127–134, Tenth Semiannual Report to Congress (January–June 1951).

TABLE 1.—URANIUM PROCESSING PLANTS

Company	Location of mill	Present contract terminates	Tons of ore per day	Estim[illegible] cost of [illegible]
Anaconda Co.[a]	Grants, N. Mex.	12/31/66	3,000	$19,2[illegible]
Climax Uranium Co.	Grand Junction, Colo.	12/31/66	330	3,0[illegible]
Cotter Corp.	Canon City, Colo.	2/28/65	200	1,5[illegible]
Dawn Mining Co.	Ford, Wash.	12/31/66	400	3,1[illegible]
Federal-Radorock-Gas Hills Partners	Fremont Co., Wyo.	12/31/66	520	3,7[illegible]
Globe Mining Co.	Natrona Co., Wyo.	12/31/66	490	3,1[illegible]
Gunnison Mining Co.	Gunnison, Colo.	12/31/62	200	2,0[illegible]
Homestake-New Mexico Partners	Grants, N. Mex.	3/31/62	750	5,2[illegible]
Homestake-Sapin Partners[a]	do.	12/31/66	1,500	9,0[illegible]
Kermac Nuclear Fuels, Corp.	do.	12/31/66	3,300	16,0[illegible]
Kerr-McGee Oil Industries	Shiprock, N. Mex.	6/30/65	300	3,1[illegible]
Lakeview Mining Co.	Lakeview, Oreg.	11/30/63	210	2,6[illegible]
Mines Development, Inc.	Edgemont, S. Dak.	3/31/62	400	1,9[illegible]
Phillips Petroleum Co.[a]	Grants, N. Mex.	12/31/66	1,725	9,5[illegible]
Rare Metals Corp. of America	Tuba City, Ariz.	3/31/62	300	3,0[illegible]
Susquehanna-Western, Inc.[b]	Falls City, Tex.	12/31/66	200	2,9[illegible]
Susquehanna-Western, Inc.[c]	Riverton, Wyo.	12/31/66	500	3,5[illegible]
Texas-Zinc Minerals Corp.	Mexican Hat, Utah	12/31/66	1,000	7,0[illegible]
Trace Elements Co.	Maybell, Colo.	3/31/62	300	2,2[illegible]
Union Carbide Nuclear Co.	Rifle, Colo.[d]	3/31/62	1,000	8,5[illegible]
Union Carbide Nuclear Co.	Uravan, Colo.	3/31/62	1,000	5,0[illegible]
Uranium Reduction Co.	Moab, Utah	12/31/66	1,500	11,1[illegible]
Utah Construction & Mining Co.[e]	Fremont Co., Wyo.	12/31/66	980	6,9[illegible]
Vanadium Corp. of America	Durango, Colo.	3/31/62	750	[illegible]
Vitro Chemical Co.	Salt Lake City, Utah	3/31/62	600	5,5[illegible]
Western Nuclear, Inc.	Jeffrey City, Wyo.	12/31/66	845	4,3[illegible]
		TOTALS	22,300	143,[illegible]

PROPOSED MILLS

Company	Location of mill	Present contract terminates	Tons of ore per day	Estim[illegible] cost of [illegible]
International Resources Corp.[f]	Bowman, N. Dak.			
Petrotomics Co.[g]	Carbon County, Wyo.	12/31/66		

[a] Amended contracts which include provisions for delivery stretch-out to 1962–66 period:

	Tons U_3O_8
Anaconda Co.	2,000
Homestake-Sapin Partners	700
Kermac Nuclear Fuels Corp.	1,850
Phillips Petroleum Co.	500
Total	5,050

[b] Under construction.

[c] Formerly Fremont Minerals, Inc.

[d] Union Carbide Nuclear Co. also buys and upgrades ore at Slick Rock, Colo. and Greenriver, U[illegible] feed for the Rifle, Colo. mill.

[e] Formerly Lucky Mc Uranium Co.

[f] Pending contract would provide for plant having initial capacity of 200 tons/day with propo[illegible] crease to 600 tons/day after April 1, 1962.

[g] Commission contract provides that Petrotomics Co. may, at its option, construct a mill for prod[illegible] of U_3O_8 covered by the contract in the 1962–66 period or make arrangements with existing mills f[illegible] recovery.

NOTE: The above listed mills are privately owned and operated and are licensed to buy urani[illegible] from producers. The USAEC buys the concentrate product under the terms of a contract with ea[illegible] operator.

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Present contract terminates	Tons of ore per day	Estima... cost of ...
12/31/66	3,000	$19,…
12/31/66	330	3,…
2/28/65	200	1,…
12/31/66	400	3,…
12/31/66	520	3,…
12/31/66	490	3,…
12/31/62	200	3,…
3/31/62	750	2,…
12/31/66	1,500	5,…
12/31/66	3,300	9,…
6/30/65	300	16,…
11/30/63	210	3,…
3/31/62	400	2,…
12/31/66	1,725	1,…
3/31/62	300	9,…
12/31/66	200	3,…
12/31/66	500	2,…
12/31/66	1,000	3,…
3/31/62	300	7,…
3/31/62	1,000	2,…
3/31/62	1,000	8,…
12/31/66	1,500	5,…
12/31/66	980	11,…
3/31/62	750	6,…
3/31/62	600	…
12/31/66	845	5,…
		4,…
TOTALS	22,300	143,…
12/31/66		

...tch-out to 1962–66 period:

	Tons U_3O_8
	2,000
	700
	1,850
	500
	5,050

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The concentrate stored at Grand Junction, Colo., had been bought from uranium processing mills under earlier contracts that provided the Commission would purchase vanadium extracted from uranium-vanadium ores when vanadium production was in excess of current commercial requirements. Such contracts helped maintain uranium production from ores of the Colorado Plateau containing values of both uranium and vanadium—originally the only domestic source of uranium. Commitments of this kind have been reduced by revision of mill contracts, and will terminate March 31, 1962. An additional ... million pounds of vanadium is being offered for sale with bids to ... opened in January 1961.

...dioactive Hazards in Mills and Mines

The Commission transferred administration of the contract for operation of the Process Development Laboratory at Winchester, Mass., from the Division of Raw Materials to the Division of Biology and Medicine, effective July 1, 1960. Originally operated to develop and improve ore processes, this laboratory has been working since 1957 ... techniques and procedures for determining and reducing radiation hazards connected with milling operations—work that will benefit from being more closely associated with other biomedical studies.

The Division of Raw Materials continues to act in a liaison capacity with the milling industry with respect to radiation hazards and will continue to sponsor meetings for technical discussions in this area. ...h a meeting was held in October at Grand Junction, Colo., attended ... representatives from the milling industry, the Public Health Service, State organizations, and personnel from various Commission ...isions.

Compliance actions relating to licensed uranium milling operations ... reported in the section on Licensing, Regulation and Indemni...ation.

Enforcement of mine safety, including control of radiation hazards, ... principal responsibility of the States. Most uranium-producing ...tes have established permissible concentration levels in mines for ...on and its decay products. However, mine management also must ...me major responsibility for maintaining safe working conditions ...ablished by the States as mine workings are continually being ex...ded and adequate ventilation must be provided for new working ...s.

The Commission controls several uranium mining properties that ... operated privately under lease agreements, and has arranged with the Bureau of Mines for periodic health and safety inspections, including radiation surveys. As a result of these surveys and Commission inspections, ventilation and dust control have been improved. These gains are believed to demonstrate that, in most cases, the concentrations of radon gas—a radioactive decay product of radium always associated with uranium—can be controlled in mines, without unduly prohibitive costs.

In December, a conference of the governors of the States concerned with uranium mining was held in Denver, Colo. This conference, sponsored by the Secretary, Department of Health, Education, and Welfare, and attended by representatives of interested government agencies, was called for the purpose of discussing possible radiation hazards in uranium mines.

FOREIGN ACTIVITIES

Deliveries of foreign uranium concentrates to the United States during 1960 totaled 15,770 tons of contained U_3O_8 with 11,310 tons coming from Canada and the rest coming from Australia, Belgian Congo, Portugal, and South Africa under contracts of the Combined Development Agency.

Canada

In November 1959, the Canadian Government and the Commission announced an agreement for stretching out deliveries of uranium under existing contracts.[4] The announcement also stated that the Commission would not exercise its options to purchase additional Canadian uranium concentrates in the post-1962 period.

The stretch-out arrangements will result in a major deferral of United States deliveries amounting to approximately 9,300 tons of U_3O_8 which will be delivered in the period March 31, 1962–December 31, 1966, when the Commission's total purchase commitments are lower.

Overseas Procurement

Deliveries under Combined Development Agency contracts with Australia, Portugal, and South Africa were normal. Shipments under the Agency contract for Congo uranium were completed.

[4] See pp. 61–62, Annual Report to Congress (January–December 1959).

Belgian Congo (The Republic of Congo)

Union Miniere du Haut-Katanga began refining some ores to metal-grade uranium oxide in 1958 and deliveries of this product, in lieu of concentrate, began in December of that year.

Deliveries from the Congo in September completed the contract with CDA's most important historic supplier. Since the first delivery in the latter part of 1942, over 30,000 tons of U_3O_8 were produced from the Belgian Congo, most of which came to the United States. Throughout World War II, the Shinkolobwe mine, located in Katanga Province, Congo, in Africa, was the principal source of uranium and supplied most of the material for the early weapons program. It continued to be the most important source for a number of years after the war when supplies of uranium were critically short.

South Africa

In February, exploratory discussions were held in South Africa between representatives of the Combined Development Agency and the South African Atomic Energy Board regarding a possible stretch-out in production and in deliveries to the Agency. Discussions were continued in Johannesburg in November.

Assistance to Foreign Countries

Limited technical assistance in uranium exploration in Brazil, Chile, and Peru was terminated at the end of the year.

Production of Special Nuclear Materials

During calendar year 1960, production of special nuclear materials required for weapons manufacture, research and development, and for peaceful applications of atomic energy, was in accordance with schedules. The total cost of the special nuclear materials program in 1960 was $553 million as compared with $541 million in 1959, an increase of 2.2 percent.

Raw materials receipts at the two feed processing plants located at Fernald, Ohio and Weldon Spring, Mo., were in line with current requirements. The eight graphite reactors at Hanford, Wash., and the five heavy water reactors at Savannah River, S.C., were operated to produce the requirements for both plutonium and tritium during 1960. The gaseous diffusion plants located at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio, were operated to produce the 1960 requirements for uranium 235. Process development effort was directed toward technical plant support to assure continuity and safety of operations, development and improvement of processes and equipment, and attainment of the required production levels.

Disposition of Facilities

Following an operations analysis study, the feed materials processing plant at Destrehan St. in St. Louis, Mo., was closed in June 1958. In August 1960, bids were received for building demolition and site restoration, and a demolition contract was awarded to Arch Wrecking and Salvaging Co. on October 25. Demolition is expected to be completed in May 1961. The buildings and equipment are owned by the Commission, the land by the Mallinckrodt Chemical Works.

Mallinckrodt will take over the land and some of the buildings and facilities which the company has agreed to purchase, such as the incoming power station and equipment, the steam power plant and equipment, storage tanks, fencing, railroad siding and tracks, as well as some of the metal plant buildings. Before the demolition contract was let, $1,461,000 worth of usable equipment at acquisition value was transferred within the Commission or to other Government agencies, and an additional $402,000 worth of equipment, at acquisition value, was sold to Commission licensees in the uranium industry. Restricting the sale of this equipment to licensees made it unnecessary to decontaminate the equipment prior to sale.

New Production Reactor

Design and construction of the New Production Reactor (NPR) at Hanford, Wash., proceeded satisfactorily during 1960. As of November 30, design was estimated to be 80 percent complete, construction was 7.5 percent complete, and about 60 percent of the major equipment had been ordered.

Completion of construction is scheduled for October 1, 1962, the original target date. Costs of the reactor are expected to remain within the $145 million authorized by Public Law 85–590. These costs do not include supporting facilities, estimated at an additional $7.2 million.

The NPR fuel elements will be slightly enriched uranium metal clad by co-extrusion with zircalloy-2. The co-extrusion and fuel element finishing operations will be performed by the General Electric

Co. at Hanford. Proposals from private industry were received during the summer in response to an invitation for proposals to manufacture, in private facilities, the uranium metal billets for the coextrusion process. The prices quoted by private concerns exceeded by a substantial margin the costs of producing these billets in Government facilities. Consequently the Commission decided to produce the fuel billets in Government facilities.

A study on the economic feasibility of converting the NPR for the recovery of electric power was made by the Federal Power Commission (FPC); its report was published during February 1960.[5] Arrangements have been made for additional studies, including an updating by FPC of its earlier report, to be available in 1961.

Gas Centrifuge Studies

The Commission has recently increased its effort on development of the gas centrifuge process of isotope separation to an expected total of approximately $2 to $3 million per year. The development program will continue to be classified. (See Appendix 20 for AEC statement on gas centrifuges.)

The expanded program includes three major areas:

Continuation of basic research which has been underway at the University of Virginia, Charlottesville, Va.

Experimental operation of small groups of machines incorporating presently available technology. This work is being performed for the Commission by Union Carbide Nuclear Corp. at Oak Ridge, Tenn.

Development of advanced gas centrifuge models. Interested private companies with the best capabilities for contributing to the program will be invited to submit proposals to perform development work on the advanced machine under contract for the Commission.

Military Application

Production of nuclear weapons by the Commission continued during 1960 as authorized by the President. The production effort included

[5] "Reactor Power Plant Economic Feasibility Study" TRD–5762. Price $2.50, available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

meeting new weapon system capabilities, modernization of older and less efficient designs in stockpile, and a retirement program for obsolescent weapons.

The Commission's program of weapons research and development has consisted during 1960 essentially of laboratory study and analysis of data obtained on the 1958 Hardtack and earlier nuclear test series with a large portion of the effort being devoted to translating these results into operational weapons to meet specific Department of Defense requirements. These efforts have been fruitful and defense needs for numerous weapons of various weights and yields have been met.

Further intensive research and refinements by the United States nuclear weapons organizations, even without tests, can continue to produce some design improvements. However, without nuclear testing, major advances in nuclear weapons design do not appear possible.

Test Facilities

The Eniwetok Proving Ground and its facilities were maintained on a stand-by basis until June 30, 1960, when the facilities were made available to the Department of Defense for its Pacific Missile Range. The Proving Ground will remain available for Commission activities if needed. Weapons test facilities at the Nevada Test Site have been maintained on a stand-by readiness state.

Weapons Facilities

Work was initiated on the construction of a $2 million plant for treatment of chemically and radiochemically contaminated liquid wastes generated by the metallurgical, chemical, biological and cryogenic laboratories at Los Alamos Scientific Laboratory, Los Alamos, N. Mex. Construction also began on a $3 million special metal fabrication plant at Oak Ridge, Tenn. to meet weapons production requirements.

Transfer of ballistic drop test operations from the Salton Sea Test Base, Calif. to Tonopah Test Range, Nev. began during 1960 and is expected to be completed during 1961 at which time the Salton Sea Base will be placed on a standby basis. The Tonopah Test Range is northwest of the Navada Test Site and is used for determining the ballistic characteristics of inert (non-nuclear) weapons shapes dropped from aircraft and for firing high altitude research rockets.

Computer facilities are being expanded. Additional computing systems are required to solve complex weapons research problems. In addition, there are problems which require computer solutions in other fields of research being carried on by those laboratories participating in research on such programs as controlled thermonuclear reaction and nuclear propulsion.

Mutual Defense Agreements

Exchanges of information under Agreements for Cooperation with other nations for mutual defense purposes, reported in the Annual Report to Congress for 1959,[6] continued during 1960. The United States-United Kingdom Agreement for Cooperation, which is considerably broader than other agreements, involves the exchange of classified information on nuclear weapons and the exchange of visits between scientists of the two countries.

The United States has mutual defense agreements in effect with Australia, Canada, France, the Federal Republic of Germany, Greece, The Netherlands, Turkey, the United Kingdom, and the North Atlantic Treaty Organization (NATO).

Weapons Test Negotiations and Related Research

The United States voluntary suspension of nuclear weapons tests continued in 1960. This suspension dates back to October 31, 1958, when negotiations between the United States, the United Kingdom and the Union of Soviet Socialist Republics began at Geneva on a treaty for the discontinuance of nuclear weapons testing.

To put in perspective the United States position on its voluntary suspension of nuclear weapons tests it is necessary to review the history of the test cessation negotiations beginning with the 1958 Conference of Experts at Geneva. This group, comprising representatives of the United States, United Kingdom, France, Canada, Soviet Union, Poland, Czechoslovakia and Rumania, met from July 1 to August 21 and concluded that it was technically feasible, within

[6] See p. 66.

certain limits, to set up a world-wide control system for the detection of violations of a possible agreement on the cessation of nuclear weapons tests. Following this, President Eisenhower announced on August 22, 1958, that the United States, taking account of the Geneva conclusions, was prepared to proceed promptly to negotiate an agreement with other nations which have tested nuclear weapons for the suspension of nuclear weapons tests and the actual establishment of an international control system on the basis of the experts' report. He also announced that, provided the Soviet Union did likewise, the United States would suspend nuclear weapons tests for a period of one year from the beginning of the negotiations.

Representatives of the United States, United Kingdom and Soviet Union began negotiations on a test ban treaty on October 31, 1958. As the negotiations proceeded it became apparent that it would be difficult to reach agreement with the Russians on the establishment of an effective control system to police any test ban treaty. A special United States scientific panel concluded that, on the basis of data which had become available since the 1958 Conference of Experts as a result of the underground nuclear explosions of HARDTACK II—the last series of United States weapons tests held at Nevada Test Site in the fall of 1958—underground explosions are more difficult to identify than had been previously believed. This information was presented to the United Kingdom and the Soviet Union in Geneva in early January 1959. On January 22, the Soviet Union responded by questioning the need to consider any new information which differed from the agreed conclusions of the Conference of Experts.

In April and May of 1959, President Eisenhower's proposal to ban all nuclear tests in the atmosphere as an initial step in arriving at a safeguarded treaty was rejected by Soviet Premier Khrushchev who insisted that the treaty encompass the testing of nuclear weapons in all environments. However, Mr. Khrushchev did agree in a letter to President Eisenhower dated April 23, 1959, that it should be possible to establish such controls as would guarantee strict observance of the treaty. He also agreed to have the Soviet Union join in an experts meeting on controls for high altitude nuclear detonations. Later the Soviet Union agreed to have their experts re-examine underground detection with the United States and United Kingdom. However, this latter conference which convened in November 1959 concluded with major disagreement between the experts of the Western allies and the experts of the Soviet Union.

In December 1959, President Eisenhower noted that the negotiations had been in progress for 14 months and that no satisfactory agreement was in sight. He called attention to the fact that prospects

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for an agreement had been injured by the unwillingness of the politically guided Soviet experts to give serious scientific consideration to the effectiveness of seismic techniques for the detection of underground nuclear explosions. Therefore, he said the voluntary moratorium would end on December 31, 1959, and the United States would consider itself free to resume nuclear weapons testing but would not do so without announcing its intention in advance of any resumption.

In February of 1960, the United States proposed a phased treaty which would immediately end all nuclear weapons tests in environments in which controls could be established. These would include tests in the oceans, those above ground as high as effective controls could be agreed upon, and underground tests above a seismic magnitude of 4.75 (equivalent to a 19 kiloton yield in Nevada tuff). The proposal also called for a research program among the three countries to improve the capability of detecting underground seismic events below a magnitude of 4.75. The United States proposal was rejected immediately by the Soviet Union, but on March 19, 1960, a Russian counter-proposal was made which accepted the threshold figures, provided that the negotiating parties agree not to test below the 4.75 seismic threshold while a joint research program to improve underground detection capabilities was being conducted. The Russians estimated that this research program would take 4 to 5 years. On March 29, 1960, President Eisenhower and British Prime Minister Macmillan offered to agree to institute a unilateral moratorium of agreed duration, and effective on treaty signature, on tests below the 4.75 seismic threshold, provided that a treaty was signed and that a coordinated program for improving the capability of detection and identification of underground nuclear tests was agreed to and instituted without delay.

The Russians indicated general agreement on May 3, and on May 11 a conference of scientists from the United States, United Kingdom, and the Soviet Union met in Geneva to exchange views on the conduct of a coordinated seismic research program. These experts reached what appeared to be a wide area of agreement. On May 27, however, the U.S.S.R. delegate to the test cessation negotiations overruled the views of the U.S.S.R. experts and stated instead that: the Soviet Union continues to recognize the recommendation of the 1958 Experts Report as being adequate; furthermore, the Russians would not conduct a seismic research program in Russia; and they would not carry out high explosive experiments which their scientific experts had indicated they would perform. In addition, the U.S.S.R. delegate subsequently stated that all aspects of any United States seismic research program, including the interpretation of all data generated, would have to be open to Russian participation, and the devices used would be subject to Soviet internal inspection. Otherwise, the Russians said, they would consider that the United States had resumed nuclear weapons testing and they would do likewise.

The importance of the research program can be illustrated by the following discussion of the problems involved in monitoring a possible agreement on nuclear weapons test cessation. Nuclear weapons tests can be conducted in four environments:

In the *atmosphere*, with the resultant production of fallout. However, an adequate number of air sampling detection stations and aircraft sampling flights could detect nuclear detonations of any appreciable size. Such a series of stations and flights was recommended by the 1958 Geneva Conference of Experts.

Deep underwater. It is expected that detonations of moderate size carried out deep in the oceans would probably not produce atmospheric fallout in amounts adequate for detection at appreciable distances. Hydroacoustic stations could monitor such underwater signals and radioactivity would be dispersed rapidly in the vast quantities of water which would be evidence that such a test had taken place. However, pinpointing the violator in this case would be difficult.

Detonations *above the sensible atmosphere* produce little, if any, fallout. Adequate detection methods for such tests do not now exist and, in fact, cannot be proven to be effective without further extensive research and experimentation in this medium.

Underground tests produce no fallout if they are completely contained beneath the earth's surface. This lack of fallout eliminates the one established way in which nuclear detonations might be proven. There is no known way of proving that an underground nuclear explosion has occurred other than by on-site inspection which, in order to achieve the difficult objective of proving a violation, involves extensive drilling operations to obtain a sample of radioactive debris. Current instrumentation if installed in a world-wide control system could provide information on the location of significant seismic events and in some cases identify the event as an earthquake. It cannot identify all seismic events as being natural in origin, nor can it distinguish between nuclear and conventional explosives. Further complicating the picture is the possibility of nuclear detonations being hidden by the decoupling technique, the use of a large underground cavity as the site for a nuclear test in order to reduce, up to perhaps a factor as great as 300, the resulting distant seismic signal.

The Russian negotiators at Geneva have offered to permit only three "on site" inspections per year in their country for all unidentified seismic events. The United States position is that, in view of the fact that more than 100 locatable seismic events of greater than 4.75 magnitude occur each year in the Soviet Union, 20 percent of these should be eligible for inspection (20 inspections per year). The proposed treaty would cover only events above seismic magnitude 4.75 and there are thousands of seismic events lower than the 4.75 threshold annually in that country.

On the proposed research program to improve capabilities of detecting and identifying underground nuclear events, the Russians have taken the position that no such program is needed and that adequate capability already exists. However, they have demanded the right to participate in the United States program and to inspect both the internal and external construction of any devices which the United States proposes to use in its seismic research program. They have rejected two United States offers to guarantee that no weapons development information would be obtained from any nuclear tests in the seismic research program. One of the two United States proposals rejected by the Soviet Union would permit Russian inspection of United States devices, provided they also contributed devices and allowed United States inspection. Yet, they have threatened to resume nuclear weapons testing if the United States should use any nuclear devices in its seismic research program without their agreement on the safeguards to be employed for assuring no weapons development.

In the United States view, an adequate capability for detecting and identifying underground and outer space nuclear detonations must be developed, if possible. To do this it is necessary to:

a) Develop improved instrumentation and techniques to detect and identify the nature of seismic events. The improvement necessary can be obtained only by developing and assembling necessary instrumentation and testing its capability through a seismic improvement program which includes both nuclear and chemical detonations.

b) Develop instrumentation and techniques for the detection of nuclear explosions in space.

c) Establish an adequate world-wide detection network based on the recommendations of the Geneva Conference of Experts improved on the basis of data gathered since 1958 and on data which must be obtained from further scientific efforts and experimental research programs.

d) Obtain agreement on a sufficient number of on-site inspections to be reasonably sure that no clandestine underground testing of nuclear weapons is taking place above an agreed threshold. This agreement must have a reasonable relation to the number of natural seismic events which occur in each country, and the capability of the system.

To improve the capability of detecting and identifying seismic events and detecting detonations in space, the United States has embarked on the VELA program which is aimed at attempting 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. During 1960, the Commission participated with other Federal agencies in this program.

Project VELA is under the direction of the Advanced Research Projects Agency, Department of Defense. It grew out of recommendations by the Berkner Panel on Seismic Improvement—a panel of scientists competent to advise in this field which was appointed by the President's Advisor on Science and Technology and chaired by Dr. Lloyd V. Berkner, president of Associated Universities. Its recommendations were made known to the Geneva negotiators on June 12, 1959.

On May 7, 1960, President Eisenhower approved a major expansion of the research and development directed toward seeking an improved capability to detect and identify underground nuclear explosions. He announced that $10 million was funded for the fiscal year that ended June 30, 1960, and that an estimated $66 million was contemplated for fiscal 1961. Participating in the program are the Commission, the Department of Defense, the Department of Commerce, the Department of Interior, universities and private organizations.

The VELA program has three parts:

VELA-UNIFORM—to increase the level of basic research in seismology; procurement of instrumentation for a world-wide seismic research program; development of improved seismic instruments; construction and operation of prototype seismic detection stations; and an experimental program of underground nuclear and high explosive detonations to provide signals for the experimental research.

The Commission in a program related to project VELA conducted successfully a series of non-nuclear high explosive experiments between December of 1959 and March of 1960 in the Carey Salt Mine near Winnfield, La. The purpose of these experiments was to measure seismic effects resulting from these explosions and to verify the theory of decoupling, that is, the use of a large underground cavity as a site for an explosion to reduce the seismic signals generated. These experiments proved that decoupling is possible and that the seismic signals are reduced markedly if a detonation occurs in a sufficiently large hole. Unexpectedly, these experiments also proved that lesser, but significant, factors of decoupling also occur in holes which are smaller than the size predicted as adequate by the theory.

Laboratory study and investigation have been carried out by the AEC on various phases of the seismic research program. In addition, bids have been asked for exploratory drilling in a Mississippi salt dome to determine if it is suitable for use as a possible site for nuclear detonations as part of the seismic research program. The Commission also is preparing sites at its Nevada Test Site for detonations in this program. VELA program plans call for 11–12 high explosive and about 11–13 nuclear detonations. Final schedules have not yet been established.

VELA-SIERRA—to develop ground-based instruments for possible detection of nuclear explosions in near space.

In this program, the Commission's Los Alamos Scientific Laboratory has developed and is testing an experimental air fluorescence detection station and is having developed an experimental direct optical detection station to examine reactions to natural phenomena in the upper atmosphere and near space.

VELA-HOTEL—to develop satellite-based instruments and systems to detect nuclear explosions in space.

In this program, Los Alamos and Sandia Laboratory, which is operated for the Commission by Sandia Corp., a subsidiary of Western Electric Co., Inc., have carried out research and development on nuclear detection instrumentation for possible inclusion in satellites, and Lawrence Radiation Laboratory is engaged in some space background measurements under this program.

The Seismic Improvement Program is being carried out solely for the purpose of increasing our basic knowledge of seismology and for development of instrumentation and techniques necessary for improving the monitoring capabilities of a control system. The Seismic Improvement Program is not part of PLOWSHARE, the program to develop nuclear explosives for peaceful purposes.

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As 1960 drew to a close, the three negotiating countries in Geneva—after negotiating for more than 2 years—still had not reached agreement on the major issues.

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Military Reactor Development

ARMY REACTORS PROGRAM

Major emphasis during 1960 in the Commission-Army program was on development of four types of reactors that are compact and lightweight, and capable of being set up rapidly and at minimum cost to provide power and heat at remote military installations. The four types are the pressurized water, boiling water, gas-cooled and compact reactor systems.

Pressurized Water Reactors

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

On July 1, 1960, responsibility for the SM–1 pressurized water reactor was assumed by the Army's Corps of Engineers, following more than 3 years of successful operation by a Commission contractor. The 1,855 kwe (kilowatts electric) plant, the first prototype reactor developed within the Army program, continued in operation for training military operators, for research and development test projects, and for production of electricity at Fort Belvoir, Va., where the plant is situated.

The first core had produced 16,470 thermal kilowatt years of power by April 28, when the first replacement of fuel was necessitated. This was 1,430 kilowatt years more than expected on the basis of design analyses. More than 28 million kilowatt hours of electricity was produced with the first loading. In September, two fuel elements were replaced with special test elements and the other elements were rearranged to further extend the core burnup and to test the two added elements.

At the year's end, 92 military operators had completed one-year training courses conducted in conjunction with plant operation. The operators include personnel from the three military services who will operate military field plants such as the SM–1A in Alaska and the PM–2A in Greenland, as well as the SM–1 itself. Additional military crews will be trained to operate the PM–1 at Sundance, Wyo., and the PM–3A at McMurdo Sound in the Antarctic.

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

The SM–1A, located at Fort Greely, Alaska, is essentially a direct extrapolation of the SM–1 design to a higher power output to provide

1,640 ekw of electric power and 38 million BTU's per hour of steam for space heating (the SM–1 does not provide any space-heating steam). Construction, which began in June 1958, was delayed several months by steel shortages, local strikes and in-transit damage to plant equipment, but is expected to be essentially complete in March 1961. Acceptance of the completed plant by the Army is anticipated for June 1, 1961.

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

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 Nike-Zeus missile sites. As a result of a later Department of Defense decision not to use nuclear power for these sites there now is no direct requirement for the SM–2 plant. Accordingly, the SM–2 core and pressure vessel program will be continued only to complete certain design and development test work now in progress which will provide a substantially complete design.

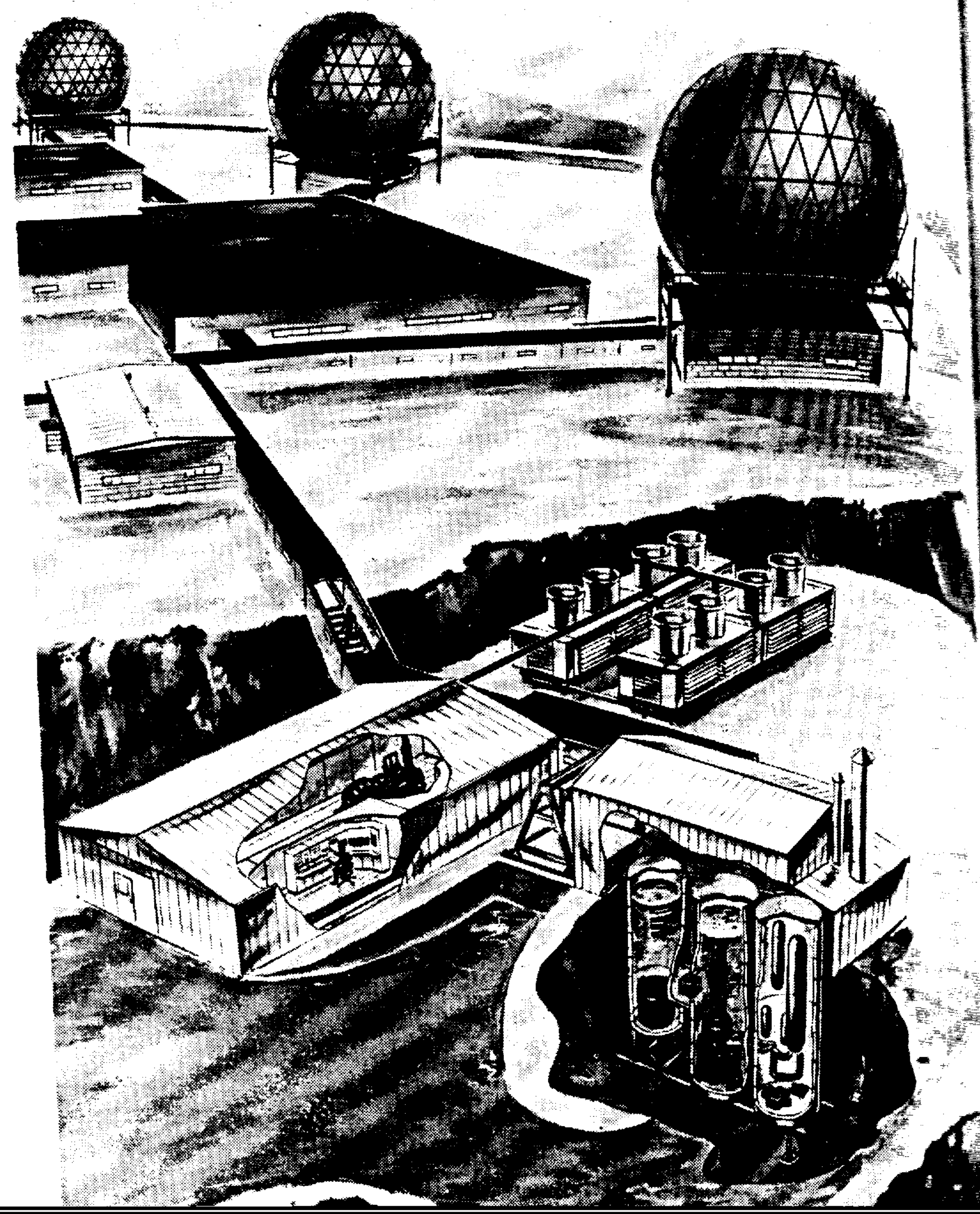
Portable Medium Power Plant No. 1 (*PM–1*)

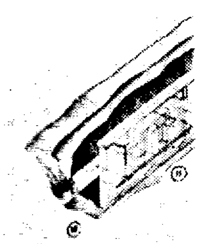
This pressurized water prototype is a factory-assembled, modular, air-transportable nuclear power plant developed under Commission contract with the Martin Co. and funded in part by the Air Force. Initial operation at Sundance Air Force Station, Wyo., is scheduled for September 1961.

This plant is capable of being transported in 16 cargo aircraft and can be erected within 60 days. These two features are of particular importance at remote installations where construction time and support facilities are severely limited. For example, in polar environments the construction season is so short that any on-site construction requiring more than 3 or 4 months must necessarily extend over 2 or more years. The PM–1 is the first plant incorporating stainless steel, uranium oxide, tubular fuel elements.

Portable Medium Power Plant No. 2A (*PM–2A*)

The PM–2A, located at Camp Century in Northern Greenland, about 150 miles east of Thule, is a further development based upon the SM–1 design. This plant was fabricated in 27 packages which were assembled and subjected to nonnuclear tests at Dunkirk, N.Y.





1. Core
2. Reactor
3. Primary Shield
4. Steam Generator
5. Pressurizer
6. Pump
7. Vapor Container
8. Hot Waste

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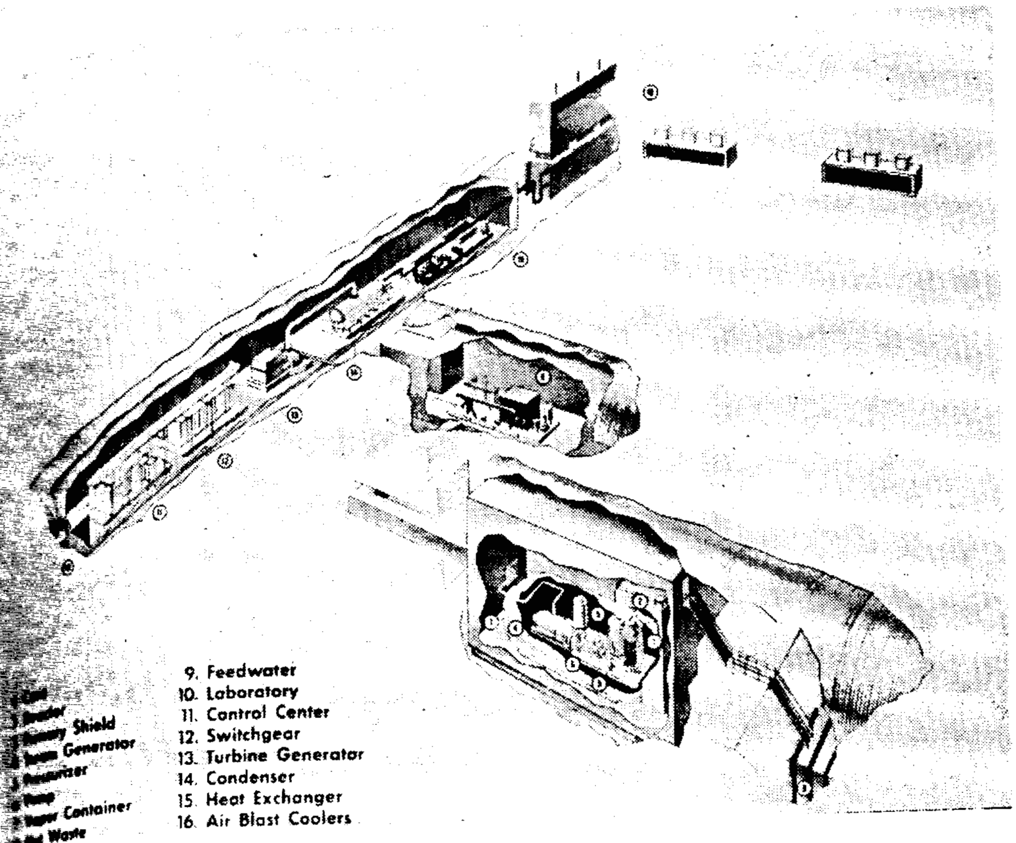
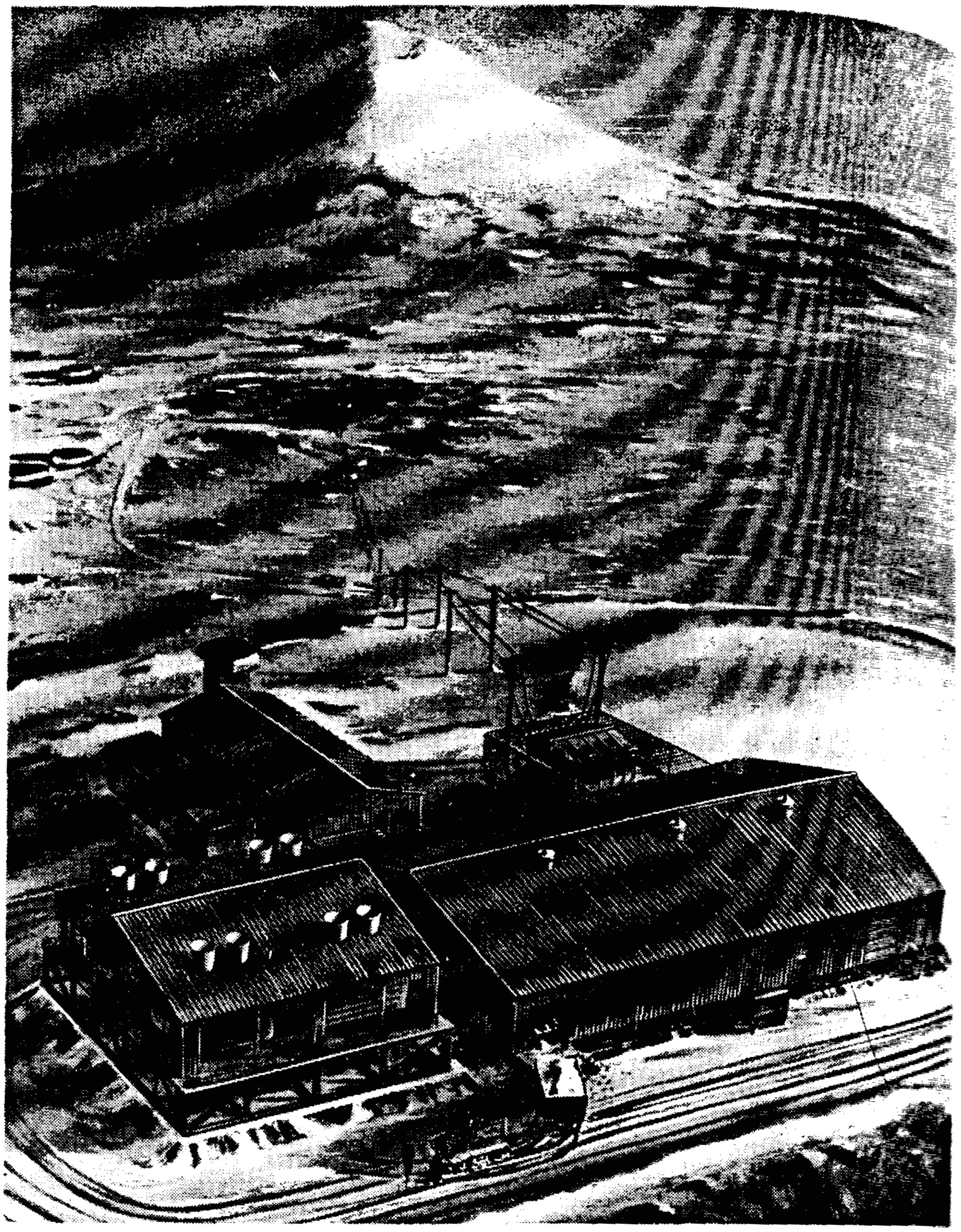


[illegible]*rctic Reactor.* Artist's cutaway view of the Portable Medium Power Plant No. [illegible] (PM-2A) now in operation at a remote Army post in northern Greenland. The 1,500 ekw pressurized water reactor plant was shipped to Greenland in 27 [illegible]ckages during June and installed in snow tunnels. It became operational [illegible] November and is the first reactor to provide power and heat for a remote [illegible]itary post. The only above-snow portions of the plant are the cooling towers [illegible]pper right of photo).

The plant then was disassembled and shipped by air and sea to Camp [illegible]entury. On-site construction and testing in tunnels in the Green[illegible]land Ice Cap, where the average temperature is 5° F., required 3½ [illegible]onths. Full power operation was attained in November, the first [illegible]actor to start supplying power and heat for a remote military post. The plant produces 1,500 ekw and 1 million BTU's per hour in the [illegible] of steam for space heat.

[illegible]able *Medium Power Plant No. 3A* (*PM–3A*)

[illegible] August a contract was awarded to the Martin Co. for design, [illegible]struction and test operation of a prepackaged 1,500 ekw pressurized [illegible] plant to be shipped, in November 1961, to McMurdo Sound [illegible] the Antarctic Continent. Martin's proposal was selected from [illegible]ng three submitted.



Antarctic Power Plant. The Portable Medium Power Plant No. 3A (PM-3A) is expected to look like the above artist's conception when installed on a ridge overlooking the Naval Air Facility at McMurdo Sound in the Antarctic. The plant, using a pressurized water reactor, will produce 1,500 kilowatts of electricity for the principal base of all United States scientific efforts on the southern continent. The plant is scheduled to be shipped, in sections, to the Antarctic during November 1961.

The contract was for a fixed price with guaranteed performance and contained provision for payment of liquidated damages in event of failure to deliver on schedule, or to perform according to specifications.

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On March 31, the Commission reported to Congress on a study of the economics of nuclear power at various remote military installations. Ten sites were investigated in different areas throughout the world, and it was established that at several remote locations military requirements for power could be met economically with nuclear power. McMurdo Sound in the Antarctic was one of the most promising sites found.

In May a further report was presented to the Congress on the Byrd and South Pole stations in the Antarctic. Power required at these two stations was less than the range of 5,000 to 40,000 ekw established as criteria for the original study. At both these two locations, nuclear power shows a marked economic advantage over conventional power in view of the fact that delivered diesel fuel costs several dollars a gallon. Construction of nuclear plants was authorized at Byrd and South Pole sites in Antarctica but funds were not appropriated during 1960.

Nuclear Test Plant (NTP)

This core test facility was scheduled for completion in late spring 1962, with a SM–2 core, the first to be tested. As a result of a change in plans cancelling immediate requirement for the SM–2 core, and because of the absence of definite plans to use small pressurized water plants in appreciable numbers in the near future, it was decided not to construct the NTP.

Pressurized Water Reactor Model and Code

The Martin Co. continued the program to develop a nuclear physical model and fuel calculation code for pressurized water-cooled and moderated reactors. The ultimate objective is to provide methods to permit design of cores with longer life, improved power distribution, reduced coolant flow and pressure requirements, and to refine methods of reactor control. Through an associated experimental physics program, the physical models and calculation codes developed will be verified and compared experimentally with critical experiments, and actual reactor operating data.

Boiling Water Reactor

Stationary Low Power Plant No. 1 (SL–1)

This small stationary boiling water plant continued to operate during 1960 at the National Reactor Testing Station, where it was used primarily as an operating prototype for the design and development of the PL–1 and PL–2, 200 ekw and 1,000 ekw prepackaged versions, respectively. Also, the reactor was used to train military operators and to provide operating data relating to military use of this kind of plant.

Development and fabrication of a stainless steel core to replace the installed aluminum core was underway. Installation of the core in the SL–1 is scheduled for mid-1961. As of the end of 1960, the plant had operated for 9,300 equivalent full power hours and had generated about 1.9 million kilowatt hours of electrical power.*

Gas-Cooled Reactor Systems

Gas-Cooled Reactor Experiment (GCRE)

This reactor achieved initial criticality at the National Reactor Testing Station on February 23. Full power operation at 2 Mw (thermal) started in July. The initial developmental core containing plate fuel elements was replaced in September by a core containing new pin elements. The GCRE achieved full power with the second core in November.

The reactor was operated to develop engineering data for incorporation in the Mobile Low Power Reactor No. 1 (ML–1), a prototype gas-cooled mobile plant. The ML–1 (reactor and power conversion equipment combined) is to be transportable by standard military semi-trailer or aircraft. It will have a net capacity of 300 to 500 kw depending on ambient temperature conditions.

Construction of the prototype ML–1 reactor will be completed by Aerojet-General Corp. in January 1961 and reactor criticality is scheduled for April 1961 at the National Reactor Testing Station, Idaho.

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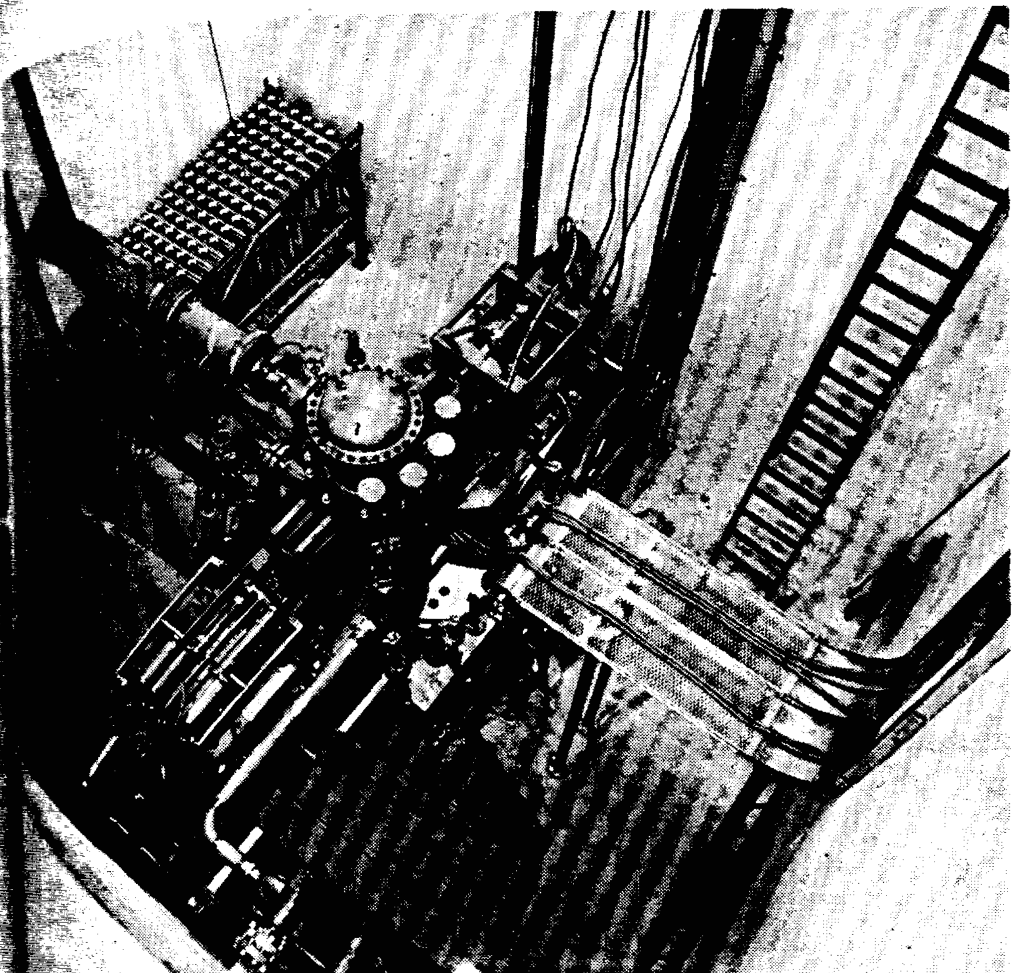
* On January 3, 1961 an accident at the SL–1 reactor caused the death of two Army and one Navy man who were getting ready to start the closed-down reactor. Determining the cause of the accident and measures to be taken to prevent its recurrence was engaging a large task force of experts as this report went to press.



-Cooled Experiment. Successful full-power operation of the Gas-Cooled ... Experiment (GCRE) during July marked an important milestone in ...pment of the first direct- and closed-cycle gas-cooled reactor in the United ... In such a system the gas, heated within the reactor core, is used to drive ... and then is recycled to the reactor. Photo shows view looking down ...CRE pit at National Reactor Testing Station in Idaho.

Compact Reactor

...ry Compact Reactor (MCR) Program

...June 27, a contract was signed with the Nuclear Development ... of America for preliminary design and development of a mo-...ht weight, compact nuclear power plant having a power rating ... to 3,000 ekw. Such a plant could serve a variety of military ...ations. The principal subcontractor for the project is General ... Corp. Preliminary design and development effort will con-... the end of June 1961.

Supporting Activities

Army Reactor Experimental Area (AREA)

A section of the National Reactor Testing Station is designated as the Army Reactor Experimental Area (AREA). Reactors in the Army Program and necessary support facilities are located within AREA.

Construction of support facilities, including hot cells, a shop and maintenance building, and necessary utilities was completed by Teller Construction Co., Idaho Falls, Idaho, on February 29. Phillips Petroleum Co. was selected in May as operating contractor. Hot cell operation started in August.

NAVAL REACTORS PROGRAM

Nine nuclear-powered naval vessels were launched during 1960, including 8 submarines and an aircraft carrier, as the United States continued the expansion of its nuclear fleet. Fourteen nuclear submarines were in operation, 21 others were under construction and more authorized; a guided missile cruiser, a guided missile destroyer (frigate), and an aircraft carrier were under construction.

The nuclear submarines continued to hang up "firsts"—a midwinter cruise of 6,000 miles submerged under polar ice; a submerged circumnavigation of the earth.

The first nuclear submarine equipped with Polaris missiles bearing nuclear war-heads has started its first mission after a series of successful tests with unarmed missiles.

Nuclear Fleet

Submarine Fleet Reactor (S3W/S4W)

In January and February, the USS *Sargo* carried out the first midwinter cruise under the polar ice cap. Sailing from Pearl Harbor she gained access to the Arctic Basin by way of the Bering and Chukchi Seas, thus proving it possible for a nuclear-powered submarine to travel this shallow route at any time of year. The *Sargo* surfaced at the North Pole February 9 and returned to the open Pacific via the Bering Sea. She steamed 6,000 miles under ice in 31 days and surfaced 20 times, frequently through the ice.

In August, the USS *Seadragon* completed an east-to-west crossing from the Atlantic to the Arctic Ocean by way of Baffin Bay and Parry Channel. After reaching the North Pole, the *Seadragon* entered the

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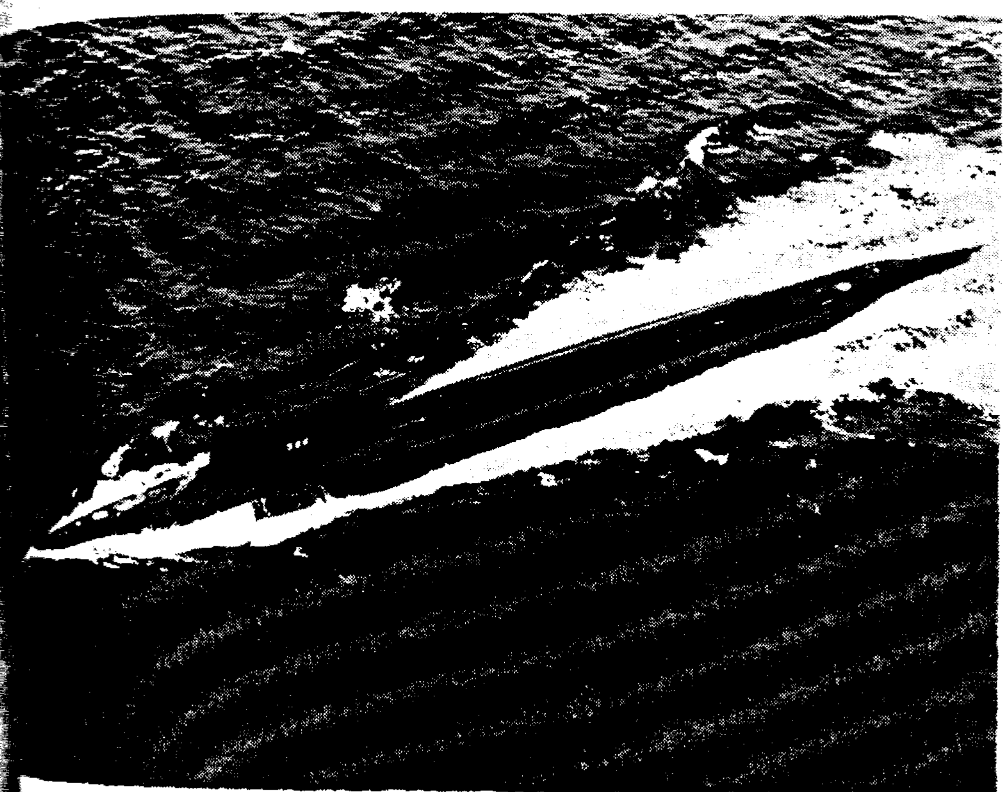
Pacific by way of the Chukchi and Bering Seas and continued on to Pearl Harbor in Hawaii. She steamed a total of 11,231 miles of which 10,415 were submerged. *Seadragon* proved the feasibility of an all-weather Northwest passage for submarines.

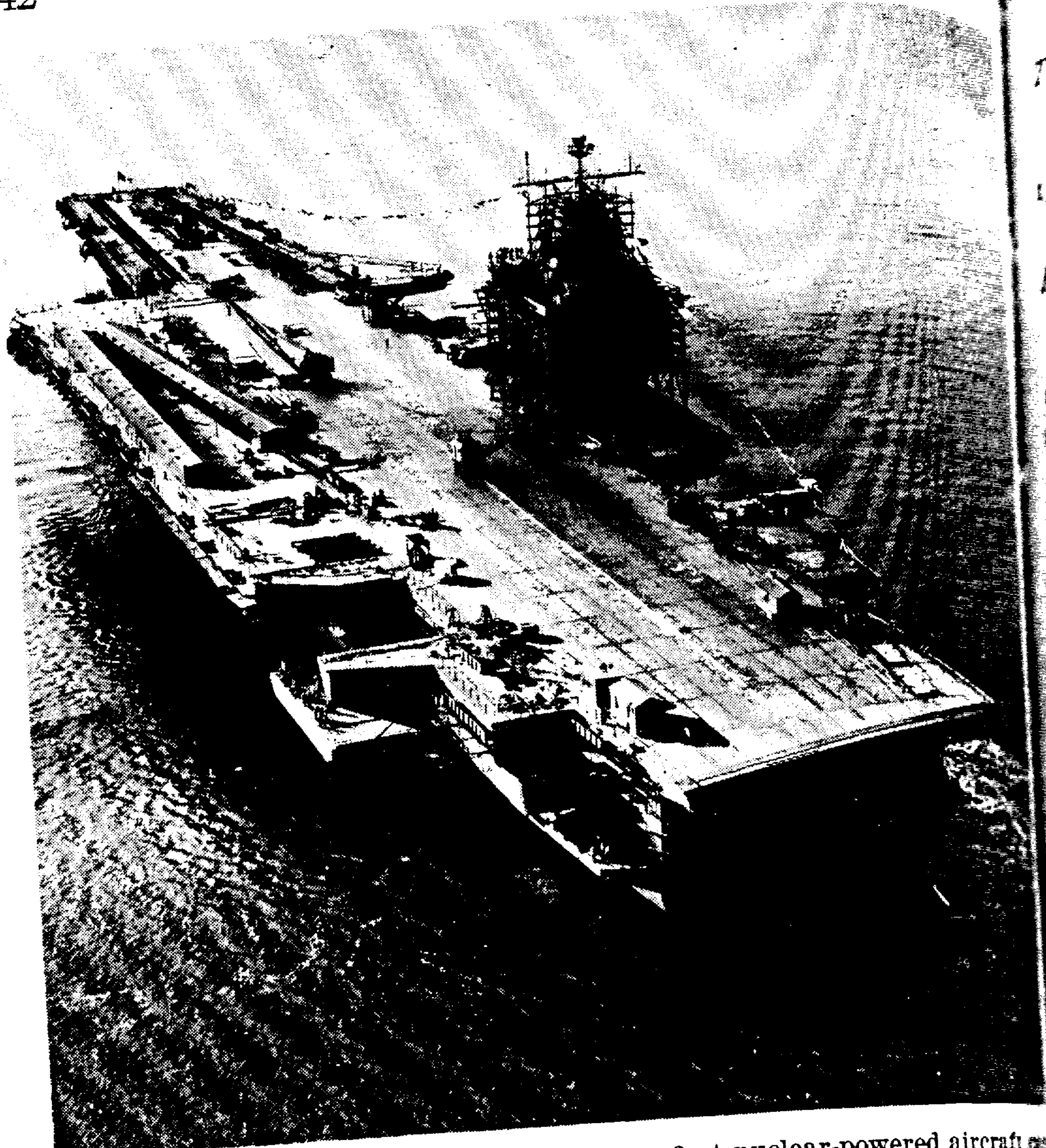
High Speed Submarine Reactor (S5W)

The High Speed Submarine Reactor is the plant used by most of the nuclear submarine fleet. A total of 37 submarines which will use this plant have been authorized by Congress, including 23 attack submarines and 14 Polaris ballistic missile-launching submarines. Two high speed attack submarines, the *Sculpin* and the *Shark*, were launched in March, a third, the *Thresher*, in July, and a fourth, the *Scamp*, in October. The *Scorpion*, commissioned in July, is the second of these attack type submarines to become operational. The *Skipjack* was commissioned in April 1959.

Three Polaris-launching submarines are operating. The *George Washington* was commissioned in December, 1959, the *Patrick Henry* on April 9, and the *Robert E. Lee* on September 16, 1960.



Traveler. Ever since the USS *Nautilus* put to sea, the U.S. Navy's nuclear-powered submarines have been performing history-making voyages. The exploit during 1960 was the 36,014-nautical mile submerged voyage around the world of the USS *Triton* (shown above). The *Triton* is the first submarine with twin reactors for propulsion power.



Nuclear-Powered Carrier. When the nation's first nuclear-powered aircraft carrier, the *Enterprise*, is commissioned she will be able to make 20 trips around the world at speeds up to 30 knots without stopping to refuel. The 85,000-ton ship will use eight reactors for power, and has a flight deck that is 1,101 feet long and 252 feet wide. Photo shows the *Enterprise* being moved by tugs to the outfitting dock after her September 24, 1960, launching at Newport News, to

Triton's Cruise

The nuclear-powered radar picket submarine *Triton*, powered by two reactors of the S3G type, completed a submerged circumnavigation of the world on May 10. Navigating over much the same route taken by Ferdinand Magellan, the *Triton* steamed 36,014 nautical miles submerged in 83 days and 10 hours.

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Tullibee Now Operating

The hunter-killer nuclear submarine, *Tullibee*, which uses an S1C type reactor plant, was commissioned November 9.

Enterprise and Long Beach

The aircraft carrier *Enterprise*, powered by eight A1W Type reactor plants, was launched September 24 at Newport News, Va. Construction of the guided missile cruiser *Long Beach*, powered by two C1W-type reactors, was interrupted by a strike at Bethlehem Shipbuilding Co. which lasted from January 23 to June 22.

Destroyer (Frigate) Construction

Construction of the guided missile destroyer *Bainbridge* at Bethlehem Shipbuilding Division, Quincy, Mass., was similarly delayed. The *Bainbridge* is to be powered by two D1G-type reactor plants.

Status of Nuclear Naval Program

The status of the naval nuclear propulsion program is summarized in Table I.

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 naval reactor cores under the naval reactors program of the Commission. Four of the prototypes are in operation, one is under construction, and one is in the design stage.

S1W Reactor Facility

The S1W Reactor Facility, located at the National Reactor Testing Station was designed and operated originally as the land-based prototype of the reactor plant installed in the submarine *Nautilus*. The S1W plant now is operated as a flexible test facility in support of advanced development work on improved submarine reactor systems, components, and cores. In 1960, the third refueling of the S1W plant was underway. Several special subassemblies are to be inserted in the core for testing in support of advanced core development work.

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.
SSR(N)586 Triton	Radar picket	do	Do.
SSG(N)587 Halibut	Regulus missile	do	Mare Island.
SSN588 Scamp	Fast attack	Launched Oct. 8, 1960	Do.
SSN589 Scorpion	do	Operating	Electric Boat.
SSN590 Sculpin	do	Launched Mar. 31, 1960	Ingalls.
SSN591 Shark	do	Launched Mar. 16, 1960	Newport News.
SSN592 Snook	do	Launched Oct. 31, 1960	Ingalls.
SSN593 Thresher	do	Launched July 9, 1960	Portsmouth.
SSN594 Permit	do	Under construction	Mare Island.
SSN595 Plunger	do	do	Do.
SSN596 Barb	do	do	Ingalls.
SSN597 Tullibee	Hunter-killer	Operating	Electric Boat.
SSB(N)598 George Washington.	Polaris missile	do	Do.
SSB(N)599 Patrick Henry	do	do	Do.
SSB(N)600 Theodore Roosevelt.	do	Launched Oct. 3, 1959	Mare Island.
SSB(N)601 Robert E. Lee	do	Operating	Newport News.
SSB(N)602 Abraham Lincoln	do	Launched May 14, 1960	Portsmouth.
SSN603 Pollack	Fast attack	Under construction	New York Ship.
SSN604 Haddo	do	Authorized	Do.
SSN605 Jack	do	Under construction	Portsmouth.
SSN606 Tinosa	do	do	Do.
SSN607 Dace	do	do	Ingalls.
SSB(N)608 Ethan Allen	Polaris missile	Launched Nov. 22, 1960	Electric Boat.
SSB(N)609 Sam Houston	do	Under construction	Newport News.
SSB(N)610 Thomas Edison	do	do	Electric Boat.
SSB(N)611 John Marshall	do	do	Newport News.
SSN612 Guardfish	Fast attack	Authorized	New York Ship.
SSN613 Flasher	do	Under construction	Electric Boat.
SSN614 Greenling	do	do	Do.
SSN615 Gato	do	do	Do.
SSB(N)616 Lafayette	Polaris missile	Authorized	Do.
SSB(N)617 Alexander Hamilton	do	do	Do.
SSB(N)618 Thomas Jefferson	do	do	Newport News.
SSB(N)619	do	do	Mare Island.
SSB(N)620	do	do	Portsmouth.
SSN621	Fast attack	do	Ingalls.
SSN622	do	do	Unassigned.
SSN623	do	do	Do.
SSN624	do	do	Do.
CG(N)9 Long Beach	Guided missile cruiser	Launched July 14, 1959	Bethlehem.
CVA(N)25 Enterprise	Aircraft carrier	Launched Sept. 24, 1960	Newport News.
DLG(N)25 Bainbridge	Guided missile destroyer (frigate).	Under construction	Bethlehem.

[1] Westinghouse is listed as the reactor designer for all vessels except for the *Triton* and *Bainbridge* which 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 Corporation, Pascagoula, Miss.
New York Ship—New York Shipbuilding Corpration, Camden, N. J.

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...bmarine Advanced Reactor (*S3G*)

The S3G land-based prototype located at West Milton, N.Y., con-...s of a portion of a submarine hull containing one reactor, with its ...ciated steam generating equipment, and engine room machinery ...r operating one shaft of a propulsion plant. A two reactor nuclear ...opulsion plant of this type using two shafts is installed in the USS *...riton*. After extensive operations to confirm the design features ...orporated into the shipboard plants, a comprehensive test program ...s been initiated with the S3G prototype plant in support of ad-...anced reactor plant development work.

...all Submarine Reactor (*S1C*)

The Small Submarine Reactor land-based prototype plant, designed ...r application to a small attack submarine, is located at Windsor, ...onn. Performance evaluation testing of the plant was conducted ...1960. Test operation of this highly instrumented plant continued ...provide design and operating information for the small attack ...omarine *Tullibee*.

...ge Ship Reactor (*A1W*)

The A1W prototype plant at the National Reactor Testing Station ...vides the facilities for the development and testing of a two-re-...tor power plant and associated equipment suitable for propulsion of ...ge naval surface ships. Plant operations have continued in 1960 ...provide for analysis and evaluation of dual reactor plant per-...formance and for periodic physics tests. Results of test operations ...being factored into the design and construction of the aircraft ...rier *Enterprise* and the guided missile cruiser *Long Beach*.

...stroyer (*Frigate*) Reactor Prototype (*D1G*)

The Destroyer Reactor Prototype (D1G), located at West Milton, ..., consists of a section of a destroyer hull containing a complete ...tor plant with one reactor and an engine room with machinery ...one shaft, together with related systems and equipment. Two ...tors of this type are being installed in the destroyer leader *Bain-...ridge*. Work on this plant was resumed on June 22, 1960, after an ...erruption of 5 months because of the strike against Bethlehem ...building Co. The plant is presently scheduled for completion ...961.

Natural Circulation Reactor (S5G)

Design and development work for the Natural Circulation Reac[tor] (S5G), authorized by Congress in 1959, continued at Knolls Ato[mic] Power Laboratory, Schenectady, N.Y. The land prototype plant [is] to be constructed at the National Reactor Testing Station, with com[pletion] scheduled for 1963. The natural circulation concept promi[ses] advantages in pressurized water reactors for submarine applicati[on] because of its inherent safety, plant simplification, increased reli[a]bility, and noise reduction.

AIRCRAFT REACTORS PROGRAM

The Commission-Air Force aircraft reactors program contin[ued] during 1960 to work on both direct cycle and indirect cycle meth[ods] of aircraft propulsion, placing emphasis upon the development of hig[h] temperature materials, components, and reactor systems capable [of] meeting power plant performance criteria that were established by th[e] Department of Defense.

Nuclear rocket propulsion, known as Project *Rover*, and former[ly] part of the aircraft reactor program, is described in Part One of th[is] report.

Work on ramjet propulsion (*Pluto*) and auxiliary power for spa[ce] vehicles and other applications was continued.

Nuclear Propulsion For Manned Aircraft

Based upon guidance received from the Department of Defense [in] the fall of 1959, both direct cycle and indirect cycle approaches to de[]velopment of a nuclear power plant for a manned aircraft were con[]tinued on a substantial scale. In the direct-cycle approach heat [is] transferred within the reactor core to air which has passed throu[gh] the turbo engine compressor. In the indirect-cycle approach, hea[t] from the reactor core is transferred to a liquid-metal coolant wh[ich] releases the heat to the air in a radiator within the engine. The De[]partment of Defense established an initial objective of developing [a] nuclear propulsion system capable of powering an aircraft with rela[]tively conventional aerodynamics in the 500,000-pound weight clas[s] [at] a speed of from Mach 0.8 to 0.9 at an altitude of approximately 35,[000] feet, and with a potential power plant life of 1,000 hours.

Oak Ridge National Laboratory is providing general support in re[]search, applied development, and testing in both direct and indi[rect] cycle programs. In November, following preliminary low-po[wer] critical tests, the new Tower Shielding Reactor there became available for use in obtaining shielding data and in testing an indirect cycle shield. High-power operation is scheduled for mid-1961.

Since March 1959, General Dynamics Corp., Convair Division, Fort Worth, Tex., has continued to provide airframe design support to contractors for both propulsion systems. A preliminary design of an airplane which is compatible with both systems has been accomplished. Analysis of the design indicates that such an airplane could meet and possibly exceed the Department of Defense performance criteria with current design versions of either type of propulsion reactor. The performance of the two propulsion cycles as applied in this airplane analysis is based on projected fuel element and reactor capabilities to be established under the current reactor testing programs.

Direct Cycle

The direct cycle approach is being developed by General Electric Co. under Commission contract, at Evendale, Ohio, and at the National Reactor Testing Station in Idaho.

Heat Transfer Reactor Experiment No. 3 (HTRE–3), a development project to obtain the experience and engineering data needed to operate a flyable nuclear propulsion system, completed its testing program in December. Designed to operate with two modified J–47 turbojet engines, HTRE–3 operated for 146 hours at a 32-megawatt power level in February. This experiment was a more sophisticated and higher power test than HTRE–1 in January 1956. HTRE–2 (HTRE–1 modified to test inserts in a central hole in the reactor core) was used during the year to test several high temperature fuel elements.

Research and development and planning continued on the component and reactor designs and tests to be pursued.

Indirect Cycle

Development of the indirect cycle approach is being carried out under Commission contract by the Pratt and Whitney Aircraft Division, United Aircraft Corp., at the Connecticut Aircraft Nuclear Engine Laboratory (CANEL), Middletown, Conn. Research and development continued on the reactor and liquid metal loop components required for a 10-thermal megawatt high temperature experimental reactor as an initial program objective.

In August, operations were initiated in a hot laboratory facility at CANEL that contains seven hot cells for working with materials and components exposed in in-pile test programs.

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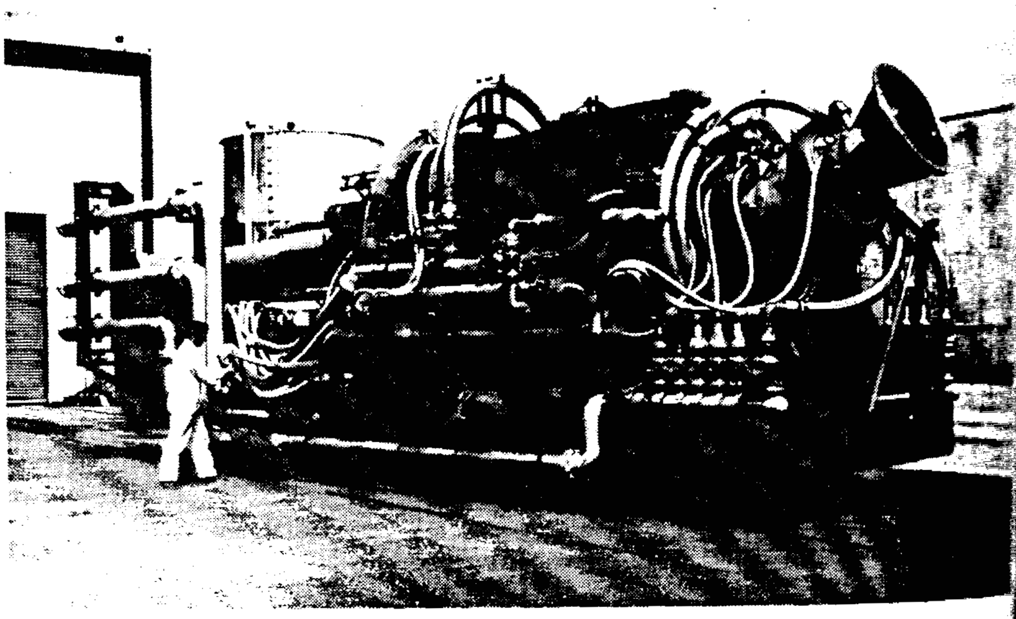
In February, the Blaw-Knox Co. was retained as architect-engineer for the design of indirect cycle facilities which will be required at the National Reactor Testing Station. Construction of a reactor test facility is planned to start in early 1961.

Nuclear Power For Unmanned Vehicles

Application of nuclear energy to unmanned vehicles is carried on in the program of nuclear ramjet propulsion, designated Project *Pluto*, and the program to develop Systems of Nuclear Auxiliary Power designated Project *SNAP*.

Nuclear Ramjet Propulsion

Project *Pluto* is a joint Commission-Air Force program aimed at demonstrating the feasibility of a nuclear ramjet propulsion system. Reactor work is under the direction of the E. O. Lawrence Radiation Laboratory, University of California, at Livermore, with some support on materials research supplied by the Atomics International, a division of North American Aviation. The Air Force has the Marquardt Corp. under contract to provide engineering studies of ramjet engine performance.



Propulsion Reactor. Shown above is the Tory–IIA, one of a series of engineering test reactors being used in the Commission-Air Force program of developing a nuclear reactor for the propulsion system of high-speed, ramjet missiles. The reactor is expected to provide engineering, thermodynamic, and nuclear experience necessary for development of a ramjet reactor. In photo, the Tory-IIA is mounted on a test which facilitates its movements to and from the experimental area at the Nevada Test Site.

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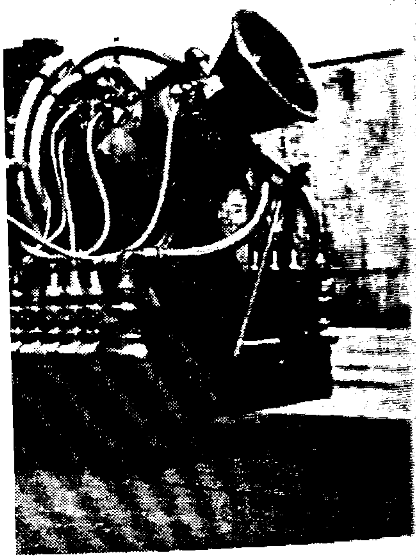

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The program consists of conducting a series of reactor tests at the Nevada Test Site (NTS) beginning with Tory IIA an engineering test reactor which is expected to provide the engineering, thermodynamic and nuclear experience necessary for development of a ramjet reactor. Tests of Tory IIC, a more advanced reactor which will more closely approximate a flight reactor is scheduled for NTS in the future. A milestone in this program was attained when Tory IIA achieved criticality on December 9.

Systems for Nuclear Auxiliary Power (SNAP)

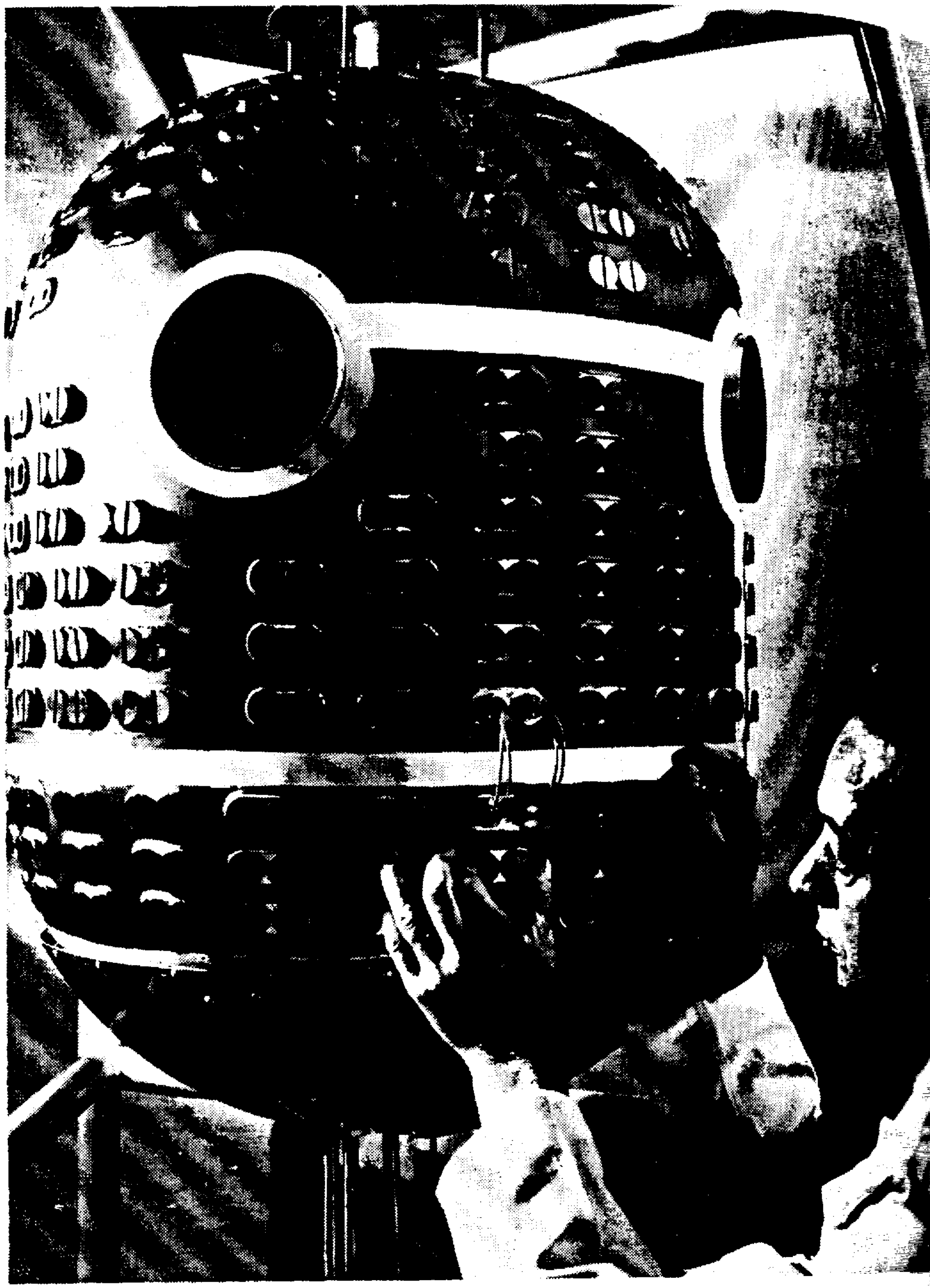
The aim of the SNAP program is to develop small, lightweight nuclear powered electric generators for satellites, space vehicles, and special applications. Two approaches to provide nuclear heat are under development; one using the heat from the radioactive decay of a radioisotope to generate electricity in thermocouples (as in SNAP-1A and SNAP-3), the other using heat from very compact reactors to drive turbines (as in SNAP-2 and other even-numbered SNAP projects). Other work sponsored by the Commission, using the first approach, is described in the section of this report on Radioisotope and Radiation Development.

Thermoelectric projects. In October 1959, the Department of Defense curtailed its requirement for SNAP-1A. This two-module system, in which each module produces 125 electrical watts, was to be for an Air Force satellite.

As work was already well under way, hardware development is being completed by building three prototype units and the first and second are to be tested with an electrical heat source. The third unit, fueled with cerium 144, is scheduled to undergo test in June 1961, as a demonstration of high power radioisotope units.

SNAP-3, a 3.5-watt, polonium-fueled thermoelectric generator used as a proof-of-principle device, has satisfactorily completed shock, vibration, and acceleration tests and is undergoing a life-test to complete this program by June 1961. The Commission's Mound Laboratory at Miamisburg, Ohio, produced two refueling capsules for this device, the first containing 2,200 curies and the second 2,400 curies of polonium 210.

The U.S. Coast Guard has requested the Commission to provide prototype 5-watt and 30-watt units powered with strontium 90 for use in coastal light buoys. This will be an 18-month program with the units designated as SNAP-7A and B. Initial proof-of-principle work in this field was carried out under the Commission's Isotopes Development Program, reported elsewhere.



Electricity Generator. Above is the SNAP–1A, "big brother" of the grapefruit-sized, 2.5-watt SNAP–3 which was unveiled during 1959 by President Eisenhower. In this larger electricity generator, heat from tightly sealed pellets of cerium 144 is converted into 125 watts of electricity by the hundreds of thermocouples leading to the outer surface of the device. The generator was developed by The Martin Co. for the Commission's Systems for Nuclear Auxiliary Power (SNAP) program.

Similar 5 and 30-watt strontium 90 units will be developed to meet a Navy requirement for automatic weather station power supplies. These units are designated SNAP–7C and D. Deliveries of first prototypes are scheduled for August 1961 and March 1962.

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actor projects. The goal of SNAP–2, which has been under development since 1956, is to develop a 3 ekw reactor-powered turboelectric system for space application. A lightweight SNAP–2 prototype, the SNAP Experimental Reactor (SER), achieved full power (50 kwt, 1200° F) in November 1959, and ran until November 18, 1960. The reactor was operated at 50 thermal kilowatts for 4,200 hours and accumulated a total of 6,052 hours before shut down for post-operational analysis. Hydrogen leakage rates, xenon buildup, temperature coefficients, and other operating performance data are being determined.

SNAP–2 turboelectric conversion equipment, designed to produce 3 ekw at 40,000 revolutions per minute (rpm), has undergone endurance runs. The first test of the SNAP–2 combined rotating unit including turbine, bearings, alternator, and pumps, was terminated after … hours of continuous operation at 35,000 rpm and 2 kilowatts. A smaller version of this mercury vapor turbogenerator package has operated for 2,500 hours at 40,000 rpm, which is equivalent to the design lifetime of this unit. The conversion equipment is scheduled to be mated to a SNAP–2 reactor in the SNAP Environmental Test Facility in early 1961. The end objective in the SNAP–2 program is delivery by 1964 of a system capable of being used in flight.

SNAP–8 will be a reactor turboelectric conversion system designed to meet National Aeronautics and Space Administration (NASA) requirements. The system will produce 30 ekw with one power conversion unit and 60 kilowatts with two power conversion units coupled to the same reactor. NASA has selected Aerojet-General as the system contractor to develop conversion equipment for SNAP–8. The Commission has responsibility for development of the reactor, reactor controls, and shielding. Design and analysis is under way with the first reactor power test scheduled for early 1962. Objectives are proved system lifetime of 90 days by late 1963 and 1-year proved lifetime by late 1965. A Commission-NASA Coordination Committee will coordinate development of the SNAP–8 reactor and conversion system.

The development effort on SNAP–10, a 300-watt thermoelectric … has been redirected and the project has been redesignated SNAP–… Program effort now is aimed toward the production of a convection-cooled system utilizing the SNAP–2 reactor and the thermoelectric conversion materials developed for SNAP–10. In the SNAP–… device, reactor heat is transferred to the converter by a mixture of liquid sodium and potassium, which is circulated through a loop by a small electromagnetic pump. This system, weighing about 700 pounds, will be capable of producing 500 watts.

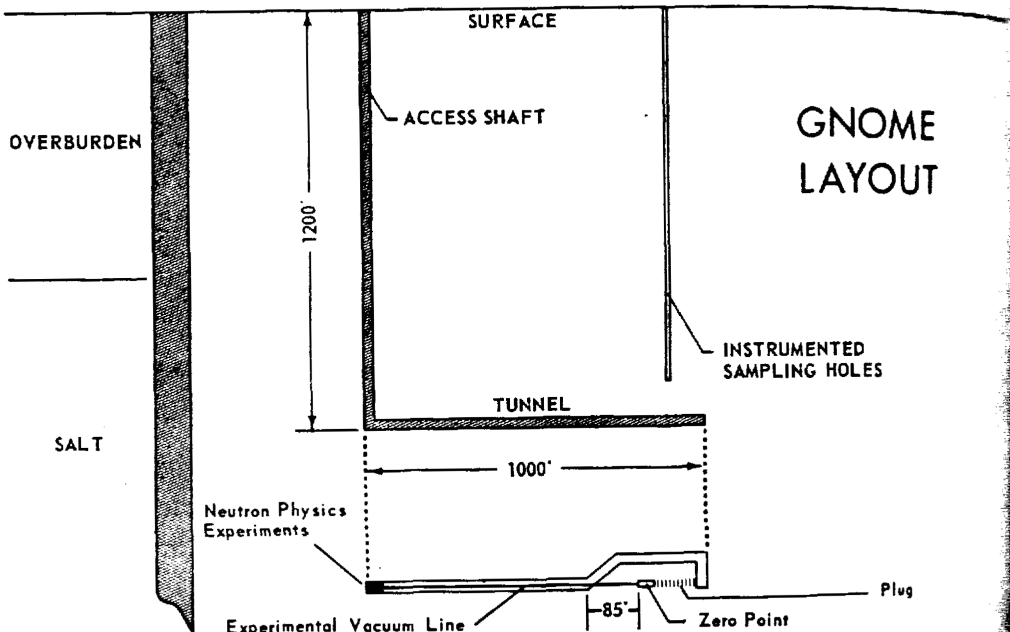
Aerospace Nuclear Safety Board

An Aerospace Nuclear Safety Board, established within the Commission in late 1959, is analyzing nuclear safety problems relating to nuclear-propelled aircraft and missiles and systems of auxiliary power. Operation of these devices requires that safeguards be developed in advance to meet such problems and contingencies as (a) release of fission products under routine or accidental conditions, (b) shielding of aircrews and supporting ground personnel from direct radiation, (c) contamination of ground facilities, (d) launch and pre-orbital failures, and (e) random return to the earth of intact or partially intact devices.

The Board was briefed on aerospace programs, visited installations, and met with representatives from Federal agencies and private groups in order to develop criteria for safe use of nuclear-powered aerospace devices. The Board is preparing a report to the Commission incorporating recommendations on aerospace policy and procedures and standards of safe practice.

Civil Uses of Nuclear Explosives

During 1960, the Commission's Plowshare program of research and development to investigate possible civil uses of nuclear explosives included theoretical studies and laboratory and field experiments with high explosives.



Possible Experiment. If the United States should decide to detonate a nuclear device to demonstrate civilian use of nuclear explosives, one of the first Plowshare program experiments would be conducted in southeastern New Mexico. The project, called Gnome, would be to study the production and recovery of heat and isotopes produced in a contained nuclear explosion. Above is a schematic diagram of how a 1,200-foot shaft would be sunk into a thick subsurface salt bed for detonation of a 10-kiloton explosive.

Engineering

A series of high explosive cratering experiments was conducted during the year. These experiments were designed to increase knowledge of crater formation and to establish scaling laws in different rock and soil media, in order that more accurate data may be available for the design of nuclear cratering experiments.

Three projects at Nevada Test Site constituted the major portion of this program for 1960.

Toboggan was an experiment with linear high explosive charges in alluvium.

Buckboard was a series of 1,000-pound and 40,000-pound high explosive shots in basalt.

Scooter was a 500-ton high explosive shot in alluvium.

In Project Chariot, a study to determine the feasibility of a possible excavation experiment for civil engineering projects, environmental background studies were continued by Commission contractors. Approximately 75 people were in the field during the working year.

Nuclear explosive techniques for possible construction of earthfill dams, canals, and other large earth-moving projects also are being examined.

The Gnome Experiment

Planning for a nuclear experiment in the Salado Salt Basin near Carlsbad, N. Mex., as reported in the Annual Report to Congress for 1959[1] continued during 1960. In this experiment, designated Gnome, plans call for a 10-kiloton explosive to be detonated at a depth of 1,200 feet in a thick subsurface salt bed in southeastern New Mexico. Gnome may be carried out only if authorized by the President of the United States.

Detailed measurements are planned in Gnome to study the production and recovery of heat and isotopes produced in a contained nuclear explosion. Observations will be made to increase understanding of underground nuclear explosion phenomenology in a salt medium.

In addition, the plan has been enlarged to include taking certain new physical measurements to enlarge basic knowledge of atomic interior. This added program of physics and radiochemistry research will be conducted jointly by Lawrence Radiation Laboratory, Los Alamos Scientific Laboratory, and Brookhaven National Labora-

[1] See p. 92.

tory. The work consists of four neutron experiments that are either impossible or extremely difficult to perform with presently available laboratory techniques.

Three of the basic experiments utilize moderated (1–1,000 ev) neutrons which have traveled down a 1,000-foot vacuum pipe to provide time-of-flight separation of neutron energy spectra. The neutrons will be used to study fission and capture reactions as well as resonance parameters for various heavy nuclei.

The fourth basic experiment, utilizing fast neutrons, will study the direct interaction process in inelastic scattering in carbon. These experiments also will help establish techniques for the utilization of nuclear explosions as a research tool.

Technical and scientific construction, and preparations up to, but excluding, the emplacement of a nuclear device, were authorized March 16, 1960. On June 9, the prime contract for Gnome construction was awarded.

Laboratory investigations of (*a*) the chemical and thermal effects and (*b*) the mass and heat transfers associated with power, isotope, and chemical production have been started. Corrosion rates of materials of construction are being studied. Phase equilibria studies at high temperature and pressure also are planned for other media of interest in the Plowshare program.

Exploitation Of Natural Resources

Drilling and mining operations at the Rainier site (Nevada Test Site) have demonstrated the possibility, by using commonly accepted mining methods, of mining back into the area of underground nuclear explosions in volcanic tuff. Experimental mine installation at Rainier has demonstrated that it may be possible to apply nuclear explosives in preparation for economic mining by a modified block caving technique.

Another potential application of nuclear energy to mining operations would be the use of nuclear explosives to shatter a buried orebody so that the ore could be leached *in situ*, thereby recovering metal from a deposit that would not repay mining by conventional means.

A study is continuing on the feasibility of using nuclear explosives in the recovery of petroleum products from tar sands and oil shale. A small-scale high explosive experiment, called Pinot, to measure migration of gaseous products along bedding planes in oil shale was conducted in August 1960 at Rifle, Colo.

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General Research

Improved design of Plowshare nuclear explosive devices and greater accuracy in the prediction of their effects are the objectives of a Lawrence Radiation Laboratory research program in the field of strong shocks in solids. This program includes development of laboratory experiments to simulate the shocks from underground nuclear detonations, the design of instruments to measure shock parameters, and a thorough investigation of strong-shock phenomenology in rock materials similar to those in which future Plowshare experiments might be conducted.

Underground Explosions Research

Work on the phenomenology of contained underground explosions is continuing. Plowboy was a post-Cowboy excavation study of effects of a high explosive shot in salt. The actual detonation was conducted under the Cowboy project, a part of the Seismic Improvement Program.

Special Devices Research

The Commission has recognized that many peaceful applications of nuclear explosives will require nuclear explosives designed specifically for these uses and is conducting theoretical and laboratory studies of several possible design concepts. Generally, these devices would be designed to minimize the production of radioactive debris and to minimize the cost and utilization of special nuclear materials.

Safety

The Commission places major emphasis on safety in its studies of each Plowshare proposal. No nuclear detonation for the Plowshare program has yet been authorized and the Commission will not recommend authorization of any detonation until all safety requirements have been met. Studies which assist decisions on safety include such subjects as radiation release; weather prediction; blast and shock propagation; seismic damage; possible ground water contamination; and possible effects on any biological systems. All these factors are being continuously evaluated in connection with all proposed Plowshare experiments.

The Plowshare Advisory Committee met in October and, among other things, considered the emphasis placed on public safety in Plowshare work. It reviewed the program in total from the safety point of view and took into account precautions and experiences of the weapons test organization, analysis of weapons effects tests and special field experiments with high explosives designed to furnish solutions to safety problems.

Physical Research

Some 18 percent of the Commission's $167 million expenditures for physical research programs in the year that ended June 30, 1960, were for the design and construction of research facilities. Chief among these facilities are large particle accelerators which are essential to research in high energy physics which helps scientists increase their understanding of nuclear phenomena.

During the year, Brookhaven National Laboratory completed construction of the new $31 million Alternating Gradient Synchrotron (AGS), and produced a beam with an energy of more than 30 billion electron volts (Bev)—the highest so far achieved by any machine in the world. Design and components of the AGS are described in this report. The initial research program will be devoted to a thorough search for hitherto undiscovered nuclear particles which the great energy of this machine makes it possible to produce.

During this year, the Commission returned the 3 Bev Cosmotron at Brookhaven to operation after modifications and improvements; planned major improvements on the 6 Bev Bevatron at the University of California E. O. Lawrence Radiation Laboratory; went ahead with construction of the 10 to 15 Bev Zero Gradient Synchroton (ZGS) at Argonne National Laboratory, the 3 Bev Princeton-Pennsylvania Proton Accelerator and the 6 Bev Cambridge Electron Accelerator; began design and engineering work on the Stanford University linear accelerator project.

Among other projects are plans for construction of two high-flux research reactors costing between $10 and $15 million each, one at Brookhaven, the other at Oak Ridge National Laboratory, which will produce 3 to 5 million billion neutrons per square centimeter per second.

The research activities and results, usually described in this section of the Annual Report to Congress, have been made the subject special report to the Congress in 1960.[8] In this regular Annual Report to Congress, the Commission describes construction and improvement of various research facilities.

PARTICLE ACCELERATORS

Brookhaven's Alternating Gradient Synchrotron

The outstanding accomplishment in high energy physics in the United States during 1960 was completion of construction and successful operation of the United States newest and most powerful particle accelerator—the Alternating Gradient Synchroton (AGS) at Brookhaven National Laboratory. On July 29, this machine for the first time produced a beam of protons at an energy of more than 30 billion electron volts (Bev), the highest yet attained anywhere. The highest energy so far attained with the AGS is between 32 and 33 Bev. An accelerator of similar design was completed late in 1959 at the European Organization for Nuclear Research (CERN) Laboratory at Geneva, Switzerland. Its beam has an energy of some 28 Bev. Other new accelerators being planned or built in the United States are in the 10–15 Bev range. The Soviet Union is constructing a proton synchroton in the 60–70 Bev energy range.

With successful operation of the AGS, scientists and technicians are concentrating efforts on perfecting its performance—increasing the intensity of the beam and determining its characteristics. These studies will help provide information used to determine arrangement of auxiliary equipment for guiding beams from the machine into the research devices.

Research Program

Early research with the AGS will be devoted to indentification of nuclear particles generated when protons from the machine collide with the nuclei of target atoms, and to a thorough search for hitherto undiscovered particles. The high energy beam makes it possible to produce new particles of masses intermediate between electrons and protons (mesons); others of mass greater than protons (hyperons); and antiparticles corresponding to most of them. It is believed that

[8] "Atomic Energy Research in Life and Physical Sciences—1960," A Special Report to Congress by the United States Atomic Energy Commission, January 1961, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., $1.25.

understanding these particles may give scientists the key to the basic structure of the atomic nucleus.

One purpose of a high energy accelerator is to produce large quantities of various types of *mesons* found by physicists to be intimately involved with the powerful forces that hold nucleons together within the nucleus.[9] The AGS will make possible studying meson interaction with protons and other atomic nuclei at much higher energy than previously available in the laboratory. The new accelerator also will be an important and prolific source of *hyperons*—important members of the family of elementary nuclear particles, the discovery of which was instrumental in developing the useful theory of "strange nuclear particles."

Another important research program for the new accelerator will deal with *antimatter;* such as antiprotons and antineutrons. The higher energy of the AGS will produce these particles in greater abundance so that their detailed properties can be studied with the hope of opening a new chapter in the field of particle physics.

Research Methods

Mesons and other high energy nuclear phenomena will be observed by means of the newly developed device known as the "bubble chamber." Until recently, interactions were observed primarily by means of "cloud chambers," where charged particles produced condensation of supersaturated vapor and left a visible trail of liquid droplets. But in cloud chambers the density is low and interesting collisions between particles occur with relative infrequency. Moreover, a comparatively long time must elapse after a single picture has been taken of a nuclear event to clear the chamber and make it ready for the next event.

The bubble chamber overcomes these limitations by using a liquid medium instead of gas; for example, hydrogen cooled to a temperature of −414° F under a pressure of about 70 pounds per square inch. When this pressure is released, the liquid is momentarily superheated, i.e., ready to "boil". If a stimulus, such as a charged particle, is introduced into the medium, boiling begins along the track of the particle. The particle thus makes a visible track of bubbles in the liquid hydrogen, and these can be photographed by special cameras located behind a glass wall of the chamber. The cameras are syn-

[9] See pp. 78–79. Atomic Energy Research in Life and Physical Sciences, 1960; January 1961, Superintendent of Documents, Washington 25, D.C., $1.25.

chronized with a high-voltage light-source, the entering beam of bombarding particles, and the mechanism controlling the pressure in the chamber. In this way, photographs are taken for each pulse of particles from the accelerator. Increasing the pressure in the chamber makes the bubbles disappear, erases the track and makes the bubble chamber ready to receive and register another pulse of particles. Six large bubble chambers now are used at Brookhaven in connection with the 3 Bev Cosmotron accelerator; in the future most of these will be used at the AGS. In addition, an 80-inch hydrogen bubble chamber, expected to be the largest in the world, now is under construction at Brookhaven. A 72-inch hydrogen bubble chamber, the largest chamber built to date, is in use at the Bevatron.

Counters provide another important group of tools for research at the AGS. These include both scintillation and Cerenkov counters which indicate the passage of ionizing elementary particles by means of light flashes. Very large and complex arrays of counters are used to identify nuclear particles and to help in determining their paths and velocities.

Design and Construction

The AGS was authorized and funds allocated for its construction in 1954, following completion of preliminary design studies which had been started in 1952. Three Brookhaven scientists, E. D. Courant, M. S. Livingston, and H. S. Snyder, had evolved the idea [10] that particles could be accelerated to greater energies than were then being achieved through use of "strong", or "alternating-gradient", focusing of the accelerated beam.

Total cost of the AGS and its buildings is approximately $31 million.

The staff working on the AGS consists of over 170 people. The project has been under the direction of L. J. Haworth, Director of the Laboratory, and of G. K. Green, Chairman of the Accelerator Development Department, and J. P. Blewett, Associate Chairman, all of whom played important roles in the design and construction of the older Cosmotron.

Various elements of the AGS are pictured and described in the accompanying series of photographs.

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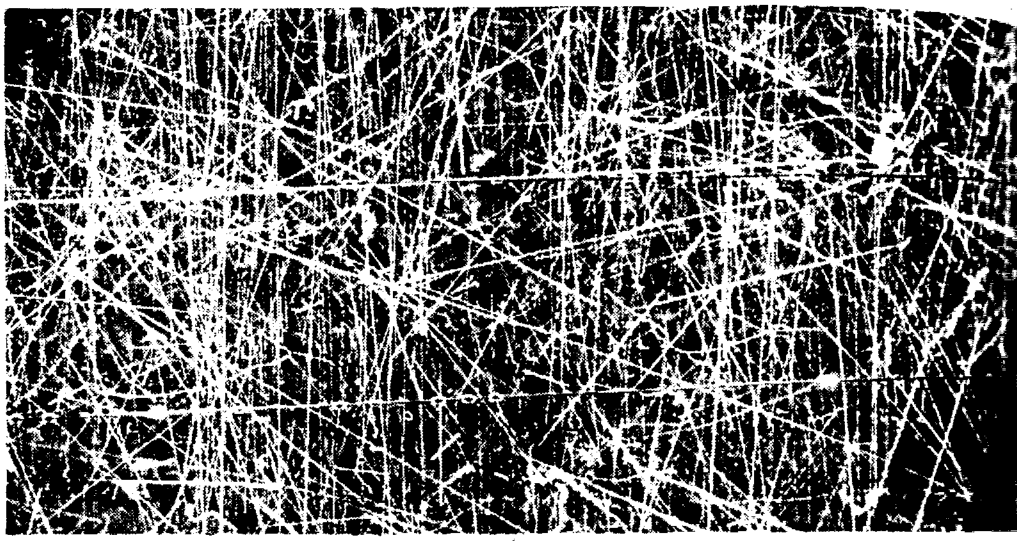
[10] It since has been found that a similar idea of strong focusing had been proposed earlier by N. Christofilos of Greece.

Atomic Particle Accelerators

Just as the telescope enables the astronomer to probe the heavens and the microscope aids the biologists' quest for the secrets of nature and the life processes, the high energy particle accelerator, or "atom smasher", makes infinitesimal bits of matter perform in a manner that can be observed, thus providing man with increased knowledge of the characteristics of the atom.

The key to accelerating particles is the fact that like electrical charges repel each other, while unlike charges attract each other. By using alternating electrical fields within vacuum chambers, science is able to speed up the flight of electrons and protons to such a velocity that their collision with other atomic nuclei smashes the target atom, sending its component particles streaking or whirling off into space. Detection, through photographic and other means, and analysis of the paths of these component particles provides man with knowledge of the structure and binding forces of the atom.

The photos on the following pages show some of the major equipment used in the Commission's high energy physical research program.



Ionized particle tracks in this early "cloud" chamber photograph offered new information on the structure and binding forces of the atom. Taken in 19.., it is one of the first cloud chamber photos obtained with the Cosmotron accelerator at the Commission's Brookhaven National Laboratory. It shows high energy particles resulting from a single pulse of 1.2 billion electron volt (Bev) protons striking a ⅛-inch brass target inside the Cosmotron. The cloud chamber itself was located 125 feet from the target. Particles reaching it traversed the one-inch stainless steel outer wall of the Cosmotron's vacuum chamber, two heavy doors and the ¼-inch stainless steel wall of the cloud chamber. Subsequent development of the "bubble" chamber and the means for accelerating particles to greater speed enabled science to make more "readable" photographs of nuclear events.

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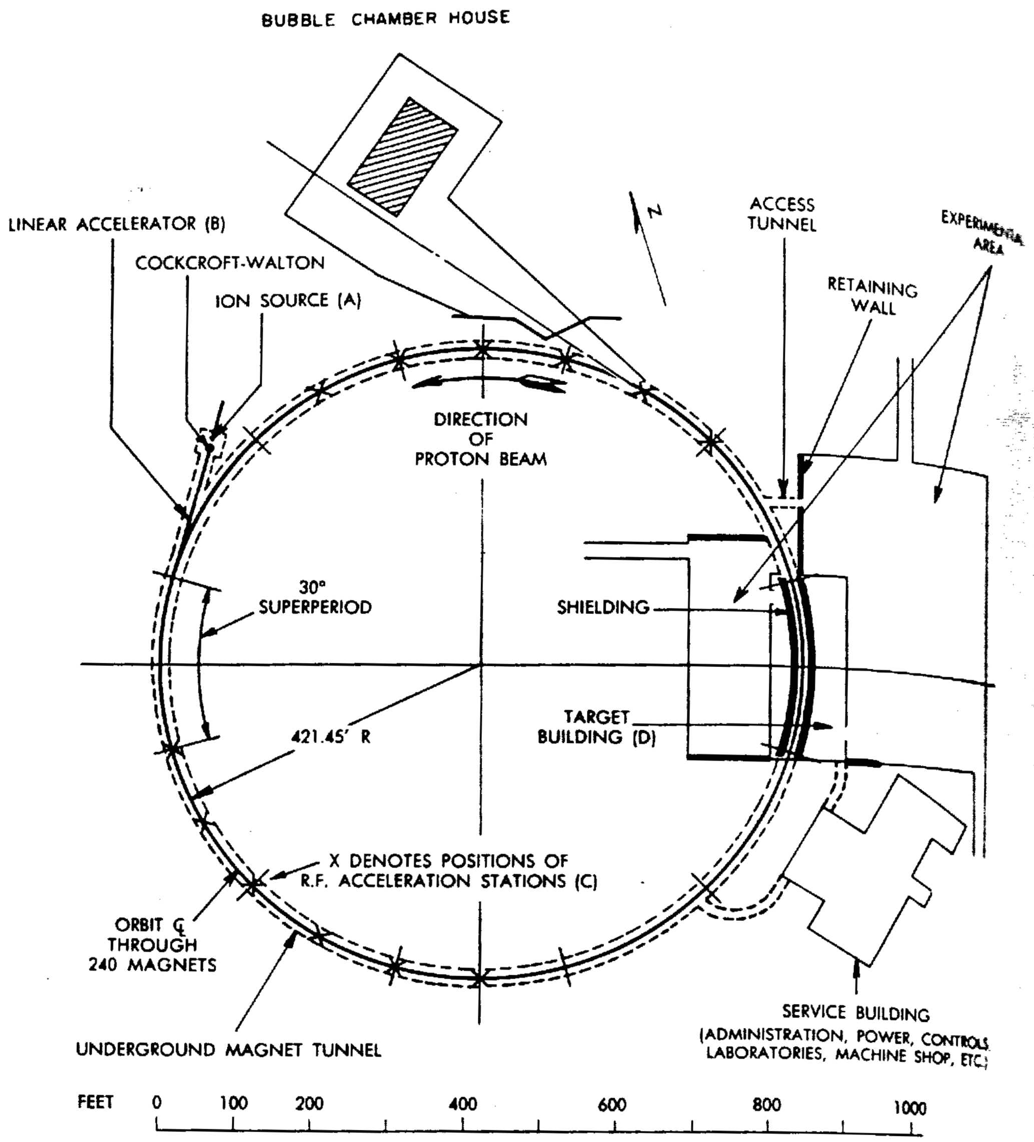
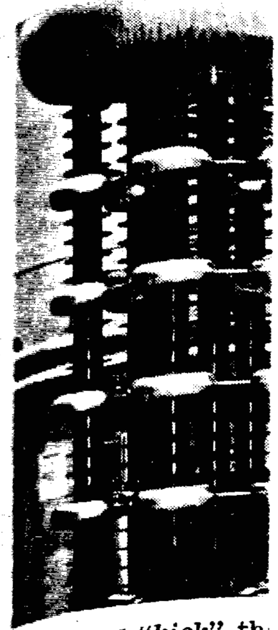
New Alternating Gradient Synchrotron

Newest member of the Commission's "family" of high energy particle acceler-ators is the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory. In July, 1960, the AGS accelerated a beam of protons (hydrogen atoms stripped of their electrons) to an energy of more than 30 billion electron volts (Bev), the highest energy yet obtained with a particle acceler-ator. In the above photo, the outline of the tunnel housing the 843–foot dia-meter, half-mile circumference magnetic ring can be discerned. The accelerator is located within an 18-foot square, concrete-lined tunnel that is covered by ? feet of earth. The particles are injected into the accelerator from the small building (bottom, left) and make a one-second journey of more than [illegible] miles around the magnetic track before crashing into an atomic target located within the research building astride the tunnel (top of photo). The particles' pathway is an oval-shaped vacuum pipe, about 7 x 3 inches, that passes through the jaws of C-shaped magnets. There are 240 magnet units, each weighing 16 tons. The magnets hold the particles in a relatively stable orbit within the vacuum chamber while they pick up speed as they pass through radiofrequency accelerating units. Each unit gives the particles an 8,000-volt boost in speed so that toward the end of their journey they are traveling at a velocity within a fraction of 1/10 of one percent of the speed of light, or approximately 186,000 miles per second. According to Einstein's theory of relativity, the mass of the protons has been increased by more than 30 times at this velocity. Heavy shielding (earth and concrete) is required for pro-tection against the Cosmic-type radiation given off by high energy particles.



A particle's path as it is accelerated and put to research use at the AGS can be traced on the above diagram of the Alternating Gradient Synchrotron's principal features. Protons are produced in the ion source (point A) by passing hydrogen through an electric arc which strips the electrons off the hydrogen atoms. The resulting protons then are given an initial acceleration in the Cockcroft-Walton generator to 750,000 electron volts (750 Kev) before being injected into the Linear Accelerator (point B) where their energy is boosted to 50 million electron volts (50 Mev). At this energy they are injected into the AGS magnetic ring where they make some 370,000 circuits around the half-mile track in a second before being forced into a 30–32 Bev collision with an atomic target in the research building (point D). The shower of atomic sub-particles resulting from the collisions are detected by photographic equipment in the bubble chamber house (top) or in special detection devices located in the experimental area (right).



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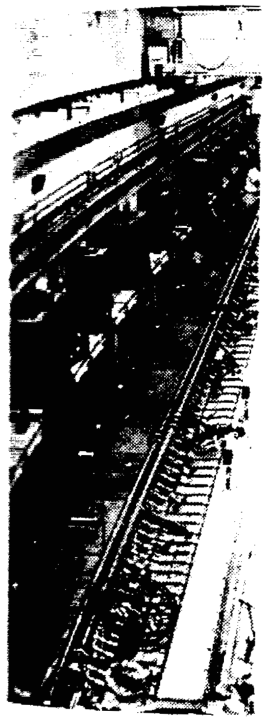

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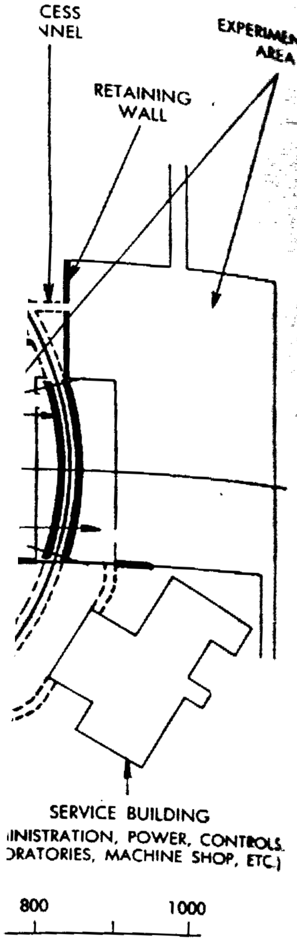

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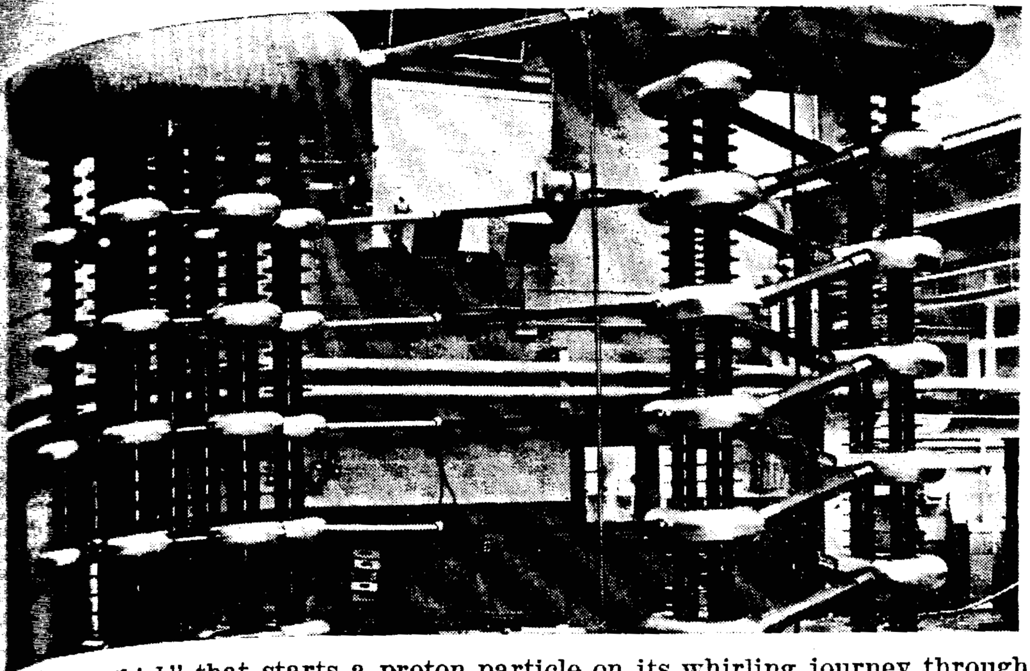
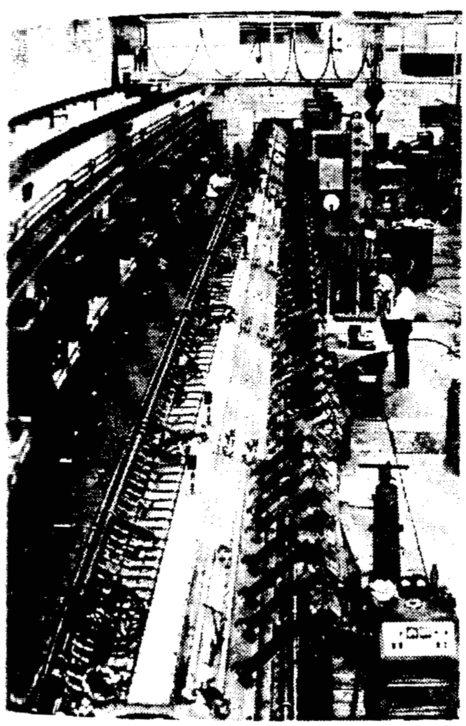
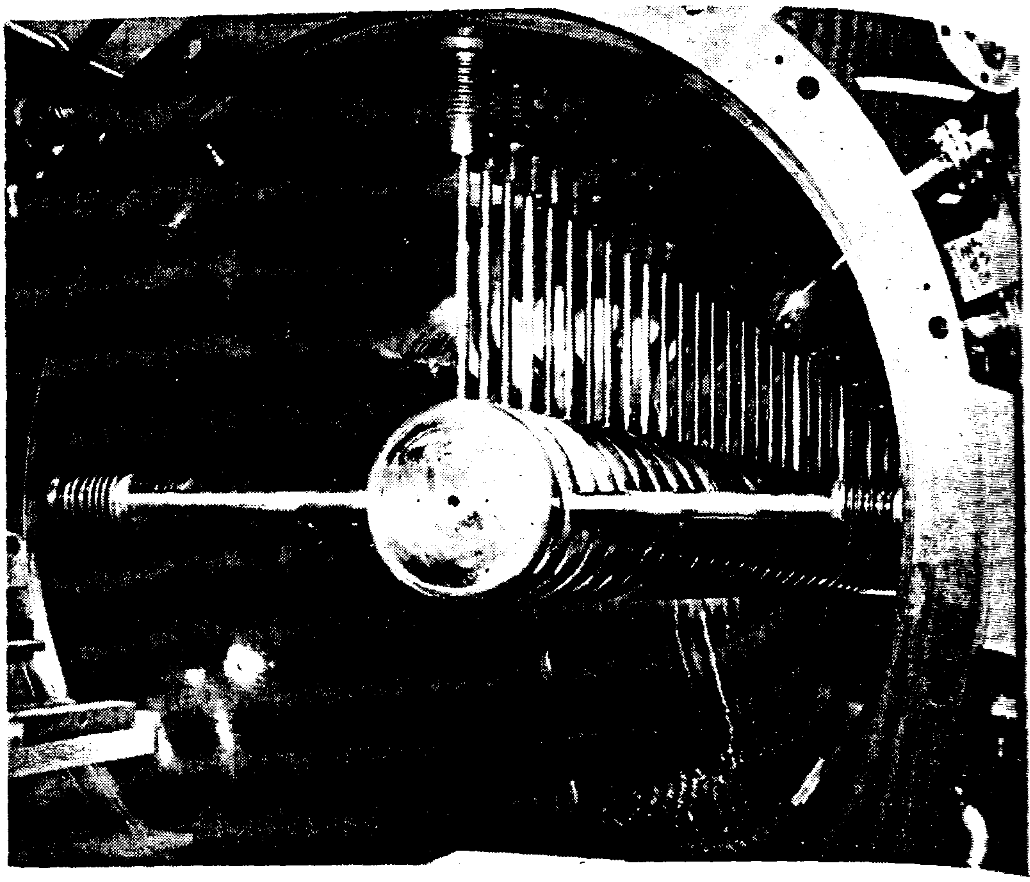


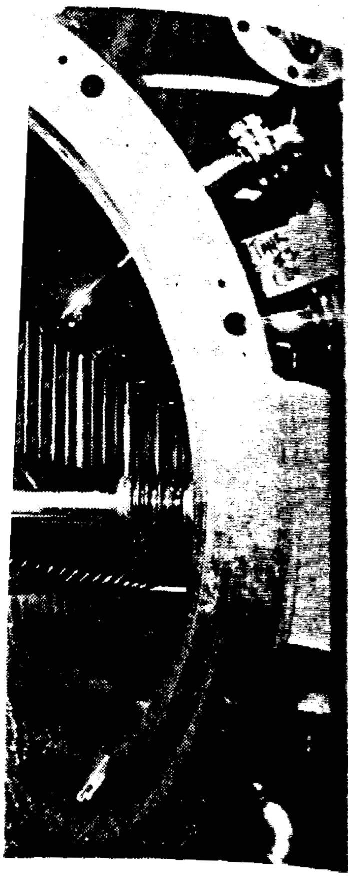
The initial "kick" that starts a proton particle on its whirling journey through the AGS is applied by a Cockcroft-Walton generator, the type of accelerator used 29 years ago to obtain the first artificial nuclear transformation. The particle is ejected from the generator, shown here during its installation at the AGS site, with an energy of 750,000 to 800,000 electron volts (750–800 Kev) and passes through a second accelerator, the Linac, before entering the AGS.

The proton's second stage of acceleration occurs in the 110-foot length of the Linear Accelerator (Linac) where the particles are given an incremental velocity as they pass through each gap between 124 accelerating electrodes activated by a high frequency electrical source. Leaving the vacuum tank of the Linac, the proton has an energy of 50 Mev. Photo shows the length of the Linac, looking toward its terminal with the AGS (hidden by concrete brick wall). To the right rear of the Linac are four "towers" which house the high power radiofrequency system. The system pulses the acceleration electrodes, or "drift tubes", at a rate of 200 million cycles per second. With each pulse cycle, the attracting and repelling force of alternate drift tubes is reversed. Resonant frequency tuners located within the vacuum tank, working on a radar-like principle, energize the electrodes only when the proton is crossing a gap between the tubes. Thus, the repelling force of the tube behind aids the attracting force of the tube ahead to give the proton an accelerating "kick".





Although the tank of the Linear Accelerator has a 37.4-inch inside diameter, the pathway for the proton beam is only one-half of an inch across at the low energy end, where the particles enter from the Cockcroft-Walton generator. The particle beam passes through the small hole in the center of the 124 accelerating electrodes, or "drift tubes", which can be seen with their vertical and horizontal support stems in place within the tank. Alternating gradient focusing magnets within the drift tubes exert forces to keep the protons from wandering very far from the central axis. The particles receive an accelerating "kick" as they pass across the gap between each of the tubes, and in the upper right hand section of the tank can be seen the ball tuners which serve to provide the proper resonant frequency of the tank. The copper-lined outer tank is 110 feet long and this length is maintained constant by circulating water with a temperature constant to 0.1 degree. A high vacuum is maintained with minimum organic contamination by the use of 20 titanium evaporation pumps. The 50 Mev Linac is itself a major accelerator and is one of the three largest existing proton linear accelerators in the world; the others are the 50 Mev machine at CERN, Geneva, Switzerland, and the 70 Mev research linear accelerator at the University of Minnesota.



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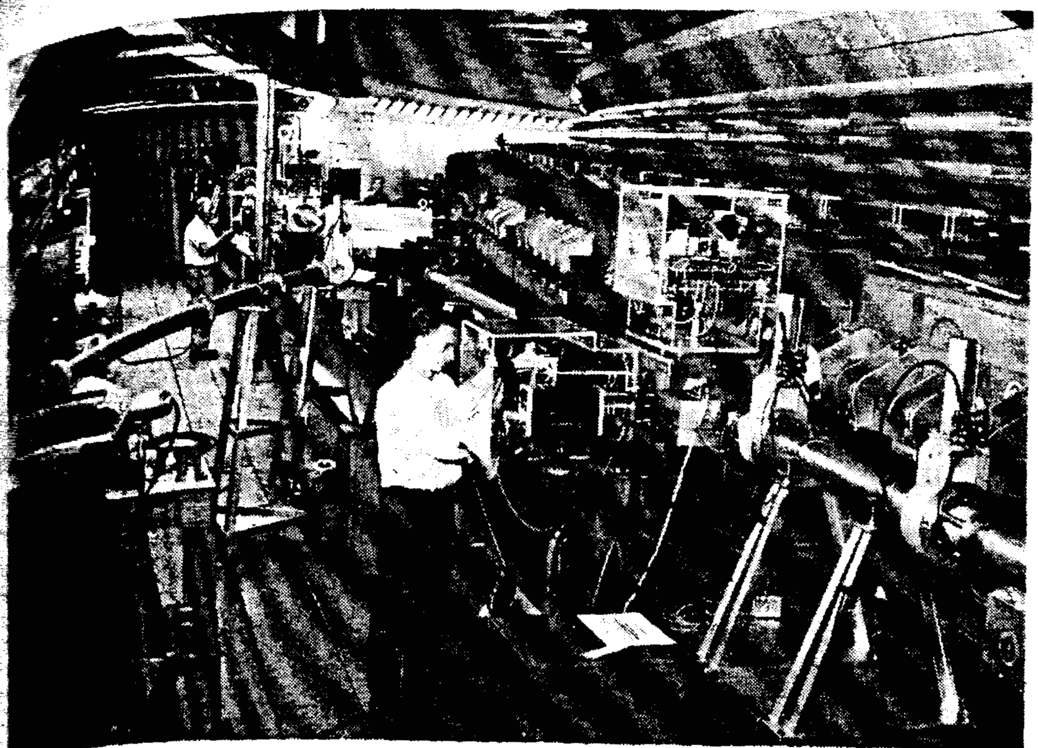
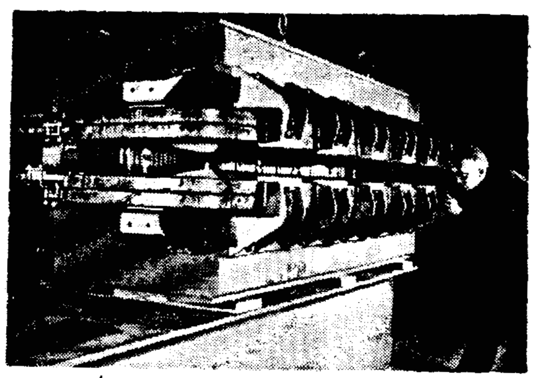


The proton beam leaves the Linear Accelerator (behind shielding wall, left rear of photo) through the four-inch pipe (leading to lower right of photo) and passes through a series of focusing lenses and steering magnets into the orbit of the AGS magnet ring. The pipe extending across the aisle (to left) is the exit pipe for an analyzer magnet which bends the proton beam through 25° to determine the energy spread of the protons. In the foreground is a viewing box with lucite covers over the drive mechanisms. Inside it are adjustable slits which are used to align the proton beam and to examine its spatial and angular distribution in order that the correct focussing adjustments can be determined. Inside the viewing box there is also a quartz plate which can be rotated into the beam for visual observation of the beam position and dimension; the protons impinging upon the quartz produce light, which is observed by means of the TV camera in front of the man in foreground.



Huge magnets, each 90 inches long and weighing 16 tons, keep accelerated protons on a relatively stable orbit path. Each magnet section is made up of about 3,200 laminations of 0.035-inch steel plates. The vacuum tube fits between the C-shaped jaws of the magnets, which alternately exert horizontal and vertical forces on the particles to keep them from "wandering" within the vacuum tube.

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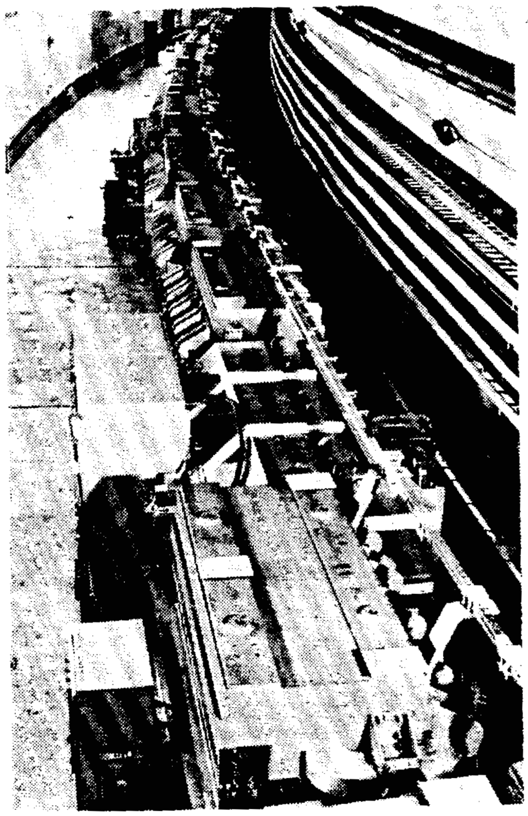
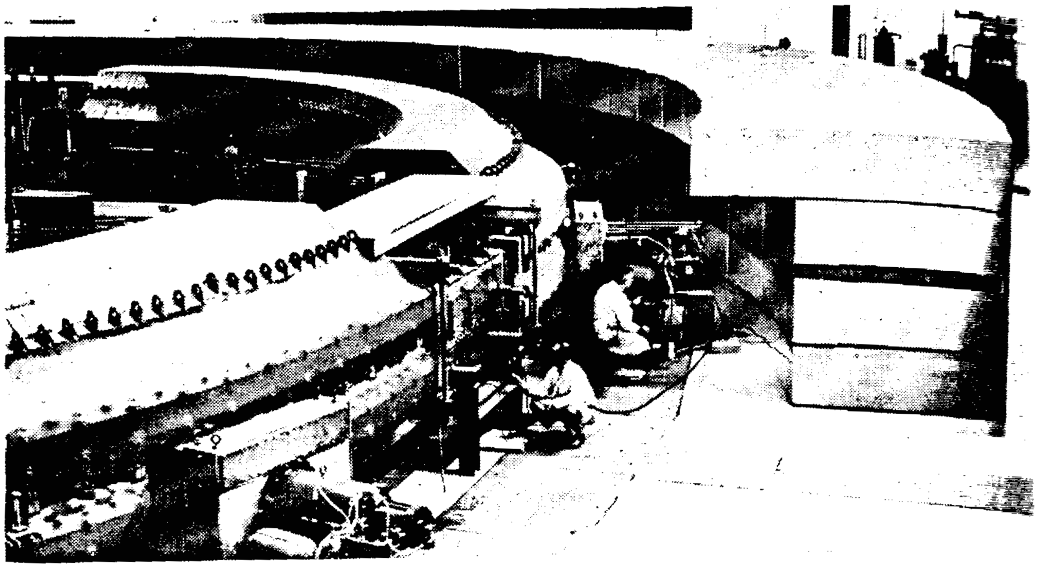
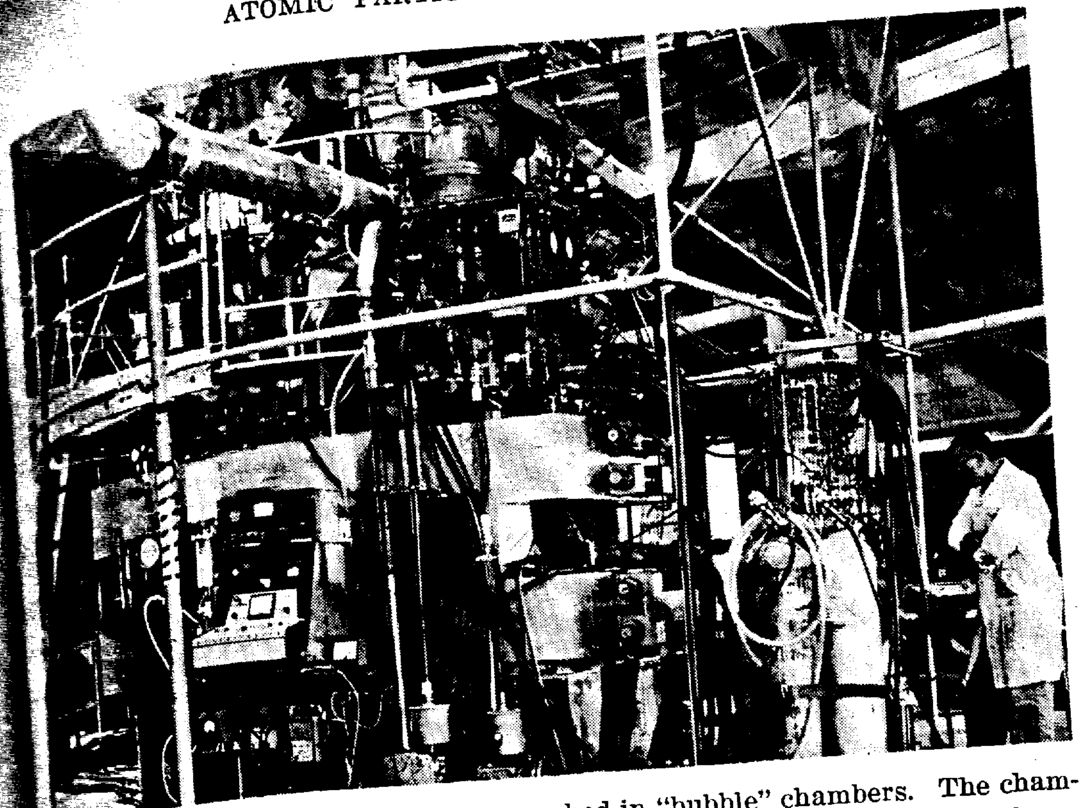


The easy curved pathway the proton beam follows within the AGS can be seen in this photo. In foreground is one of the magnet sections used to bend the speeding protons in a circular path. Just above is one of the 12 radiofrequency accelerating stations (container with handles) used to boost the particle's energy. In center rear of photo is one of the 48 titanium evaporation pumps used to maintain a vacuum in the beam passageway, and the cylindrical object at top of photo is the survey monument used in aligning the ring of magnets. Alternate groups of magnet sections are faced in opposite directions to help the portons maintain a steady orbit path.

Other Accelerators and Equipment

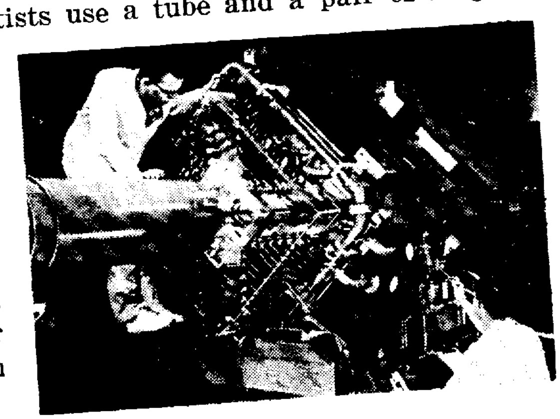


Also located at Brookhaven and first operated in 1952, the 3 Bev Cosmotron is the oldest of the Commission's multi-Bev accelerators. The 60-foot diameter 2,200-ton ring magnet was the first manmade device to accelerate protons to velocities above a billion electron volts. Two of the 12 vacuum pumps which exhaust all air from the particle beam passageway can be seen. By removing rows of lead bricks (dark objects) from the massive concrete block shield tunnels can be formed through which the secondary particles produced by atomic collisions within the accelerator can pass and be detected by research instruments located behind the shield.



Energized particle tracks can be photographed in "bubble" chambers. The chambers are normally filled with liquid hydrogen which is superheated by a sudden reduction in pressure timed to coincide with the billionth of a second that pulsed particles from an accelerator enter the chamber. The particles leave trails of tiny bubbles or "tracks" which are photographed by high-speed cameras. The characteristics of tracks indicate the mass, electric charge, momenta, and other properties of the particles. Early experimenters had to use "cloud" chambers which produced less definitive results. Photo shows the 20-inch bubble chamber used with the Cosmotron at Brookhaven; a 72-inch chamber is located at the Commission's laboratory on the University of California campus; and an 80-inch chamber is planned for the Alternating Gradient Synchrotron facility.

To make more accurate determinations of the interactions occurring among accelerated particles, Brookhaven scientists use a tube and a pair of magnets in extracting the mesons produced in the Cosmotron. Photo shows the magnets, known as a "strong focusing pair", which intensifies the meson beam in much the same manner as a "burning glass" intensifies the sun's rays. By focusing the particle beam and allowing the particles to bombard atom nuclei, scientists can make use of a greater number of the mesons produced within the Cosmotron.



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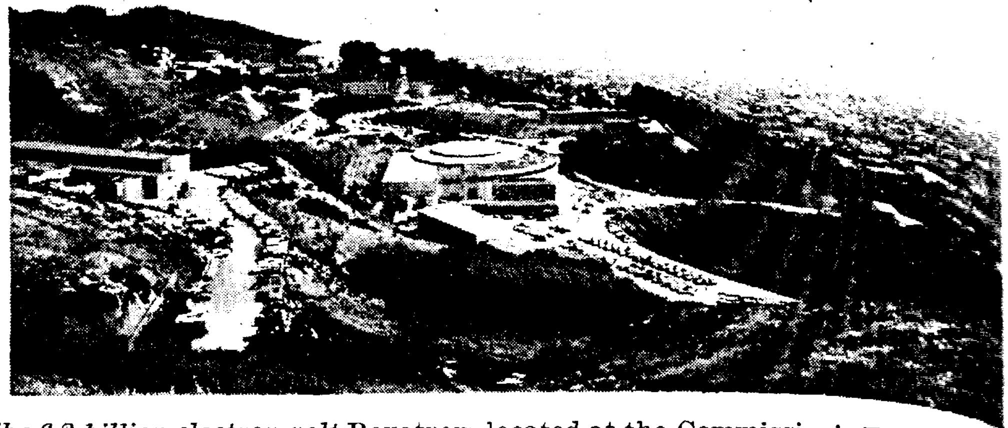
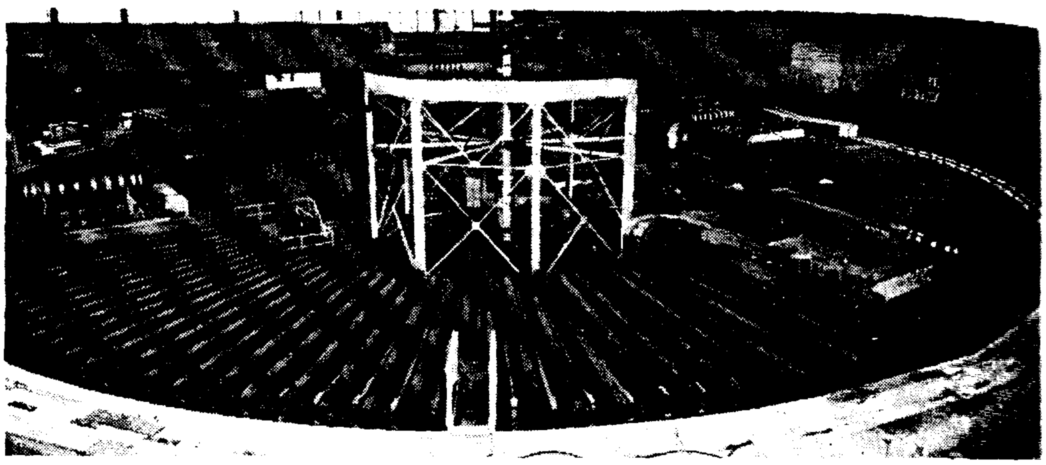


The 6.2 billion electron volt Bevatron, located at the Commission's E. O. Lawrence Radiation Laboratory at the University of California, has been a prolific contributor of new basic knowledge for nuclear science. First operated in 19[illegible], research with the Bevatron has since led to discovery of at least three important high energy particles—the anti-proton, the anti-neutron, and the neutral cascade hyperon called "Xi-zero". Photo shows the Bevatron building (center) located in the hills above the university campus. In the background is the circular building housing the 184-inch cyclotron, a 730 Mev accelerator. In the distance is the city of Berkeley.



The Bevatron (below), with a diameter of 125 feet and a ring magnet containing 9,700 tons of steel, was the Commission's highest energy accelerator until the new AGS went into operation. Accelerators such as the Bevatron, Cosmotron and AGS use a series of magnets, which are pulsed on a synchronized pattern to increasingly greater strength, to accelerate proton particles as they orbit within a vacuumed passageway located within the magnet sections. The crane (top of photo) was used to lift the heavy magnets and sections of the concrete shielding (foreground) during recent repairs to the Bevatron.

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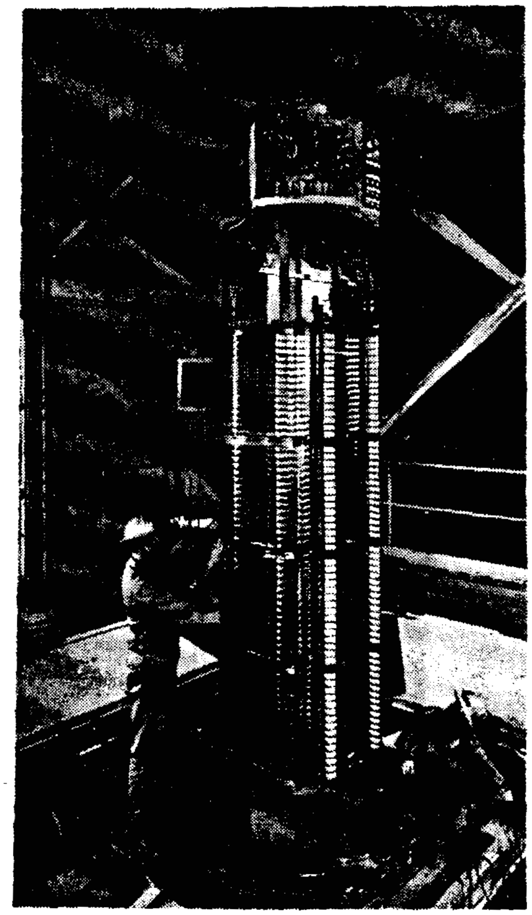
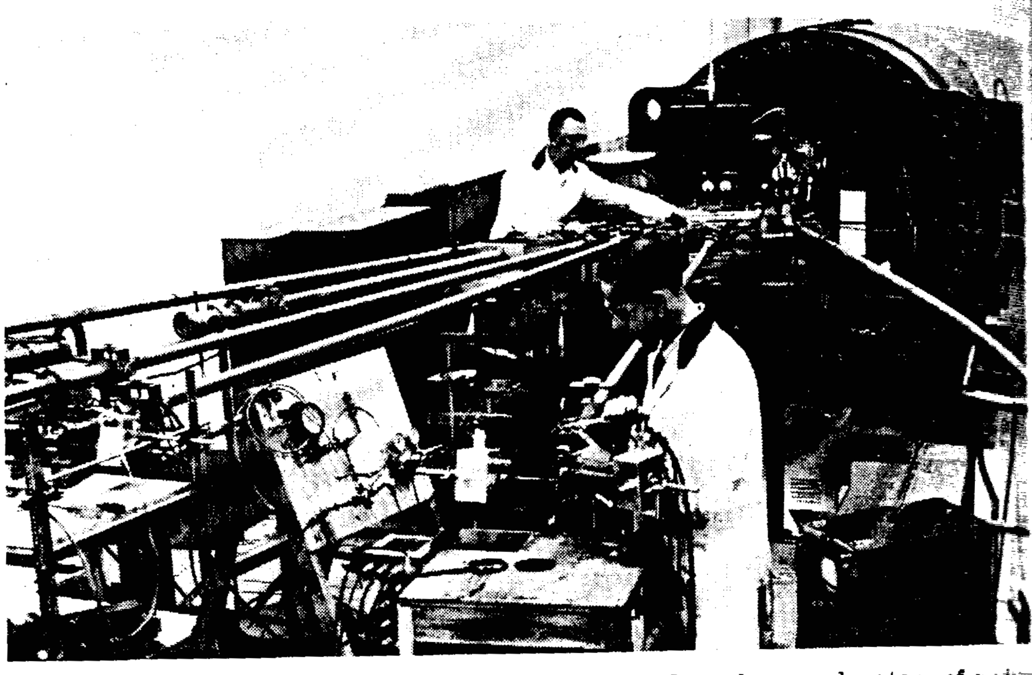
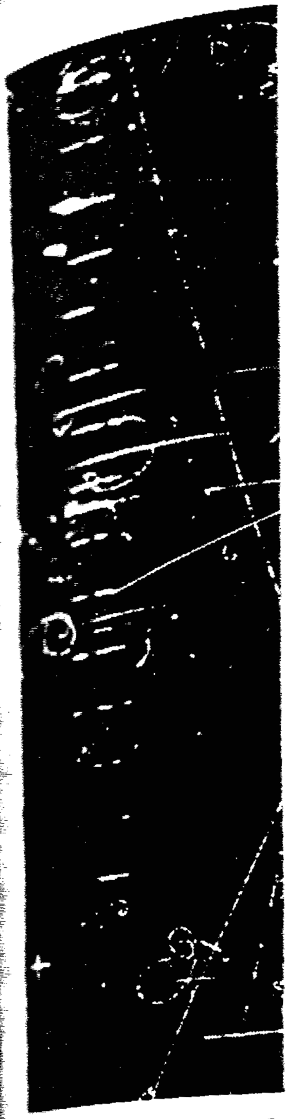
The Van de Graaff generator is the second oldest type of accelerator to still be useful in high energy physics research—the Cockcroft-Walton is the oldest. Shown at right is the inner column of the new Van de Graaff being installed at the Commission's Los Alamos Scientific Laboratory. Inside this column is the belt which carries the electrical charge from the bottom of the machine to the high-potential head. A portion of the belt can be seen at the top of the column. When the machine is in operation, the vessel (top of photo) is lowered over the column and a gas separation column inside the vessel fits snugly around the inner column. When completed, this accelerator has ten sections in the insulating column instead of the four shown, and stands 20 feet high.



The separation column of the Los Alamos Van de Graaff machine with its interpotential shells removed is shown in photo at right. This type of accelerator uses the electrostatic generator principle of a rotating belt that builds up a tremendous electrical potential—in the same manner that a static electricity charge is created by running a comb through a person's hair. Since a hollow body will accept any available electrical charge, irrespective of its own voltage, it is possible to build up the potential by continually supplying an electrical charge to the semi-sphere atop the machine. For high energy physics research, the electron discharge is drawn off the top of the generator by means of a hollow tube, allowing high-voltage ions to strike an atomic target at energies up to 10 Mev.



Some high energy physics research can best be done by accelerators of medium energy. *Photo above* shows the 18-inch cyclotron (background) used at Brookhaven for measuring neutron energies by "firing" 2.8 Mev protons at targets of various materials. In the cyclotron the particles circulate between the poles of a magnet and within two hollow D-shaped electrodes placed back-to-back, between which is applied a radiofrequency voltage. *Photo below* shows a 3 Mev electrostatic generator (cylindrical object) used at Brookhaven to "fire" deuterons (double-weight nuclei of hydrogen atoms) down the tubes at complex atoms such as carbon and beryllium, scattering them in patterns which can prove meaningful to physicists studying the structure and energy of matter.



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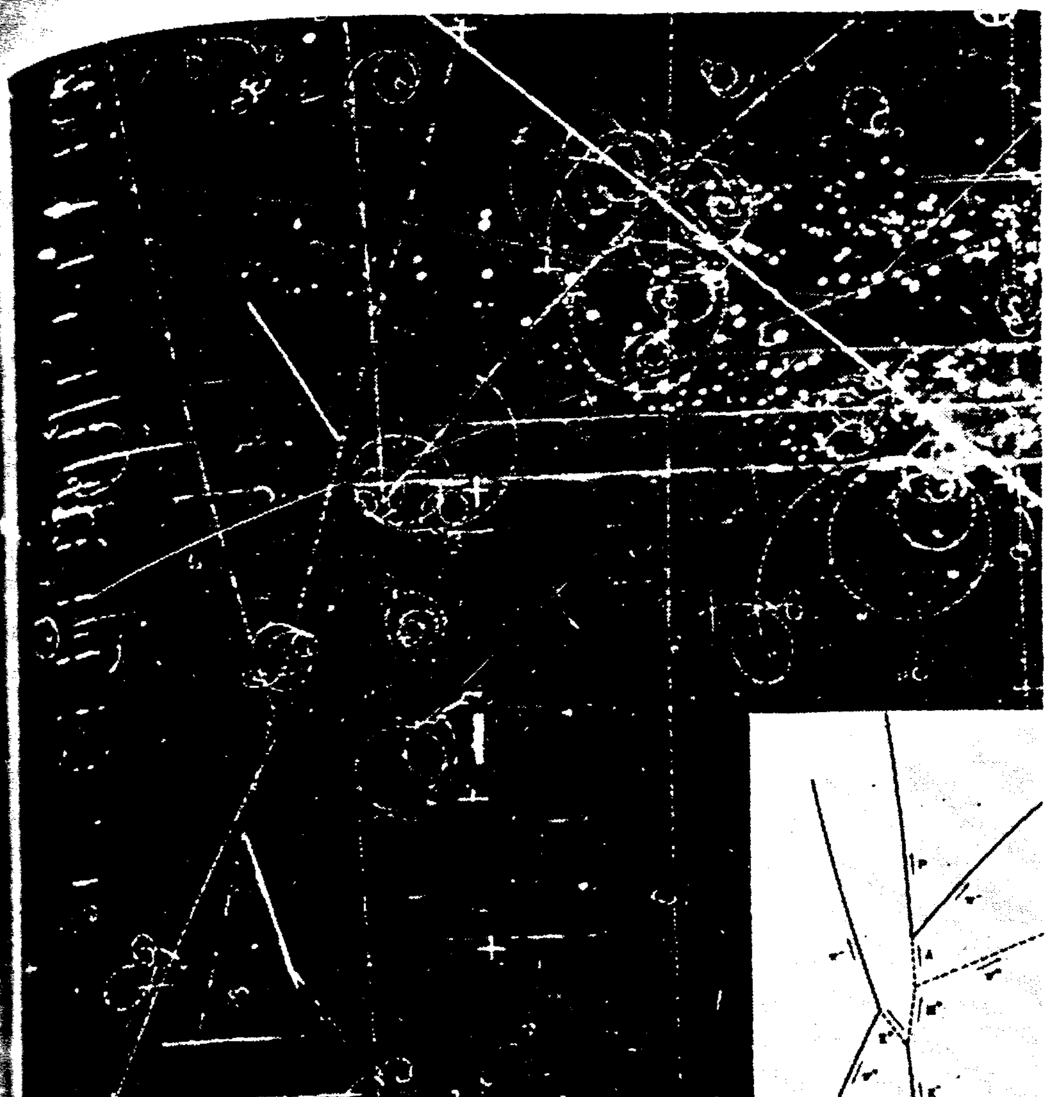

The "*bubble*" *chamber photograph* above, made at the Commission's Lawrence Radiation Laboratory, led to the announcement in March 1959, of the discovery of a previously predicted ghostly atomic particle, the "Xi-zero", a neutral cascade hyperon. The unique discovery—involving analysis of two invisible tracks"—was made after more than a year of effort during which the Laboratory's 15-inch bubble chamber was bombarded with negative K mesons produced in the Bevatron, and some 70,000 photographs had been taken. On the basis of other discoveries, scientists foresaw that such a particle could exist and that since it would not have an electrical charge it could not be photographed but would have to be deduced from other tracks. This is the only photo that positively showed the anticipated event. The diagram inset helps explain the action. The entering negative K meson (K—) shows a track that suddenly ends, having collided with a proton and producing two neutral particles. Some distance from the track's end are the characteristic V-shaped tracks formed by decay of the neutral particles into charged particles. However, the upper "V" is not at a normal angle, leading to the scientific conclusion that the K—-proton collision produced the predicted Xi zero(Ξ°) which decayed into a lambda (Λ) and Pi meson (Π°). In turn, the decaying lambda became a proton (P) and a negative Pi Meson (Π—) which formed the visible "cocked" angle tracks. The whirls are the tracks of low-energy electrons.

Other Accelerators

Cosmotron

The 3 Bev Cosmotron proton synchrotron at Brookhaven National Laboratory, initially completed in 1952, was the world's first particle accelerator to operate in the billion electron volt range. Extensive modifications and improvements were undertaken on the Cosmotron during 1958 and 1959 to increase its efficiency.

The machine still has minor operational difficulties, but a number of extensive experiments were carried out in late 1959 and during 1960. The improvements are designed to permit most experiments to be carried out with high intensity proton beams external to the ring.

Bevatron

A major improvements program of the 6-Bev Bevatron at Lawrence Radiation Laboratory, Berkeley, is being planned, which, over a period of some 4 years, will almost completely overhaul and modernize the machine. Its beam intensity will be increased, the experimental facilities expanded (including external beams), and the general reliability and flexibility of the machine's performance improved.

Three New Accelerators

Three multi-Bev synchrotrons are at present in various stages of development.

Construction of the 10–15 Bev *Zero Gradient Synchrotron* (*ZGS*) at Argonne National Laboratory is proceeding approximately on schedule with completion of the basic machine expected in the summer of 1962. Extensive expansions of the experimental facilities for this project are to be carried out concurrent with the construction, and following completion, of the basic synchrotron machine.

Completion dates of late 1961 are now indicated for the 3-Bev *Princeton-Pennsylvania Proton Accelerator* (*PPA*) at Princeton, N.J., and the 6-Bev *Cambridge Electron Accelerator* (*CEA*) at Cambridge, Mass.

Stanford University Accelerator Project

The Atomic Energy Commission's 1961 Authorization Act includes $3 million for start of design and engineering work on a 2-mile long linear electron accelerator at Stanford University. The Commission was approved the selection of Actron, Blume, and Atkinson as architect-engineer subcontractor under Stanford University. The project, estimated to cost more than $100 million and to require 6 years to build, was the subject of detailed hearings in 1959 and 1960 before the Joint Committee on Atomic Energy. The advantage of such an accelerator is that it can provide a high-intensity, well collimated beam of electrons.

Results of additional cost studies and conceptual design work carried out during 1960 are to be placed before the Congress early in 1961.

Accelerator Models

Work on assembly of a 30–50 Mev electron model of the Midwestern Universities Research Association (MURA) *clashing beam accelerator* was completed at Madison, Wis., and test operations began early in 1960. Simultaneous acceleration of beams traveling in opposite directions was successfully carried out. This model should provide basic information during the spring of 1961 as to whether or not such an accelerator is technically feasible. If the experiments are successful, MURA probably will submit a proposal to the Government for construction of a large-scale accelerator.

An electron cyclotron model, the *Cyclotron Analogue II*, is being built at Oak Ridge National Laboratory. It will have a maximum energy of about 450 kev and is designed to study the dynamics of the proposed Oak Ridge 850 Mev fixed-frequency proton cyclotron, particularly with respect to beam extraction.

Tandem Van de Graaff Accelerators

The Commission in November 1959 signed a contract for purchase of three 10 Mev tandem Van de Graaff accelerators to be delivered in the summer of 1961.

Two accelerators will be installed at Commission research centers, one at *Argonne* and one at *Oak Ridge*. The third machine will be installed at *The Rice Institute*, Houston, Tex.

Research Facilities

Model C Stellarator

Princeton University operates one of four major laboratories carrying out Commission research to determine the feasibility of using controlled thermonuclear reactions to produce power. A research program initiated in 1951 at Forrestal Research Center focuses on the "stellarator concept" employing a device in which ionized gas is confined within an endless tube by means of a very strong externally applied magnetic field.

A number of small stellarators have been constructed in succession beginning in 1952. Stellarators, with their novel magnetic field configurations and methods of heating the gas plasma, are complex devices and require a great deal of careful design and fabrication.

Because the small stellarators have limited and specialized capabilities, a larger facility known as the Model C complex has been under construction for several years. Completion now is scheduled for 1961, a year later than originally planned. Model C will be strictly a research facility designed to yield scientific information, and is not expected to be a net power producer. The initial cost of Model C, including buildings and supporting facilities, is expected to be about $35 million.

High Flux Research Reactors

High neutron flux reactors are needed for producing very heavy elements for research purposes—californium 252 and other transplutonium isotopes—for conducting radiation damage experiments, for producing intense neutron beams, and for other specialized research. The neutron flux required is in the range of 10^{15} to 10^{16} (one million billion to 10 million billion) neutrons per square centimeter per second. While for certain uses, fluxes in the 10^{16} and higher are desirable, current technology is adequate only for construction of reactors with a flux not higher than 3 to 5 x 10^{15}. Reactors of this type, with supporting facilities, are estimated to cost between $10 and $15 million each.

The Commission has been authorized to construct two high-flux reactor facilities, one at Brookhaven National Laboratory, and one at Oak Ridge National Laboratory. Design work is under way.

The *Brookhaven High Flux Beam Reactor* (HFBR), scheduled to be completed in 1963, will be used for general nuclear research activities; the *Oak Ridge High Flux Isotope Reactor* (HFIR), scheduled to be completed in 1964, will be optimized for the production of transplutonium elements and special isotopes of lighter elements. It is expected to serve as a national facility for producing transplutonium isotopes.

Materials Research Facilities

The Federal Council for Science and Technology has recommended as part of the national materials research program, establishment on university campuses of interdisciplinary laboratories for materials research in order to foster training of students in this important field. The Council has further asked that Federal agencies which support materials research determine which institutions they were prepared to support.

The Congress has authorized the Commission to provide a facility of this kind at the *University of Illinois*. The Illinois facility would consist of a laboratory building and equipment for basic research in science related to materials development at advanced graduate and postgraduate levels.

Other Construction Activities

Among additional research facility projects, the Commission is sponsoring construction of two high current cyclotrons of novel design, the *Oak Ridge Isochronous Cyclotron* (ORIC) Oak Ridge National Laboratory and the *88-inch Cyclotron* at Lawrence Radiation Laboratory.

Also being built or designed are new *Central Research Laboratories* and *Transuranium Facilities* at Oak Ridge National Laboratory, special *Hot Laboratory Facilities*, Argonne National Laboratory and a new *Research Reactor* at Ames Laboratory. New *Physics* and *Chemistry* buildings are being built or planned at Brookhaven National Laboratory and Lawrence Radiation Laboratory.

Various physical plant facilities for nuclear research also are being sponsored by the Commission at university sites, including *Columbia and Yale Universities* and at *Massachusetts Institute of Technology*. The *California Institute of Technology* for many years has been operating a 1 Bev electron synchrotron provided by the Commission. The Commission also, in cooperation with the Office of Naval Research, helped fund the 1 Bev synchrotron at *Cornell University* and the 1 Bev Mark III linear electron accelerator at *Stanford University*.

Biology and Medicine

For research in the medical and biological fields—life sciences—the Commission expended $50 million for the fiscal year that ended June 30, 1960, including about $2 million for construction. Some $34 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 $16 million was for research in universities, colleges, and other nonprofit institutions carried out under 593 research contracts. This Annual Report to the Congress describes selected major activities during the past year pertaining to studies of nuclear civil effects and fallout. Results of basic research in the life sciences at major Commission installations were described in a special report to Congress.[11]

FALLOUT STUDIES

During 1960, studies of the mechanisms of radioactive fallout showed a revision of the trends in fallout rates and related uptake of radioactivity in foods; during the period since November 1959, no tests of large-scale weapons (French tests were not of this type) had been conducted and it was possible to follow the curves without interruptions due to new detonations. The total fallout studies program was described in detail in a previous report.[12] The Commission's research program in this field is not designed to monitor fallout radioactivity throughout the United States, but to support specific projects in biology and medicine related to fallout. The responsibility for monitoring environmental levels of radioactivity resulting from fallout was assigned to the Department of Health, Education, and Welfare by Executive order in August 1959, which gave that agency primary responsibility within the executive branch of the Federal Government for the collation, analysis, and interpretation of such data.

Current studies provide a body of data on levels of fallout at sites throughout the world but the main purpose of the measurements was to establish a base for continuing collection of data to improve understanding of fallout distribution, rate of deposition, and residence time in atmosphere.

With issuance of the Commission's April Quarterly Statement on Fallout (April 28, 1960), the Commission ceased to publish these statements directly; instead, the Commission supplies all such type of information to the U.S. Public Health Service, Department of Health, Education, and Welfare, for such publication as Public Health Service wishes to make in connection with its compilations including radiological health data from other Federal and State agencies, and

[11] "Atomic Energy Research in Life and Physical Sciences—1960", a Special Report to Congress by the United States Atomic Energy Commission, January 1961, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., $1.25.

[12] See pp. 239–266, Annual Report to the Congress for 1959 (January–December 1959).

...her sources. The Public Health Service issues these reports ...nthly; at quarterly intervals the reports include information sum-...aries of the type previously made public through the Commission's ...uarterly Statement on Fallout. The Commission has continued to ...sue technical reports on its fallout program.

Soil and Air Measurements

...il Samples

...trontium 90 levels in soil were sampled at locations throughout ...e world during 1958 cooperatively by the Commission's Health and ...afety Laboratory (New York, N.Y.) and the U.S. Department of ...griculture. These measurements provide information in the total ...rontium 90 deposition to specific dates from past weapons tests. ...uring 1959, soil samples were taken from nearly all the United ...tates as compared with only 17 locations in previous years.

The increase in strontium 90 in the soil from 1958 to 1959 agrees ...ith findings from monthly collections of fallout during that time. ...onthly collections (steel pots, ion-exchange columns, precipitation) ...the world-wide network of stations showed the highest rate of fall-...t to be early in 1959; this was followed by a lower rate. In the ...s quarter of 1959 a few collections in the United States showed a ...nd toward some increase in fallout but readings were below the ...gest rate observed earlier in 1959. Too few data for 1960 were ...ailable at the time of this report to warrant conclusions as to sea-...al variations.

...spheric Studies

...hodium 102 produced in tracer amounts at a high altitude by weap-... tests, and tungsten isotopes produced in other shots during the ... U.S. Eniwetok Proving Ground tests, provided means of study-... transport and rate of fall of radioactive debris placed in the ...sphere by these United States tests. These studies are being ...y the Air Force Cambridge Research Center with partial sup-... the Commission. Results obtained so far imply that the time ...d for material to move from the high stratosphere to the sur-... is much longer than for material placed initially in the low ...sphere. Comparisons between rhodium and tungsten tracers in ... indicate different histories of the debris mixing in upper and ... stratospheres. However, the information so far collected is not ...ent to establish either the distribution or the residence time of ...m 102 in the total atmosphere.

In addition to these studies to analyze stratospheric patterns, balloon sampling of stratospheric quantities of fission products was continued at San Angelo, Tex., during 1960 in cooperation with the Air Force under the technical direction of the U.S. Weather Bureau. Current results from this program are not yet available.

Levels of gross or total fallout beta radioactivity in surface air continued to decrease or remained about the same during the period July 1959 to June 1960 in both hemispheres. Levels in the Southern Hemisphere remained relatively stable during this period.

During late February and spring of 1960, transient increases in radioactivity in air and in precipitation samples were found at some stations. Identification of radioisotopes indicates that this debris apparently originated about mid-February and early April 1960, from the tests held by France in the Sahara Desert. These data show relatively small increases in fallout, persisting for a few days only, at levels much lower than observed in the spring of 1959. This fresh debris will add about 0.1 to 0.2 percent to total world-wide fallout of long-lived fission products.

At Argonne National Laboratory detailed studies of gamma radiation in air and soil have been made for several years.

The peak monthly levels of radioactivity from fallout at Argonne due to past tests occurred during April and May 1959. The rate diminished in a few months to a few percent of the peak rate. Cesium 137 still is accumulating slowly and had reached a value of about 200 millicuries per square mile in early 1960. Based on Argonne's calculated ratio of 1.6 between the amounts of cesium 137 and strontium 90 from fallout the amount of strontium 90 in soil would be about 125 millicuries per square mile. Radioactivity from French tests was observed in snow during late February, but no activity from this source was found in either soil or air samples.

Based upon these measurements integration of the whole-body dose from fallout in the Chicago area shows an expected increase of 1.1 to 3.3 percent greater than that which arises from natural radiation of that area.

Test Site Area

The Los Alamos Scientific Laboratory and University of California at Los Angeles have studied fallout at the Nevada Test Site and adjacent areas during all test activities there. The most recent work involved the 1959 test of Kiwi-A (a nuclear reactor for propulsion of unmanned vehicles, a part of the Rover Project).[13] In this device

[13] See p. 77, Annual Report to Congress (Jan.–Dec. 1959).

propellant is heated in the reactor core and ejected to the atmosphere through a jet nozzle. Studies were undertaken to measure in detail the resultant particle sizes, air concentration, and ground deposition of radioactive substances resulting from passing the propellant through the reactor core. Deposition velocities calculated at certain points showed wide variations from point to point and generally were larger than predicted from particle sizes.

The pattern of contamination was very narrow, levels were erratic, and off-site deposition was negligible. Attempts to combine the data with meteorological measurements indicated that the pattern could not be explained by existing models and a new model for this kind of dispersion is under investigation.

Fallout Measurements In Foods And In Man

Studies were continued on uptake of fallout material in foods through collection and analysis of milk, animals, certain fresh vegetables, forage crops, and wheat. Detailed results of these studies have been reported in the Commission's Quarterly Statements on Fallout, January and April 1960, and Health and Safety Laboratory Quarterly Reports. In this report, selected findings are described.

Strontium 90 in Wheat

Wheat samples collected in 1958 and 1959 and analyzed by the Health and Safety Laboratory continue to show average levels near the maximum levels previously observed, and analyses of both wheat and milling products have produced new maximum figures. Levels of radioactivity in foods are believed to depend on both the rate of fallout, which is tending to decrease, and the total accumulated amount, which is tending to increase, although the amount each component contributes is not yet known. Further, levels in foods vary with agricultural practices, seasons and types of agricultural products. A study of milling products from 1958 wheat from 9 States showed the highest average levels of strontium 90 and calcium in the bran and the lowest in patent flour. Levels in other types of flour were intermediate between bran and patent flour.

Carbon 14 in Oils

Studies at Los Alamos of carbon 14 in lemongrass and citrus oils from a number of locations have shown an increase of carbon 14 content in these oils. By mid-1959, carbon 14 activity in the troposphere and in lemongrass and citrus oils appears to have increased by about 27 percent in the Northern Hemisphere and 20 percent in the Southern Hemisphere.

Fallout Measurements in Man

Studies of cesium 137 in humans and in cow's milk have continued at the Los Alamos Scientific Laboratory since 1956. Levels have risen slowly and irregularly during this time. Irregular peaks and troughs occurred in milk levels due to fluctuations in tropospheric fallout and seasonal changes in diets of dairy herds. A similar pattern is observed in humans but is less pronounced. Maximum and minimum levels in people lag behind those of milk by about three months.

Studies of human bone levels of strontium 90 were continued by Lamont Geological Observatory, Columbia University, during 1959. The results of analysis through 1959 have been evaluated relative to dietary levels of strontium 90 and predictions of future levels have been made. The concentration of strontium 90 in human bone continued to increase in 1958 and 1959. The concentration of strontium 90 in adult bone is independent of the age of the individual whereas levels in children vary with age. The average level in the Northern Hemisphere for Western culture adults is about 0.30 micromicrocuries of strontium 90 per gram of calcium for 1959. The 1958 level was about 0.20 micromicrocuries. The highest average concentration for any age group in 1958 was about 2.1 micromicrocuries for one-year olds.

RESEARCH RELATED TO WEAPONS

Nuclear Civil Effects

Group Shelter Study

Holmes and Narver, Inc., Los Angeles, Calif., under contract with the Commission, has completed an engineering study of a group shelter successfully tested during the 1957 test series in Nevada. The engineering included modifications based on analysis of test results to improve the protective characteristics of the structure, and to improve interior arrangements, services, utilities and management.

In addition to architect-engineering drawings, the contractor prepared a brochure, a set of specifications, and a shelter operating manual. The brochure and operating manual have been published by the Commission as a single report, CEX 58.7, "*Group Shelter Study.*" [14]

Designed to protect 100 persons for 14 days or more, the shelter is a buried, corrugated metal arch structure on a concrete slab. With a minimum of three feet of earth cover over, the shelter attenuates the radiation intensity inside of about 1/10,000th of intensity outside. It also provides protection against blast pressures up to 35 pounds per square inch and protection against thermal radiation.

Instruments

Several models have been made by the Commission and by private firms for a simple, easy-to-use radiation detection and measuring instrument for home protection in a radiation emergency.

A pilot model prepared by a Commission contractor includes a conventional radio receiver assembled from a commercially available "do-it-yourself" kit. A switch allows a choice between radio and radiation instrument circuit. A selector will set the instrument to register a particular radiation level and sound a continuous warning.

Shielding Studies

Furthering the research accomplished during the measurement of the shielding against radiation afforded by typical residences [15] and the measurement of the shielding in the Commission's Headquarters building at Germantown, Md.,[16] studies were made of nine selected homes at Oak Ridge, Tenn.

The study is reported in CEX 59.13 "Experimental Evaluation of the Radiation Protection Afforded by Typical Oak Ridge Homes against Distributed Sources." [17] The protection factor, i.e., the ratio of open field exposure dose rate to exposure dose rate in the house, ranged in all houses from 2 to 5 on the main floor and from 5 to 30 in the basements, except in a fallout shelter in one house where the

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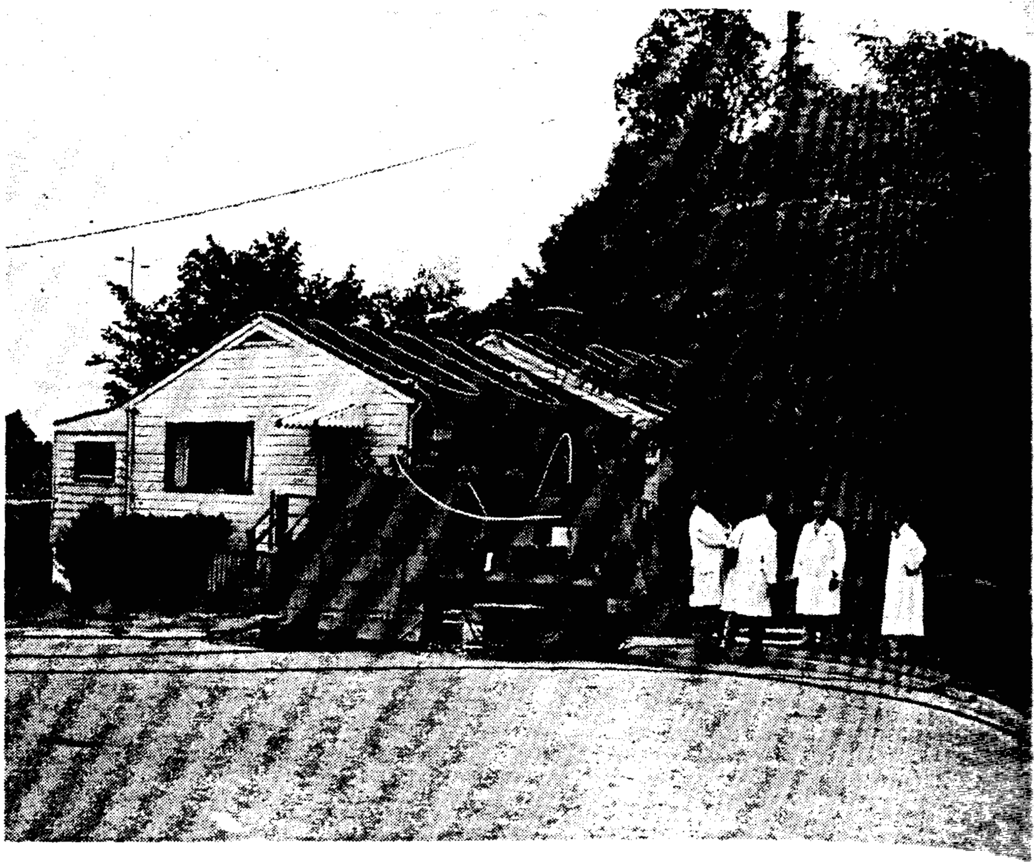
[14] Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., price $0.50.

[15] CEX-58.1, "Experimental Evaluation of the Radiation Protection Afforded by Residential Structures against Distributed Sources." J. A. Auxier, J. O. Buchanan, C. Eisenhauer, and E. E. Menker. Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Price $2.75.

[16] CEX-59.1, "An Experimental Evaluation of the Radiation Protection afforded by a Large Modern Concrete Office Building." J. F. Batter, Jr., A. L. Kaplan, and E. T. Clarke. Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Price $0.60.

[17] Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Price $0.50.



Protection Test. Work conducted at Oak Ridge National Laboratory has shown that the average home will offer a certain amount of protection against fallout radiation that might result from a nuclear war. The tests were conducted by surrounding each of several types of homes with a plastic hose through which a radioactive source was pumped to simulate radiation from wartime fallout. Inside the house, radiation detection instruments were placed in all rooms and at all levels to record the amount of radiation penetrating the structure to a specific area.

protection factor was greater than 100. On sloping lots, the protection factors were typically lower than in basements built on level lots.

During July, an experimental evaluation was made of the shielding in a modern medical laboratory building at Brookhaven National Laboratory; in September, measurements were made of the shielding afforded by a typical southwestern residence in Las Vegas, Nev., and at the request of the Office of Civil and Defense Mobilization, measurements were made on a new 20 by 100-foot, underground metal arch shelter at that agency's Region III headquarters in Thomasville, Ga.

Dosimetry Studies

Field experiments conducted during weapons tests in operations Plumbbob, (1957) and Hardtack, Phase II (1958) provided data to

...ck the reliability of the estimates of the neutron and gamma ray ...posures as estimated for survivors of the Hiroshima and Nagasaki ...onations in Japan. In Japan, through the program of the Atomic ...mb Casualty Commission, shielding histories of individuals are ...ing obtained so that it may be determined for each case how much ...ielding against radiations there was between the subject and the ...urces of radiation.

To improve understanding of the shielding effect of various con...ntional materials and structures under field conditions, plans are ...ing made to simulate emission of bomb neutrons and gamma rays by ...spending a small, low-power, unshielded reactor from a balloon ... the Nevada Test Site.

To provide accurate, early data on neutron and gamma ray emis...ns in the event of a criticality accident, a Nuclear Accident Dosim...try system was put into effect in mid-1959 for the use of Commis...on laboratories and plants.

Regional Surveys

...rial Measurements

An extensive program of Aerial Radiological Measurements and ...rveys, called the ARMS Program, has been conducted by the Com...ssion to measure and map background radiation levels for selected ...as. Under contract, U.S. Geological Survey aircraft have com...ted surveys of some 23 areas.

Another element of the program is the Extended Source Calibra...n Area at the Nevada Test Site. This consists of a 2,000 by 2,000-...t square on which 565 small cesium 137, cobalt 60 and other isotope ...rces can be arrayed so that the plane sources are "seen" by air...rne instruments. The low intensity field will be used for intercali...ation of aerial radiometric instruments.

Facilities For Research On Blast Biology

The Lovelace Foundation for Medical Education and Research, Al...querque, N. Mex., has been engaged in research on the biological ...ts of blast from nuclear weapons. Studies have been made of (a) ...sical phenomena related to blast to determine hazardous environ...ntal variations, and (b) the biological responses associated with ...osure to forces generated by large-scale explosions. The Com...sion has furnished the primary support for this work at its facil...s at Sandia Base, at the Lovelace Foundation laboratories in

Albuquerque, and at the Nevada Test Site during the nuclear test series in 1953, 1955, and 1957.

The facilities at Sandia Base include shock tubes of 12, 24, and ... inch diameters used to study primary blast effects associated with variations in pressure. Concurrent studies are being carried out on such effects as damage from penetrating and nonpenetrating missiles and from test subjects being projected through space by blast-produced winds.

Research In Blast Biology

Specific accomplishments of the blast biology program over the last 12 months are described in this report.

One study established mortality curves for mice, rats, guinea pigs and rabbits exposed to shock waves accompanying "instantaneously" rising overpressures 6 to 8 seconds in duration. Variations in mortality with the magnitude of the incident and reflected overpressures were summarized in a report.[18]

A laboratory study on the effects of sharply rising pressures of ... to 4 milliseconds (*msec*) duration on mice, rats, guinea pigs, and rabbits was completed during the reporting period. The results indicated that the tolerance of these four species to such pressures was the same as that when the duration was 6 to 8 seconds. A series of experiments on the effects of "sharp" rising pressures of 400 msec duration on dogs was partially completed.

The tolerance of different animal species is expressed as the P_{50}, or the pressure that kills 50 percent of a particular species. Data indicate that under the conditions of the experiments the magnitude of the pressure was the significant factor in injury and the duration of the wave less important for small laboratory animals.

A secondary blast missile can be any object from the local environment, such as fragments of glass from windows, building debris, stones, etc. By specially-devised trapping techniques, the velocities and masses of more than 20,000 secondary missiles—factors that affect the injuries caused—were determined from data obtained in 1955 and 1957 nuclear weapons tests in Nevada. A mathematical model was

[18] "Shock Tube Studies of the Effects of 'Sharp'-rising, 'Long'-duration Overpressures on Biological Systems," D. R. Richmond, R. V. Taborelli, F. Sherping, M. B. Wetherbe, R. T. Sanchez, V. C. Goldizen, and C. S. White, AF Document SWR–TM–59–2, pp. 171-18[illegible], Proceedings of the Third Shock Tube Symposium, 10–12 March 1959, Hqs., Air Force Special Weapons Center, ARDC, Kirtland Air Force Base, New Mexico.

prised which made these results generally applicable to weapons of yield and in varying atmospheric conditions.

To determine the consequence of a body being hurled through space blast winds, anthropometric dummies were placed on two shots in field tests, and one successful attempt was made to record the dummies' motion by means of high-speed photography. Under conditions of the blast and site, the dummy was thrown 22 feet, attaining a maximum velocity of 22 feet per second in one-half second. This indicated that the same mathematical model used to predict the velocity and displacement of secondary missiles could be used to predict the behavior of the dummy.

Nuclear Effects Information

Revision of "The Effects of Nuclear Weapons"

The 1957 edition of the handbook, "The Effects of Nuclear Weapons" is being revised again jointly by the Department of Defense and the Commission. Publication is scheduled for late 1961.

Comparative Nuclear Effects Data

A brochure is being prepared to summarize unclassified data to simplify the appraisal of the impact on man of a range of nuclear detonations. The information is of value to those concerned with casualty estimates, protective construction, and post-attack medical requirements. The brochure is based on data presented in "The Effects of Nuclear Weapons" and subsequent field and laboratory experiments and will be issued by the Commission as CEX 58.8 "Comparative Nuclear Effects of Biomedical interest."[19]

Radioisotope and Radiation Development

Highlights in 1960 of the Commission's program to expand and accelerate the growing beneficial applications of radioisotopes include:

An increase in the number of byproduct licensees, now numbering ... as compared with 5,417 at the same date in 1959, including a 11 percent increase in industrial licenses.

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[19] Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

Continuing high demand for radioisotopes as reflected in sales of 191,122 curies valued at $1.9 million although sales declined 14 percent and 1.6 percent, respectively, over the previous year owing to remodeling of production facilities.

Negotiation of 32 contracts for research and development on such projects as isotopic power production, water resource development, environmental contamination control, sensitive analytical techniques, and other promising applications of radioisotopes.

Development of isotopes production facilities through improvement of fission product separation processes and beginning construction of a radioisotope process development laboratory.

Price reductions for widely used carbon 14 and cobalt 60.

Advances in the development of high intensity radiation as a potential industrial processing agent with negotiation of 15 research and development contracts related to radiation technology, and initiation of construction of a new facility to study the engineering problems associated with the application of large isotopic radiation sources.

Establishment of a food irradiation processing program to demonstrate the technical and practical feasibility of this method of extending the refrigerated shelf life of certain foods.

Expansion of educational opportunities for radioisotope technology training with the award of 36 equipment grants totaling $224,107 to 37 colleges and universities in 22 States.

LICENSING, PRODUCTION AND SALES

Radioisotope Licensing

During the year ending November 30, 1,713 byproduct material licenses and 5,151 amendments and renewals of existing licenses were issued. Included in this number are 947 licenses which were issued to new licensees: 357 in the field of medicine, 284 to industrial firms, 252 to Federal and State laboratories, and 54 to users in other fields. As of November 30, 5,907 organizations and individuals in the United States possessed byproduct material licenses. There was a net increase of 490 licensees during the past year, of which 40 percent were for industrial use (after eliminating all licenses expired and not renewed). Appendix 4 shows all byproduct material licenses and new licensees by State and type of user. Thirteen licenses were issued, pursuant to Section 30.24(f) of Part 30, to authorize distribution of various types of gaging, ion generating and chromatography analytical devices under general licenses.

Production And Sales

During 1960, the number of curies of radioisotopes shipped from Oak Ridge National Laboratory, the Commission's principal supplier, showed a decline as a result of the 9-month shutdown of the Fission Product Pilot Plant (F3P). During the shutdown, the plant was remodeled for increased production capacity. At the year's end, when the F3P was ready to resume operation, a substantial backlog of orders for radioisotopes existed, including orders for 150,000 curies of cesium 137 and 1,000,000 curies each of cerium 144 and strontium 90.

As of November 30, a total of 191,122 curies had been shipped during 1960, as compared with the 222,703 curies shipped for the same period in 1959. A parallel decline in gross income from radioisotope sales also was shown, $1.9 million for the first 11 months of the year as against the $2 million in 1959. Sales of radioisotopes from Oak Ridge since the beginning of public distribution in 1946 now total 1,105,026 curies. The number of individual shipments made during 1960 totaled 11,773, down somewhat from the 12,028 of the previous year. Total shipments since August 1946 reached 143,378.

Sales of carbon 14 during the past year were up 50 percent over the 1959 figure, reflecting price reductions on carbon 14, cobalt 60, and other radioisotopes during early 1960.

During the year, the first private production of radioisotopes for commercial sale was announced. Abbott Laboratories, using a commercially owned reactor, began the production of iodine 131. The General Electric Co. and Westinghouse Electric Corp. both announced the intention of using their test reactors for the commercial production of cobalt 60. These actions are consistent with the Commission's announced policy of encouraging private industry to provide services previously available only from Commission facilities.

Shipments of radioisotopes to foreign countries continued to increase. The Commission and private processors, combined, made some 4,857 shipments during 1960 as compared with the 3,252 during 1959.

Foreign suppliers also were making sales to United States industry. Belgium, France, and Israel joined Canada and the United Kingdom as the main sources. The following figures, supplied by the Bureau of Census, show the trend of the export-import dollar volumes for radioisotopes:

	U. S. EXPORTS	U. S. IMPORTS[a]
1952	$239,298	$85,84[illegible]
1953	521,788	169,7[illegible]
1954	536,476	149,7[illegible]
1955	1,288,017	188,7[illegible]
1956	905,995	514,4[illegible]
1957	1,367,067	823,2[illegible]
1958	1,533,859	907,8[illegible]
1959	1,282,575	1,145,1[illegible]

[a] Import values include containers, encapsulation charges, devices in which the radioisotopes are employed, insurance, shipping and other costs, and thus are not a true comparison with Commission sales which refer only to unfabricated radioisotopes.

ISOTOPES DEVELOPMENT PROGRAM

Emphasis in the isotope program is placed on development of basic technology that may be widely applied, particularly to matters of public, State and municipal concern such as improving water resources, combating atmospheric pollution, assuring proper treatment of industrial wastes before discharge to the environment, and detecting crime.

During 1960, 32 research and development contracts in this field were negotiated with research centers, universities, industrial organizations and other government agencies.[20]

Isotope Electric Power Production

During 1960, the Commission made progress toward safe application of strontium 90 in programs to develop equipment that will generate electricity directly by applying the heat of radioactive decay

[20] Reports issued under these contracts are annotated in *Nuclear Science Abstracts*, in which their availability also is indicated. Final reports issued to date are listed in Appendix 6. For a general review of activities in isotope technology development to the beginning of 1960, see "Radioisotopes in Science and Industry; A Special Report of the U.S. Atomic Energy Commission." Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.25.

to thermocouples. Thermocouples are bimetallic devices which generate a small current of electricity when one end is maintained at a higher temperature than the other end. Strontium 90 is especially useful in such devices. It is available in large quantities from the waste products of chemically processing fuel elements of reactors. Its beta radiation will not penetrate outside the heat chamber and consequently the generator can be handled readily. Since strontium 90 is long-lived, the generator could operate for some years without recharging, and with only gradual loss of power. Removal of strontium 90 from wastes, if the radioisotope should be used in great volume, would somewhat reduce the problems of waste disposal since strontium 90, with cesium 137, is the chief long-lived hazard of these wastes.

An important technical advance during 1960 was the successful development by The Martin Co. under a Commission contract of a method for safely containing strontium 90 by "locking it up" chemically in a ceramic material, strontium titanate. Strontium titanate is chemically inert—that is, it will not corrode or enter into other chemical reactions—and it has the proper physical properties such as heat transfer, tensile strength, etc. Encased in stainless steel, the corrosion-proof strontium titanate can ensure against the release of strontium to the environment for at least 500 years, by which time its radiation would be reduced to 1/250,000th of its initial level.

With this accomplished, a second phase of the program was initiated under the Martin contract to prove that a strontium 90 thermoelectric generator could be constructed which would continue to provide 5 watts of electricity for as long as 10 years without recharging.

In a cooperative program with the U.S. Weather Bureau, the Commission has constructed a thermoelectric device to power an unmanned weather station for transmission of weather information from remote locations. The station was completed and testing was begun during late 1960. It will make possible continuous collection of weather data from previously unreported regions such as the Arctic.

The successful technological developments under this program have led the Navy and Coast Guard to authorize construction by the Commission of four additional units to prove their applicability in light buoys and floating weather stations (see section on Aircraft Reactors Program).

Other work to apply similar devices to provide auxiliary power for man-made satellites of the earth is reported elsewhere in this report in the section on the Aircraft Reactors Program.

Remote Weather Station. Artist's conception of the remote automatic weather station, designed for the Commission and the U.S. Weather Bureau by The Martin Co., as it might appear in the Arctic snow. The unmanned station can operate 2 years without human attention. The cylinder shown in the cutaway form is 8 feet high and 32 inches in diameter. The smaller cylinder inside contains about a pound of radioactive material, surrounded by thermoelectric elements to convert heat directly into electricity for operation of the weather measuring instruments and a radio transmitter.

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Water Resource Development

The Commission is working with the U.S. Geological Survey and other groups in developing nuclear techniques to solve water resource problems. Radioisotopes offer unique means for helping to increase understanding of underground flows of water and other water resource factors such as rainfall, runoff, ground reservoir recharge and waste disposal.

Lake McMillan, an underground reservoir in New Mexico, is being tagged with very low quantities of tritium to measure its volume. Accurate knowledge of the quantity of stored water in the reservoir will permit more efficient utilization of the water for irrigation. Tracer technology being developed in such studies may find wide application in water resource development and conservation.

Environmental Contamination Control

Air Pollution

For quick collection of data and implementation of control procedures in smog control, the Commission, in conjunction with the Air Pollution Foundation of California, is developing a trace analyzer using krypton 85 to measure instantaneously and continuously the concentration in the atmosphere of the contaminant, sulfur dioxide. In this device, chemically inert krypton 85 is bound in a material which, on contact with sulfur dioxide, releases minute amounts of the radioactive gas which then can be detected and measured.

This development is based on research begun early in the isotopes development program to explore new radiochemical analytical methods. After the instrument is completed, it will be field tested by the Air Pollution Foundation for an additional year.

A second atmospheric analyzer has been evolved as a result of the original research. A proof-of-principle model of an analyzer to measure ozone content of the upper atmosphere has been tested successfully. A test instrument flown by the Air Force in a high-altitude weather balloon proved that the technique can be used to measure ozone from the earth's surface up to 100,000 feet altitude. Development work to develop a rugged model is being carried out by the ...

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Smog Control. Working with the Air Pollution Foundation of California, the Commission is sponsoring development of devices which may help control smog problems such as is shown in the *above photo*, taken on a smoggy day in Los Angeles. *Opposite photo* is a portable air pollution sampler developed for monitoring the sulfur dioxide content of atmosphere within industrial plants. The detector (cylinder) contains an inert gas which, upon contact with sulfur dioxide, releases measurable amounts of radioactivity that can be "read" on the dial. Similar, but larger, devices are being developed for continuous monitoring of atmosphere over cities.

Water Pollution

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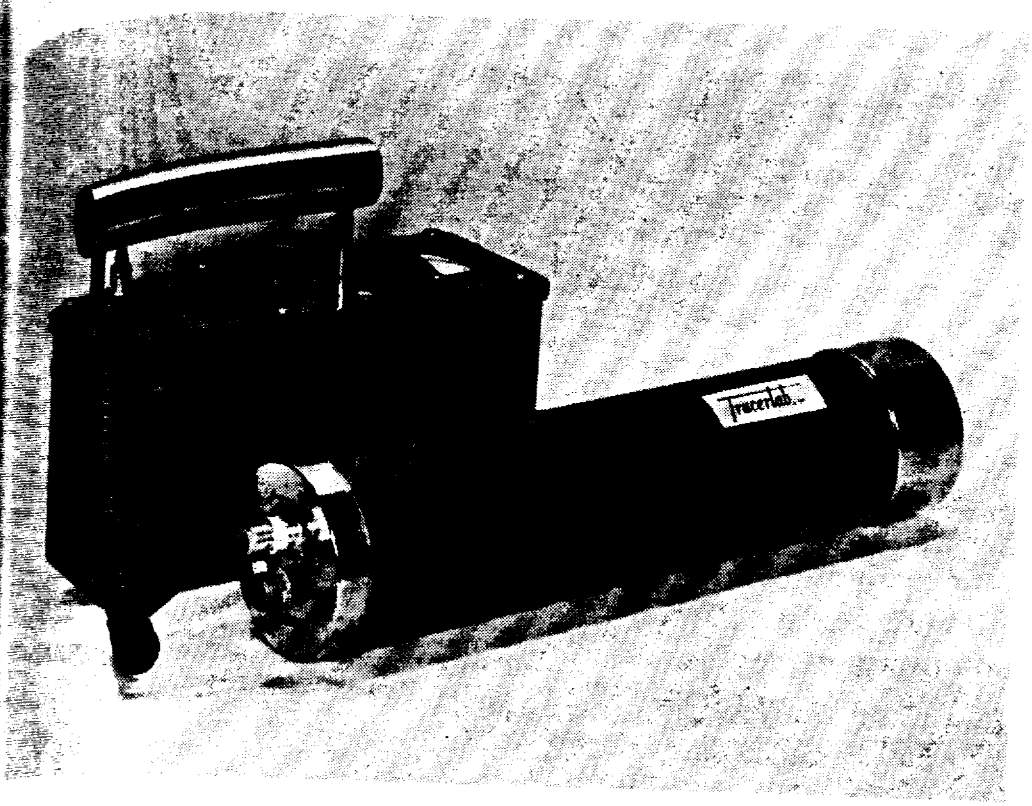
Control of water pollution is the object of other isotope technology nvestigations. A representative study in this field is application of acer methods to research on degradation of detergents by sewage sposal plants with a view to controlling excessive frothing which



hibits sewage treatment, and entry of incompletely degraded de- rgents into public water supplies.

Radioisotope tracer methods also can identify the origin of indus- al stream pollutants and help to develop control methods.

Isotopic Analytical Procedures

sotope techniques are being developed for application to a wide riety of analytical and bioassay methods potentially useful in food d drug industries. This research is based on a survey study carried by Massachusetts Institute of Technology that outlined areas of earch in which potential radioisotope techniques might be used.

of California, the / help control of / a smoggy day in / ler developed for / ndustrial plants / ntact with sulfur / an be "read" on / ntinuous monitor

Drugs and Foods

A double isotope dilution method is being developed for amphetamine, an important medicament for stimulation of the nervous system. The technique uses carbon 14 labeled amphetamine and an iodine 131 labeled reagent, and is potentially capable of determining the presence of as little as 0.05 micrograms of amphetamine in production samples. The technique is 200 times more sensitive than conventional methods.

Use of radioisotopes as indicators of biological activity is being investigated to make possible more rapid bioassay methods to test pharmaceutical products. Measurements of uptake of sodium 22, zinc 65 and phosphorus 32 by tissues of laboratory animals after injection of estrogens, androgens and growth hormones appear to offer rapid and inexpensive methods of assuring accurate composition of these drugs.

This investigation completes Commission studies in this area since it has been proved that radioisotopes offer a useful technique for measuring small quantities of medicaments in complex mixtures. A final report has been prepared.[21] Future work in this area will be carried out by private industrial or research laboratories.

The Commission is continuing developmental studies on using radioisotope techniques to detect in foods the residues of agricultural chemicals, of detergents used in washing fresh vegetables, and of toxic derivatives of wrapping materials.

Neutron Activation Analysis

Neutron activation analysis, based on measurement of radiations induced in certain elements by neutron bombardment from a small neutron source, is capable of great sensitivity and accuracy. In some cases, this technique may substitute for conventional methods that lack sensitivity. Currently neutron activation analysis is being applied as a research tool: in medicine, to determine trace metals in tissues; in

[21] "Development and Expansion of Radioisotope Applications in Pharmaceutical and Allied Industries" (NYO-2635). Nuclear Science and Engineering Corp., Pittsburgh, Pa., November 1960, 245 pages. Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., $3.00.

...stry, to analyze oil well cores and determine trace impurities in ...leum products, chemicals, and semiconductor materials; and in ...gy, oceanography, agriculture, meteorology, public health and ...r sciences, for a variety of tests. Limitations in the properties of ...sing neutron sources, nuclear reactions that interfere with analysis, ...chemical problems of source preparation are being studied.

...lated projects deal with development of automatic systems and ...puter data handling that should permit analysis of large numbers ...samples at high speed—a development important in using this ...nique with rock cores and water, soil and biological samples. ...d analog and digital computer devices to handle activation analysis ...are being tested. High speed computers also should increase ...uracy of analysis by making possible application of statistical ...hniques to data.

...uctive beam. Under contract with the Commission, Catholic ...ersity of America is studying the possibility of detecting hidden ...osives, as in airplane luggage, by neutron beam examination. In ...peration with the Treasury Department, an investigation is check... the possibility of identifying the origin of opium to facilitate ...rol of drug traffic. Identification of minute amounts of unique ...ents absorbed during growth of plants, thus identifying origin, ...been proved feasible for tobacco. In related industrial use, the ... of nylon thread produced at separate plants has been identified ...arly.

Process Control

...dioisotope tracer techniques are being investigated as methods of ...g variables within an industrial process to control or regulate the ...ss. A laboratory setup of a nickel refining process has been built ...ermine the feasibility of controlling iron removal from process ...by measuring changes in activity of incorporated radioactive ... and automatically adjusting chemical, temperature and other ...meters.

...his method proves out, it will have application in many other ...strial processes. Operations that could be automatically con...d by radioisotope tracer techniques are being studied.

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RADIOISOTOPE PRODUCTION DEVELOPMENT

Improved Production

Continuing progress is being made in research and development efforts to produce new isotopes, improve quality, increase availability, and reduce costs to meet the changing needs of science and technology for a wide variety of radiomaterials.

The Commission's Fission Product Pilot Plant at Oak Ridge National Laboratory was modified during 1960 to improve its capability for large-scale separation and purification of fission products. The plant is directed to research on fission products separation technology and for production of kilocurie amounts of strontium 90, technetium 99, cesium 137, cerium 144 and promethium 147.

New ion exchange and solvent extraction techniques were developed to achieve high purification of fission products used in isotope-powered thermoelectric generators. Equipment of new design was constructed for shipment of massive quantities of radioactive materials, and processes are under development to convert fission products into forms safe for shipment.

Construction of a new $1.5 million, 40,000 square foot laboratory for radioisotope process development has been started at Oak Ridge. Completion of this laboratory will facilitate research on providing a wider variety of radioisotopes of improved quality at lower cost.

The Oak Ridge Research Reactor, which has up to 300 times the neutron flux of the reactor previously used, now is contributing to radioisotope production. The greater flux makes possible larger production of short-lived isotopes and of high specific activity materials.

Several new radioisotopic materials have been made available. Krypton 85 of high specific activity and highly enriched carbon 14, containing 85 percent radioactive atoms, have been produced for the first time by thermal diffusion. Increased availability of high purity iodine 131 has been assured by a new production technique in which enriched uranium 235 is irradiated.

At Hanford, considerable work is being done in the separation of strontium, cesium, and cerium radioisotopes from production plant chemical effluents under the radioisotope production development program.

The price of carbon 14, the most important tracer used in biological research, was reduced 27 percent during 1960, following a 50 percent reduction the previous year. Major reductions, ranging up to 70 percent were made in the price of certain forms of cobalt 60, particularly for large shipments and material of high specific activity. All quantities greater than 100,000 curies now are priced at $1.00 per curie.

The stable isotope helium 3 was made available for sale to the public on July 1 from the Commission's Mound Laboratory, operated by the Monsanto Chemical Co. at Miamisburg, Ohio. Development of an efficient gaseous thermal diffusion process for separation and purification of the isotope made it available in quantity for the first time. The price for helium 3, with 99 plus percent isotopic purity, was reduced from $1,500 to $150 per liter. The isotope has a wide number of uses, but is especially useful in low temperature research.

INDUSTRIAL PROCESS RADIATION DEVELOPMENT

The Commission's program for applications of radiation sponsors research and development directed toward utilization of massive quantities—millions of curies—of radiation energy in industrial processes. Evaluations made on the current state of the technology and research and development requirements for using radiation showed the following needs:

1. The mechanisms by which radiation interacts with molecules and the excited species thus produced need to be better understood;
2. Means of increasing yields of desired products by changing experimental variables such as temperature, pressure, etc., need to be further studied;
3. Design of radiation sources and facilities so as to increase efficiency of radiation use and assure safety requires more thorough investigation;
4. Availability of radiation sources must be increased;
5. Costs of radiation must be reduced.

During 1960, 15 research and development contracts and interagency agreements were negotiated toward accomplishment of these purposes.

Process Research

Silicon Production

A representative study demonstrated that silicon of a semi-conductor grade could be produced by irradiation of silane (SiH_4) at temperatures well below that now necessary in thermal production techniques; this established the possibility of future development by private industry of a radiation process for this product. Success also was achieved in adding acrylonitrile to cotton by radiation techniques, improving its resistance to attacks of microorganisms.

Other Projects

Successful applications of radiation have resulted primarily from fundamental projects. Accordingly, Commission contracts emphasize projects aimed at developing basic information on effects of temperature, pressure, phase, purity, and other variables on radiation reaction yields and kinetics for chemical systems of potential industrial interest. Studies include mechanism of radiation halogenation of aromatic compounds, effect of solid absorbents on radiation yields in organic systems, relation of molecular structure to radiation graft copolymerization, increasing efficiency in the radiation vulcanization of rubber compositions, improvement of properties of textiles through radiation modification and use of radiation to improve sedimentation of sewage.

Fundamental investigations include determination of the nature and distribution of ions produced by impact of high-energy radiation on gas-phase molecules and extension of current theories of radiation phenomena.

Source Development

Radiation source development, including accumulation of basic engineering knowledge essential to effective and safe design of process irradiators, also is being advanced.

Gamma Ray Sources

Brookhaven National Laboratory is a center for this type of work, carrying out studies on economic evaluations, source development (other than source production), increased source efficiency, safe development of associated engineering equipment to meet radiation processing requirements, and radiation physics studies necessary for development of radioisotopic sources and evaluation of their properties and potential industrial usefulness as sources of ionizing radiation.

A new facility which will contain 500,000 curies of cobalt 60 is being constructed to permit studies on the engineering problems associated with use of high intensity isotopic sources. The new facility to be completed by late 1961 will cost an estimated $1.6 million. Experimental work has resulted in improved design concepts for large cesium 137, cobalt 60 and sodium 24 irradiators.

In a cooperative research program with the U.S. Bureau of Mines, the Commission will furnish a 100,000 curie cobalt 60 radiation source for research on the use of coal as a raw material for production of industrial chemicals through irradiation, development of improved metallurgical processes utilizing radiation, and similar research on other natural resources.

The Commission also will furnish 50,000 curies of cobalt 60 to the National Bureau of Standards for use in a cooperative research program on effects of radiation on polymeric substances, gamma ray dosimetry and extension of gamma ray standards.

Beta Sources

Beta-emitting radioisotopes represent a considerable resource of radiation energy that might effectively supplement the more penetrating radiation from gamma emitters. Ultimate use of abundant fission products such as strontium 90 is the aim of studies now under way on the technology and applications of large beta radiation sources.

Electron Beam Applications

Commercial firms have continued to produce electron beam irradiated materials, including a transparent polyethylene food wrapping, improved wire and cable insulation that has been accepted for the Polaris missile electronic system, and irradiated plastic parts with superior strength, lightness, and temperature resistance particularly suitable for weapons and missile systems.

Many commercial radiation-produced products are based on technology developed under Commission-sponsored research.

Radiation Processing of Food

The Commission's program on radiation preservation of food is aimed at developing the technology to demonstrate technical and prac-

Better Product. **Subjecting plastic materials to nuclear radiation may cause chemical or physical changes which result in a superior product. Above photo shows the results of a General Electric Co. experiment in which pieces of irradiated and nonirradiated polyethylene film were subjected to 300° F. heat. The irradiated film (left) retained its form, while the nonirradiated piece (right) "flowed" and lost its original characteristics.**

tical feasibility of using relatively low amounts of radiation to extend the refrigerated shelf life of perishable foods. Product and market development to establish low dose radiation processing of food as a routine commercial method would be the responsibility of private industry.

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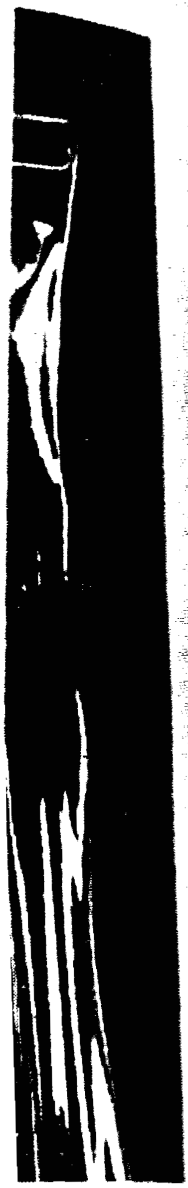

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Low dose radiation processing—in this case less than 1 million rad as contrasted with 3 to 5 million rad high dose radiation for long-term preservation without refrigeration—promises to be the most immediately useful civilian application of ionizing radiation for food processing purposes. If successful, it could assist food distribution by making foodstuffs available in as near fresh condition as possible and minimizing processing effects on quality. It could have economic value by making it possible to distribute near-fresh perishable foods in distant markets.

The Department of the Army Quartermaster Corps program is concentrated on high dose radiation sterilization of foods—to destroy virtually 100 percent of the spoilage organisms and permit long-term storage without refrigeration.

At Commission request, the American Institute of Biological Sciences has established a committee of scientists to consult with the Commission's Division of Biology and Medicine and Office of Isotopes Development on technology, nutrition and wholesomeness factors in radiation processing of food.

Two Preliminary Studies

Two specific areas of low dose processing have been investigated by the Commission preliminary to detailed research. Under contract, Stanford Research Institute has reviewed all technical aspects of low-dose processing of fruits and vegetables, and made a market analysis of the potential role of radiation processing and its economics.

A companion technical study on radiation preservation of fish has been completed by Massachusetts Institute of Technology, and related marketing factors and economics are being studied by the Bureau of Commercial Fisheries, Department of the Interior.

Next Steps

These studies, plus information developed during the Quartermaster Corps experiments, have provided a basis for programing specific experiments.

Special low dose food research irradiators are being designed at Brookhaven National Laboratory, and the first, using 25,000 curies of cobalt 60, was completed during 1960. Brookhaven will conduct continuing design studies on other specialized irradiation facilities with larger radiation sources.

RADIOISOTOPE TRAINING AND EDUCATION

The Commission's radioisotope technology training activities are intended to help incorporate appropriate background and techniques into existing and new courses in the physical sciences and engineering. The program includes equipment grants, faculty training, and course development.

Under its equipment grant program, the Commission during 1960 made 36 awards totaling $224,107 to 36 institutions in 22 States. Funds went for acquisition by colleges and universities of radiation detection devices, radioisotope handling equipment, and related laboratory demonstration apparatus. Emphasis in use of the equipment is on teaching, as distinct from research.

In cooperation with the National Science Foundation, the Commission during 1960 supported three faculty training institutes on use of radioisotopes, radiation principles, and safe handling techniques, at the Oak Ridge Institute of Nuclear Studies, Massachusetts Institute of Technology and the University of California at Berkeley. The institutes were attended by 97 members of 75 college faculties.

In developing laboratory radioisotope manuals and training aids, tested radioisotope experiments have been compiled for use in the college chemistry curriculum, together with instructors' notes. The experiments are particularly appropriate for use by institutions with limited equipment. A set of experiments on chemical use of high-intensity radiation has been developed as has a cobalt 60 irradiator suitable for laboratory experiments in advanced graduate and undergraduate courses.

The Commission also assists in training senior technical personnel of industry in radioisotope technology and, during 1960, industrial isotope courses at the Oak Ridge Institute of Nuclear Studies were attended by 135 persons.

An educational film, "Industrial Applications of Radioisotopes," in color and approximately 57 minutes in length, was prepared under Commission contract. Directed to industrial management, engineers, and technicians, the film illustrates industrial applications of radioisotopes in tracing, radiography, and gaging. The film may be borrowed for nonprofit showing from any Commission film library (see Appendix 7).

The Commission also has cooperated with various educational and industrial organizations in a series of regional conferences covering radioisotope techniques, safety practices and regulatory controls. During 1960, conferences were held in 7 locations and were attended by 1,100 industrial personnel.

International Activities

Developments during 1960 in international atomic energy activities include:

• *International Atomic Energy Agency.* The Fourth General Conference of the Agency accepted principles and procedures to serve as a foundation for an international safeguards system against diversion of special nuclear materials and equipment from peaceful uses. Some member states offered to place nuclear facilities under Agency safeguards as soon as the Agency is ready to assume these responsibilities. Arrangements were made for agreements under which the Agency will act as an agent in providing special nuclear materials to Finland and Norway, and heavy water to Yugoslavia. The Agency met an increased number of requests for technical assistance not only from allotted funds but also with special assistance from additional funds provided by the United Nations Expanded Program for Technical Assistance, and from those offered by the United States in offers for equipment in kind valued up to $192,000.

• Progress was achieved toward resolving the *public liability* question by the IAEA, Organization for European Economic Cooperation (OEEC), the European Atomic Energy Community (Euratom), and by individual nations by reaching a clearer understanding and agreement on national, regional, and international levels of this major problem. Sixteen member states of the OEEC signed an agreement establishing uniform standards governing civil liability for nuclear hazards.

• In the Euratom-United States joint program, research and development work was continued and the second round invitation for construction of two nuclear power plants to be completed by 1965 was to be issued early in 1961.

• Exchange of scientific and technical personnel and unclassified information was initiated between the Union of Soviet Socialist Republics and the United States under the McCone-Emelyanov Memorandum of Cooperation signed in November 1959.

• Visits and discussions of developments in the peaceful uses of atomic energy were arranged between scientific and technical personnel of the United States and those of India and Yugoslavia.

• Peaceful nuclear energy developments in the Western Hemisphere were promoted through the Second Inter-American Nuclear Energy

Commission meeting, the Third Inter-American Symposium on the Peaceful Uses of Atomic Energy, and through use of the Puerto Rico Nuclear Center where a 1,000 kw (thermal) reactor was dedicated in August for nuclear training and research.

INTERNATIONAL AND REGIONAL COOPERATION

International Atomic Energy Agency (IAEA)

Fourth General Conference

The fourth annual General Conference of the International Atomic Energy Agency took place at the Agency's headquarters in Vienna from September 20 through October 1. Sixty-three of the 70 member states were represented and five additional countries became members during the Conference.

As head of the United States delegation, U.S. Atomic Energy Commission Chairman John A. McCone urged in his general statement that all members increase their contribution in support of Agency programs. He also recommended a strengthening of the Agency's technical programs, continued action on international problems of health, safety and waste disposal, and the endorsement of the detailed IAEA safeguards system that had been developed by the Board of Governors.

The provisionally approved Agency safeguards were endorsed by the General Conference. Implementation of these procedures will carry out the safeguard function specified in the Agency's statute and enable the Agency to administer safeguards under U.S. bilateral agreements at the request of the Nations concerned. Seven countries announced during the Conference their willingness to have such bilateral safeguards transferred to the Agency for administration.

In further sessions the Conference approved a 1961 budget totaling nearly $8 million and adopted resolutions strengthening the programs of technical assistance, development of nuclear power, and distribution of scientific information.

Safeguards. In April, the Agency Board of Governors provisionally approved for consideration by the Fourth General Conference, recommendations on the Agency's initial safeguards principles and detailed implementing procedures as well as on the rights, privileges and immunities of safeguards inspectors. The United States figured prominently in the development of these procedures.

The September action of the Fourth General Conference was the approval of a 15-country resolution that the Board of Governors take into account, as appropriate, the views expressed in the General Conference before giving effect to the Agency safeguards principles and procedures. The Board of Governors was invited to report to the future General Conference on the Agency's implementation of safeguards.

During the Fourth General Conference also, the United States offered to place four reactors in this country under Agency safeguards. This offer was made to demonstrate that Agency safeguards do not infringe upon national sovereignty, and to provide in effect, a field laboratory in which the safeguards principles and procedures could be tested and improved. The Brookhaven Medical Reactor, the Brookhaven Graphite Research Reactor, the Piqua Organic Moderated Reactor, and the Experimental Boiling Water Reactor were included in the four-facility offer. During the period in which safeguards would be attached to these facilities, the provisionally approved safeguards principles and procedures would be applied, including verification of appropriate accounts and records, and visits by the Agency's inspectors.

Highlights of 1960 in activities of the International Atomic Energy Agency are described in the following sections.

Funds

The payment by the United States to the International Atomic Energy Agency's total regular assessed budget of $5,843,000 was $1.9 million. Voluntary contributions to the Agency's operating budget during 1960 were $957,837, of which the United States provided $500,000 that had been pledged unconditionally. The U.S. pledge to match additional contributions up to $1 million was not utilized since voluntary payments by other countries did not match the basic $500,000 contribution of the United States.

Technical Equipment and Experts

The Agency authorized two preliminary technical survey missions. One went to Greece, the Ivory Coast, the Federation of Mali, Morocco, the Sudan, and Tunisia; the other visited El Salvador, Guatemala, Mexico, Paraguay, and Peru. These missions assessed the needs for assistance in developing nuclear energy activities such as training, education, equipment, or technical experts.

As of November 30, some 170 requests were received from 33 member states for technical equipment or experts. The Agency sent about [illegible] experts to these countries for periods ranging from 6 months to 1 year to provide assistance in education, training, and planning research reactor and radioisotopes programs. In addition, the Agency planned a field program under the U.N. technical assistance program, using the services of 26 experts. The United States furnished six cost-free consultants during the year.

The Agency's 1960 budget provided $552,000 for sending experts to member states as well as $47,190 for technical equipment. Funds totaling $599,610 were also received from the United Nations Expanded Program for Technical Assistance. In addition, the United States made available nuclear equipment valued at $192,000 under its offer to the Third General Conference in September 1959. Eight member states received assistance under this United States grant through the IAEA.

Training and Exchange of Scientists

The Agency allocated $800,000 for its training program in 1960 and had received by November 30, some 640 applications for training fellowships from 43 countries. Of these, about 424 had been selected for assignment to 23 foreign institutions, approximately 40 percent for training in the United States. More than 140 IAEA fellows already have completed training.

On the recommendation of the United States, the Agency is encouraging development of an independent training capacity in several member states. Plans were approved for regional radioisotopes training courses in Cairo and regional training courses in several other locations were under consideration.

Of the two mobile radioisotopes training laboratories presented by the United States in 1958, one was used first in four Western European countries, was later transferred to Korea, and subsequently moved to the Republic of China; the second was used during 1960 in Mexico and Argentina.

Health and Safety

Standards concerning health and safety measures to be used in conjunction with materials or equipment provided through the Agency were approved. Provisional regulations concerning transport of radioactive materials were also approved for application in Agency operations and for the guidance of member states.

Management of radioactive wastes was discussed at the Agency-sponsored conference held in Monaco, November 16–21, 1959. Following this, the Agency undertook studies and prepared recommendations on the problems of waste disposal on land and in bodies of fresh and salt water.

Reactor Studies and Surveys

The Agency supported studies of different types of power reactors and of the economics of nuclear power to guide member states in planning their nuclear power programs. A power survey mission was sent to Finland to assist that country in evaluating its future needs, including the practical role to be played by nuclear stations. A similar mission, in which the U.N. Technical Assistance Administration cooperated, was sent to the Philippines.

The United States invited Agency staff representatives to observe several small and medium power reactor projects in this country. Agency personnel have visited these project sites and will regularly receive information on reactors of particular interest to less-developed countries.

The first reactor hazards evaluation of a proposed reactor was completed for Switzerland, and the Swiss Government announced evaluations would be requested for future reactors.

Nuclear Materials Distribution

In response to a request from Finland, the Agency completed arrangements to provide that country with enriched uranium for a TRIGA Mark II research and training reactor purchased by Finland in the United States.

The United States also agreed to make available, through the Agency, uranium fuel elements for use in a cooperative research program to be conducted in Norway to obtain basic nuclear data for power reactor design. Fuel for the first core of the Seibersdorf, Austria, research reactor was supplied through the U.S.-Austrian Agreement for Cooperation; however, it is expected that future cores will be obtained through the Agency.

The first request for Agency assistance in obtaining heavy water was made by Yugoslavia for a research reactor at Boris Kidric Institute. The material is to be supplied by the United States under an agreement which is in process.

The United States suggested that Agency member states with which the United States has bilateral agreements obtain all or part of their future reactor fuel supplies through the Agency. Several countries subsequently made informal inquiries and were expected to submit firm requests for fuel requirements from the Agency during 1961.

Public Liability

The Agency sponsored discussions of public (third party) liability protection against claims for damages arising from nuclear accidents involving land-based reactors, and a draft convention was prepared for consideration by IAEA member states. Agency efforts were encouraged by the success of the Organization for European Economic Cooperation (OEEC) and the European Atomic Energy Community (Euratom) in preparing similar conventions for application by their respective members.

The Agency held two panel meetings for drafting a related international convention on public liability applying to nuclear propelled vessels. A conference has been called for April 1961 to consider the draft convention.

Publications

Included in the documents released by the Agency during the year were the "International Directory of Nuclear Reactors" (Volumes II and III), "International Directory of Radioisotopes" (Volume II), and the first issue of the quarterly "Journal on Plasma Physics and Thermonuclear Fusion."

Bibliographies on different phases of work in atomic energy and proceedings of Agency-sponsored conferences and symposia held in 1958–59 also were published. A Scientific Reference Catalogue was established for use in preparing, upon request by any member states, detailed information on special subjects in atomic energy. The Agency library was expanded during the year by donations from member states, and the United States provided all additional unclassified technical publications of the Commission in 1960 as part of the updating of the Atoms-for-Peace library donated by the United States to the Agency in 1958. It is estimated that the United States has supplied, to date, more than 29,000 unclassified reports and publications to the IAEA library.

Research

Through November 30, the Agency awarded some 41 research contracts to scientific institutions in 15 countries.

The United States provided additional support to the program by ...ing research contracts through the IAEA totaling $125,319 with ...foreign institutions.

Construction was underway on the Agency's central analytical ...oratory at Seibersdorf where research projects are to be under...en. Supplementing contributions of equipment from other coun...es, the United States provided $600,000 in 1959 to assist in con...ucting and equipping this laboratory, to be completed in early 1961.

...ferences

The Agency sponsored two major international scientific confer...es in 1960; one in Vienna, September 5–9, "Small and Medium ...wer Reactors," and the other on "Use of Radioisotopes in Physical ...ence and Industry," held in Copenhagen, September 6–17. In ad...ion the Agency sponsored 10 scientific symposia on such subjects as ...emical Effects of Nuclear Transformation," "Nuclear Ship Pro...sion," and "Fuel Element Fabrication." The Agency also spon...ed numerous expert panels and seminars to consider matters such ... transportation of radioactive materials, safe and effective use of ...arch reactors and critical assemblies, reactor economics, and codes ... reactor computations.

... Dosimetry Experiment

The United States assisted in an Agency-sponsored experiment at ... Boris Kidric Institute in Yugoslavia to obtain data on the bio...al effects of an accidental high level radiation exposure to six ...ists. The experiment, conducted by France, the United King... and the United States was aimed at assessing more precisely the ...ation doses received by the scientists during a brief, uncontrolled ... of the Vinca zero-power reactor on October 15, 1958.

European Atomic Energy Community (Euratom)

... joint reactor program of the European Atomic Energy Com...ty (Euratom) and the United States entered its second phase ...g 1960 with preparations to issue an invitation for a second round ...oposals for power reactors to be completed by the end of 1965. ... one acceptable proposal for a power reactor to be in operation by ...ber 31, 1963, was received in response to the first invitation. ...ct negotiations involved in this first project were progressing ...torily.

An additional Agreement for Cooperation between the United States and Euratom, which became effective July 25, 1960, supplements the original joint program agreement of February 18, 1959. It provides, subject to Congressional authorization, for the United States to make available special nuclear materials to meet certain urgent needs outside the scope of the United States-Euratom joint program.

In its Third Annual Report, Euratom estimated that by 1980 about 30 percent of total Western European electricity requirements can and should be met from nuclear sources. This would amount to over 40,000,000 electrical kilowatts of installed capacity.

Power Reactor Program

An invitation for proposals to construct two power reactors by December 31, 1965 is scheduled to be issued by the Atomic Energy Commission and Euratom in early 1961. A date is to be stipulated for submission of proposals, and interested groups are expected to provide satisfactory assurances that proposed reactors will be in operation by the end of 1965.

Commission and Euratom acceptance of the definitive power reactor proposal by an Italian utility, Societa Elletronucleare Nazionale (SENN), submitted in response to the 1959 invitation closed out the first phase of the program for reactors to be constructed by December 31, 1963.

The SENN proposal was for a 150,000 ekw boiling water reactor near the mouth of the Garigliano River in Italy. This proposal was determined by the Joint Reactor Board to meet the specified conditions and criteria of the invitation and was subsequently approved by the United States and Euratom as an acceptable basis for developing necessary arrangements such as contracts for fuel cycle guarantees, fuel supplies, and chemical reprocessing services. Contract negotiations are in progress for a Euratom SENN Basic Contract and the Atomic Energy Commission-SENN Fuel Cycle Guarantee Eligibility Contract. The reactor is already under construction.

The Societe Nucleaire Franco-Belge des Ardennes (SENA) group comprised of French and Belgian companies, has indicated that it will propose construction of a 240,000 ekw pressurized water reactor under the second invitation of the joint program for reactors to be completed by the end of 1965. Under the special status of a "Joint Enterprise" accorded SENA by Euratom, the group will receive special economic advantages such as exemption from certain taxes. The prime contractor for the project would be the Westinghouse International Electric Co.

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The German group, formerly AKS, now the *Kernkraftwerk Baden-Wuerttemberg Planungsgesellschaft* will study the economies and technical prerequisites for construction of a 150,000 ekw atomic power plant and plans to build as a first step a small 15,000 ekw pilot power plant to obtain accurate data on construction and operation costs.

Research and Development Program

The United States-Euratom research and development program is limited to projects closely related to nuclear reactors constructed under the joint program. It is principally concerned with improving the economics of these reactors.

The Atomic Energy Commission and Euratom will issue an invitation in early 1961 for research and development work specifically related to various phases of work and technology of the SENN boiling water project. By November 30, the Joint Research and Development Board had received 311 research and development proposals of which 82 were from the United States, 147 from Euratom countries, and 82 were joint proposals by groups in the United States and Euratom countries. Fifteen of these contracts had been authorized so far in the United States and 38 contracts in Euratom countries. When proposals are accepted for construction of other types of reactors, research and development will be expanded to cover these concepts.

Supply Agency

On June 1 the Euratom Supply Agency was formally established to administer transactions involving the supply of nuclear materials for Euratom member states. Euratom control over special nuclear materials began on that date; its control over source material began …ember 1. Responsibilities include preparation of estimated requirements, review of offers and selection of suppliers, allocation of …are materials, and specification of terms and conditions of sale.

Euratom Research Program

The agreement under which Euratom will assume control of the nuclear research center at Ispra, Italy was ratified by the Italian Government on July 19. Euratom will concentrate its main nuclear research effort at Ispra, and Italy will gradually relocate its national research work to other installations.

Under the agreement, Euratom will operate the Joint Center for Nuclear Research for 99 years and will contribute substantial funds toward operation and further development of the facilities. The United States has presented an unclassified technical depository library to the Center.

Euratom agreements for research programs were also negotiated with West Germany and The Netherlands to provide for nuclear research at Karlsruhe, Germany, and Petten, The Netherlands. Another arrangement permits Euratom to use the materials testing reactor at Mol, Belgium.

Safeguards

Euratom representatives conducted their first safeguards inspection on use of nuclear material and facilities at Mol, Belgium.

Organization For European Economic Cooperation (OEEC)

During 1960, the United States enlarged its participation in those activities of the Organization for European Economic Cooperation which are concerned with peaceful uses of atomic energy.

Third Party Liability Convention

The OEEC convention on public liability to provide financial protection against nuclear hazards, a significant step forward in removing an obstacle to atomic energy industrial growth, was approved by a special council of experts and all member states signed the convention by November 30, when it became effective.

Drafted by the European Nuclear Energy Agency of OEEC during 1959, this convention is the first joint attempt by the Western European countries to remove a major obstacle to development of nuclear power. In general, the convention provides that absolute liability be placed on the operators of nuclear facilities, and that suppliers be freed from any claims. It provides that each adhering country will have a maximum liability per incident of at least $15 million, with the proviso that each country could, through governmental intervention, alter this liability level by domestic legislation or further international convention, but not to provide less than $5 million coverage.

DRAGON Project

In April, the Commission and the United Kingdom Atomic Energy Authority (UKAEA), acting as agent for the DRAGON Project the OEEC, signed an Agreement providing for exchange of detailed information on high temperature gas-cooled reactors.

The DRAGON Project, a joint undertaking of the UKAEA and other members of the European Nuclear Energy Agency of the OEEC, involves construction and operation of an experimental 20 Mw (thermal) high temperature gas-cooled reactor at Winfrith Heath, England. The corresponding United States project is the 40,000 ekw power reactor of the same type to be built by Philadelphia Electric Co. and General Dynamics Corp. under the Commission's Power Demonstration Reactor Program.

Eurochemic Project

Through exchange of visits and long-term assignment of personnel, the Commission provided the *Company for Chemical Processing of Irradiated Fuels* (*Eurochemic*) assistance in planning the design and construction of a small plant.

Construction of the chemical processing facility at Mol, Belgium, began in July under direction of the European Nuclear Energy Agency. The Eurochemic Co. is a semi-governmental, semi-private international shareholding company with members from 13 Western European countries.

Food Irradiation Studies

The Commission participated with 13 Western European countries and international organizations in meetings held under sponsorship of the European Nuclear Energy Agency to examine prospects and problems in food preservation by irradiation. The Agency was directed to undertake studies of United States progress in this area and to determine how irradiation could be applied to food processing in Western Europe with a view to establishing formal projects.

Inter-American Nuclear Energy Commission (IANEC)

The second annual meeting of the Inter-American Nuclear Energy Commission was held in Petropolis, Brazil, July 11–15, with representatives from 14 of the 21 members of the Organization of American States (OAS), including the United States. Admiral Octacilio Cunha, Brazil, was elected Chairman for 1960–61 and Dr. Carlos Martinoya, Chile, Vice-Chairman for the same term.

General Manager A. R. Luedecke presented the U.S. Reactor grant check at the dedication of the Venezuelan reactor, at Caracas, in November. Assistant General Manager Dwight Ink accompanied members of the Joint Congressional Committee on a tour of a number of European nuclear establishments.

The delegates approved resolutions calling for increased exchange of nuclear scientists and engineers, establishment of a permanent advisory committee to develop a comprehensive plan for coordinating education, training, and research in nuclear sciences and technology, and to undertake a preliminary study of public liability problems in the nuclear energy industry. Also approved were recommendations that IANEC representatives open negotiations with the International Atomic Energy Agency for formal arrangements for cooperation; that the Organization of American States make its fellowship and exchange and technical assistance programs more flexible so as to better meet IANEC needs; and that a survey under IANEC auspices be made of available nuclear information facilities and services in the Americas.

The third IANEC meeting will be held May 9–13, 1961, in Washington, D.C.

The Inter-American Commission was established April 22, 1959, under the OAS as an outcome of President Eisenhower's proposal at the July 1956 meeting of the Chiefs of State of the American Republics in Panama for cooperation of the Inter-American countries in furthering the beneficial uses of nuclear energy.

Third Inter-American Symposium

Held July 18–22 at Petropolis, Brazil, the Third Inter-American Symposium on the Peaceful Applications of Nuclear Energy was sponsored by the Inter-American Nuclear Energy Commission and the Government of Brazil. The United States provided financial support through a grant from Mutual Security Program funds, and Brazil acted as host.

More than 75 participants from 14 member states of the OAS attended the Symposium, the theme of which was "Industrial Applications of Nuclear Energy."

Advisory And Consultant Services

The Commission increased during 1960 its furnishing of consultants and experts to other countries to provide assistance on programs or jects for development of peaceful uses of atomic energy. In all, me 48 consultants and experts were provided by the Commission to countries and to projects sponsored by IAEA, EURATOM, EEC, and IANEC.

BILATERAL COOPERATIVE ACTIVITIES

Cooperation With The U.S.S.R.

The reciprocal unclassified exchanges of visits by nuclear scientists tween the United States and the Union of Soviet Socialist Republics re completed in May and July as the first formal steps in implentation of some provisions of the U.S.-Soviet Memorandum of Coeration in the Peaceful Uses of Atomic Energy which was signed on vember 24, 1959.[22]

The possibilities of United States and Soviet cooperation in peace- l uses of atomic energy were first raised by U.S. representatives and re the subject of informal discussions between Chairman McCone d Professor Vasily S. Emelyanov during the latter's visit to the ited States in September 1959 with Premier Nikita Khrushchev, S.S.R. Preliminary agreement was reached at that time on an initial procal exchange of visits to unclassified facilities. In October 59, a United States delegation headed by Chairman McCone visited viet atomic energy facilities, and the exchange was completed in e following month with a visit to U.S. unclassified facilities by a viet delegation headed by Professor Emelyanov.

Following the Soviet visit in November 1959, the formal memoran- m to cover future exchanges of personnel, information, and other operation in unclassified atomic energy fields was signed in Washing- by Chairman McCone and Professor Emelyanov. It is being implemented within the framework of the U.S.-U.S.S.R. Scientific, chnical, Educational, and Cultural Exchange Agreement for 60–61.

Under the memorandum, provision is made for cooperation in the lowing areas: Reciprocal exchanges of visits by U.S. and Soviet entists in controlled thermonuclear research, nuclear power reactor elopments, high energy physics, nuclear physics, neutron physics, structures of nucleons; and for exchange of unclassified technical ormation; and discussions of the feasibility of engaging in unsified joint projects in the peaceful uses of atomic energy. The

[22] See pp. 97–98, Annual Report to Congress of the Atomic Energy Commision for 1959.

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.

During the Fourth General Conference of the IAEA in Vienna, Chairman McCone announced that as a result of further discussions with Professor Emelyanov of the U.S.S.R., there would be a new exchange of visits by experts for exploratory talks and exchange of information in the field of waste disposal. Exchanges on fast reactor technology, originally scheduled for the fall of 1960, have been deferred until the spring of 1961.

Five U.S. scientists participated in the first formal visit in May 1960 to Soviet high energy physics facilities. At approximately the same time, the first team of five Soviet scientists visited U.S. controlled thermonuclear research installations. In July 1960, the second group of five U.S. scientists visited the U.S.S.R. and toured Soviet controlled thermonuclear facilities. Also in July, five Soviet scientists toured U.S. high energy physics laboratories.

Details of further exchanges of visits under the 1959 memorandum of cooperation as well as the possible addition of other areas of exchange are being considered by U.S. and U.S.S.R. representatives.

Agreements For Cooperation

Status of Civil Agreements

Three new bilateral Agreements for Cooperation in peaceful uses of atomic energy became effective during 1960. They were with Austria, Indonesia, and Venezuela. The new research agreement with Austria superseded and modified the terms of a previous research accord. The agreement with Indonesia is of the research type. The agreement with Venezuela was for power reactor development, superseding an existing research agreement.

During the year, the Agreements for Cooperation with Chile, Colombia, Lebanon, and Pakistan expired through mutual agreement of the countries concerned. The expectation is that these countries will seek assistance in their atomic energy programs from the International Atomic Energy Agency. Amendments came into effect modifying and extending in most cases for 2 years the agreements with Argentina, Brazil, the Republic of China, Greece, Israel, Portugal, and the Philippines. These agreements are for a limited period on the assumption that within that period the parties would reach a understanding on placing their bilateral activities under Agency safeguards or would work through the IAEA for future materials transactions. Other amendments that came into effect expand and modify the terms of existing agreements with Canada, New Zealand, and Thailand.

As of November 30, 41 agreements were in force with 39 countries (including 2 with Switzerland) and the city of West Berlin—14 for power reactor cooperation and 27 for research. These are in addition to special agreements with the International Atomic Energy Agency and Euratom (see Appendix 14).

Progress In United States Reactors Abroad

One power reactor constructed by a United States company in the Federal Republic of Germany went into operation in November 1960. Five other power reactors were being planned for construction abroad or were under construction by U.S. companies.

A contract was signed by Japan and General Electric in September for construction of a 12,500 ekw demonstration boiling water reactor at the Japan Atomic Energy Research Institute's center at Tokai. Startup date is set for early 1963.

During 1960, 8 United States-manufactured research, training and test reactors went into operation in foreign countries, bringing the total to 27. An additional 17 research, training and test reactors were being built abroad by U.S. companies as of November 30, and 7 more were being planned for construction. (See Part IV, Appendix 12).[23]

Research Reactors And Equipment Grants

Reactors

The Commission approved during 1960 research reactor project grants up to $350,000 to Pakistan and Turkey and $200,000 to Yugoslavia. These grants bring the total number committed since the establishment of the program in 1956 to 22 with a total value of $7.55 million. (See Appendix 16, Research Reactor Grants).

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[23] The apparent discrepancy between the figure of 20 research reactors shown as operable in the 1959 Annual Report and the figures of 27 reactors operable with 8 going into operation in 1960 given in this report results from a change in the definition of "Startup". In this and succeeding Annual Reports "Startup" as shown in Part IV, Appendix 12 will indicate startup date in the location shown by the table. Previously, "Startup" referred to startup date in any location.

Aid for Yugoslavia. Photo shows Commission Chairman John A. McCone (right) handing to Slobodan Nakicenovic, Secretary of the Yugoslav Federal Nuclear Energy Commission and Yugoslav Undersecretary of State, a letter of commitment for a $200,000 research reactor grant. At the same time, Mr. McCone informed Secretary Nakicenovic that the Commission had approved a $150,000 equipment grant for Yugoslavia to assist in acquisition of a hot laboratory for the Boris Kidric Institute.

During the year, payments were made of research reactor grants previously committed to Austria, Denmark, Japan, and Venezuela, raising the number of grants paid to eight for a total of $2.45 million. Other countries which have received grants are Brazil, the Federal Republic of Germany, Italy, and Spain. Grants are limited to one-half the cost of the reactor project, but not to exceed $350,000, and are paid upon completion of the project.

Requests received subsequent to June 30, 1960, are to be evaluated by the International Cooperation Administration in competition with other requests for assistance from the requesting country and are to be financed with funds available under the ICA's Technical Assistance Program.

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Equipment

By the end of the year, six countries received grants from the Commission for the acquisition of nuclear research and training equipment with a total value of $756,116. These grants bring the total number approved by the Commission to 21 for 18 countries since inauguration of the program in June 1958. As reported above, the Commission also made available through the International Atomic Energy Agency contributions of nuclear equipment to 8 countries with a total value of approximately $192,000.

Materials And Bilateral Safeguards

ials and Fuel Assistance

During 1960, 321 kilograms of uranium 235 for use in reactors and research and development programs were provided other countries on a sale or lease basis, with major shipments going to France, Germany, and Sweden. The 1960 materials transfers exceed the total of previous shipments dating from the inception of the program in September 1955 and bring the total to 630 kilograms. Sixty-two tons of heavy water were shipped during the year to France, Norway, and Japan, making a total of 468 tons of heavy water as well as smaller quantities of other materials shipped abroad since September 1955.

cessing heavy water. In May 1960, the Commission authorized use of its facilities to reprocess degraded heavy water used in four foreign reactors for which heavy water originally was purchased from the United States. The Commission will perform this service under charges and conditions now in effect for United States companies where no commercial facilities are available. This service will decrease the amount of heavy water that must be purchased for replacement in foreign reactors.

al Safeguards Administration

Under existing bilateral agreements, the United States has provided advice and assistance to cooperating countries in establishment of control systems to insure adequate accountability for nuclear materials, and control of nuclear reactors and equipment obtained from the United States. Agreements contain provisions in most cases for the possible transfer of safeguards activities to the International Atomic Energy Agency.

The Commission conducted safeguards inspections of 33 facilities in 12 foreign countries and the City of West Berlin during 1960. Inspections consisted of audit and verification of nuclear materials inventories, examination of accountability records, and physical inspections of nuclear reactors and equipment of United States origin. Countries visited were Australia, Belgium, Denmark, France, the Federal Republic of Germany, Israel, Italy, Japan, Norway, Spain, Sweden, and Switzerland. (See Appendix 15, Foreign Reactors and Critical Assemblies Subject to U.S. Safeguards.)

Education and Training

More than 275 foreign nationals from 27 countries participated in the Commission's formal training programs in nuclear sciences and technology during the year. Individual on-the-job training assignments at Commission facilities were made for 700 persons.

Guidance was given in response to several hundred requests from foreign nationals regarding educational opportunities and financial assistance for training in nuclear science and technology in United States colleges, universities, and private industrial facilities.

Since establishment of the International School of Nuclear Science and Engineering at the Commission's Argonne National Laboratory in 1955, a total number of 416 foreign students from 45 countries and 100 United States Citizens had received training at the school by December 1959.

During the year's three sessions 164 students from 20 countries and the United States attended 175 student-terms. Forty-five students were "affiliates" (individuals capable of independent research and collaborating in a full time research problem for 1 year).

Since the beginning of the *radioisotope techniques course* at the Oak Ridge Institute of Nuclear Studies in 1947, a total of 429 foreign nationals from 56 countries have received training in the use of radioisotopes in research and in industrial applications of radioisotopes. During 1960, 60 students from 27 foreign countries participated in separate sessions.

The second 9-month *course in nuclear reactor operations supervision held by* the Oak Ridge National Laboratory ended June 29, 1960, with 12 foreign students from 9 countries enrolled. The third course, which began November 7, 1960, was extended to 12 months to permit additional on-the-job reactor operating experience. Eight foreign nationals were enrolled in the extended course.

In October, the Oak Ridge National Laboratory completed its second 12-month *nuclear reactor hazards evaluation course* in which 10 students from 9 foreign countries were enrolled. The third course began November 7 with 7 participants from foreign countries.

During 1960, the *Puerto Rico Nuclear Center* offered courses in nuclear science and technology, nuclear medicine, and radiological physics for more than 16 students from 12 Spanish speaking countries and 57 from Puerto Rico and other parts of the United States. Established in 1958 by the Commission under contract with the University of Puerto Rico, the Center offers instruction at the graduate level. Dr. John C. Bugher, formerly Director of the Commission's Division of Biology and Medicine, was appointed Director of the Center as of July 1, 1960. On August 23, dedication ceremonies were held for the 1,000 kilowatt research reactor at Mayaguez.

Exchange of Information

Exchanges of scientific and technical personnel and information related to the development of the peaceful uses of atomic energy were expanded during 1960.

Technical Depository Libraries

During 1960, the Commission provided an unclassified technical depository library to France and another to the Euratom Research Center at Ispra, Italy, bringing to 85 the total number of libraries presented to 58 foreign countries and 5 international or regional organizations. These libraries are kept up to date through periodic transmittal of new documents.

Assignments and Visits

Arrangements were made for unclassified visits to Commission facilities by 1,097 foreign representatives, and approximately 381 Commission representatives visited foreign atomic energy establishments during 11 months of 1960.

The United States continued its program of exchanging scientific and technical documents with other countries.

More than 56 prints of 12 new unclassified films were made available during the year to foreign countries through the Commission's liaison offices in Argentina, Belgium, Japan, and the United Kingdom. An additional 52 copies of the 12 new and other unclassified films were provided other foreign countries and international organizations as supplements to film sets previously provided during the International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1958.

Visits and Technical Exchanges

Highlights of visits and technical exchanges during 1960 are given in the following sections.

Chairman McCone, other Commissioners and high Commission officials participated in international activities to an increasing extent during the year. In addition to events previously noted, Chairman McCone took part in disarmament and test suspension discussions in England and France and visited atomic energy installations in a number of European countries. Commissioner Graham was a member of the United States Delegation to the Fourth General Conference of IAEA in Vienna; participated in the opening of the United States exhibit at New Delhi, India, in December 1959, and also visited European atomic energy installations.

Commissioner John Floberg (resigned June 23, 1960) represented the Commission at the opening of the atomic energy exhibit in Cairo, Egypt, in May. Along with Commissioners Olson and John Wilson he attended the semiannual meeting of United States and United Kingdom atomic energy officials held in Britain in May. Commissioners Wilson and Graham spoke at the ground-breaking ceremonies for the experimental power reactor in Puerto Rico and at the dedication of the Puerto Rico Nuclear Center in August. At the invitation of Canadian Research Director W. B. Lewis, Commissioner Wilson also visited the Canadian atomic energy establishment at Chalk River, Ontario.

Canada. The United States and Canada reached agreement on a cooperative program for development of heavy water moderated power reactors to be carried out under the terms of a memorandum of understanding pursuant to the United States-Canada Agreement for Cooperation in the Civil Uses of Atomic Energy, as reported in Part Progress in Power Reactor Technology.

France. Chairman McCone and other United States officials visited French atomic energy centers at Chinon, Saclay, and Marcoule during April in response to an invitation extended by French representatives after their visit to the United States in November 1959.

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Chairman McCone and French officials discussed the nuclear programs of their respective countries and considered expanded cooperation between the two countries. Specific agreement was reached on exchange of information and personnel and joint uses of facilities related to use of beryllium oxide in gas-cooled reactors.

India. A United States technical mission visited India in February and March to tour atomic energy and industrial facilities and to discuss India's plan for nuclear power developments. This visit was a followup to visits to a number of nuclear laboratories and power plant projects in the United States during the fall of 1959 by Dr. Homi J. Bhabha, Chairman of the Indian Atomic Energy Commission, and other Indian officials.

United Kingdom. Sir Roger Makins, Chairman of the United Kingdom Atomic Energy Authority, and other United Kingdom officials visited United States atomic energy installations in August at the invitation of Chairman McCone. Discussions were held on cooperation between the two countries.

On November 16, 1959, the United States and the United Kingdom agreed on an expansion for a period of 5 years from that date of the cooperative program on gas-cooled reactors established in 1957. The reactors covered under this exchange are the UKAEA's Windscale advanced gas-cooled reactor and HERO (zero energy gas-cooled experiment at Windscale) and the Atomic Energy Commission's Oak Ridge gas-cooled reactor.

Yugoslavia. Exchange visits and discussions of cooperation in developing peaceful applications of nuclear energy were carried out in 1960 by Yugoslavia and United States delegations of atomic energy representatives. Understanding was reached on areas of mutual interest, including channeling cooperative activities through the International Atomic Energy Agency.

Conferences and Exhibits

International Conferences

During 1960, the Commission participated in the Euratom-sponsored International Symposium on Legal and Administrative Problems of Protection in the Peaceful Uses of Atomic Energy held in Brussels, Belgium, in September, and in the Tenth International

Conference on High Energy Physics held in August in Rochester, N.Y.

The United States also was represented at the Fifth Nuclear Congress held in Rome, Italy, in June in conjunction with the Seventh International Electronics and Nuclear Exhibition sponsored by the Italian National Committee for Nuclear Research. In addition to these conferences, the Commission participated in numerous bilateral meetings and other symposia and conferences sponsored by the International Atomic Energy Agency.

U.S.-Supported Conferences

Twelve international atomic energy conferences held in 1960 received support by Commission funds. Six convened outside the continental limits of the United States:

- "International Symposium on Comparative Effects of Ionizing, Ultraviolet, Visible and Near Visible Radiations," San Juan, Puerto Rico, February 15–19.
- "Third International Congress for Photobiology," Copenhagen, Denmark, July 31–August 5.
- "Symposium on Effects of Ionizing Radiation on Seeds and Their Significance on Crop Improvement," Karlsruhe, Germany, August 8–12.
- "Seminar on Use of Vital and Health Statistics for Genetic and Radiation Studies," Geneva, Switzerland, September 5–9.
- "International Conference on Uses of Radioisotopes in the Physical Sciences and Industry," Copenhagen, Denmark, September 6–17.
- "International Conference on Atomic Masses," Hamilton, Ontario, Canada, September 12–16.

Six topical conferences receiving financial support from the Commission occurred in the continental United States:

- "International Conference on Organic Scintillation Detectors," Albuquerque, N. Mex., August 15–17.
- "Seventh International Soil Science Congress," Madison, Wis., August 15–2[illegible]
- "International Symposium on the Use of Radioisotopes in the Study of Bone," Princeton, N.J., August 28–September 3.
- "Fifth International Congress on Nutrition," Washington, D.C., Sept. 1–[illegible]
- "International Conference on the Biological Aspects of Metal Binding," State College, Pa., September 6–9.
- "International Symposium on Response of the Nervous System to Ionizing Radiation," Evanston, Ill., September 7–9.

International Nuclear Energy Exhibits

World Agriculture Fair. A daily average of 35,185 people, and a total of 2,850,000 viewed the Commission exhibit at the New Delhi World Agriculture Fair.

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United States Information Service reported that the nuclear displays were featured in approximately 180,000 column inches in periodical publications—equal to more than 30 average copies of the New York Times.

A TRIGA research reactor, operated at the exhibit in cooperation with the Indian Atomic Energy Commission, produced a total of 132 isotopes during its 66 days of operation. The first medical radioactive sodium used for diagnosis in India was produced in the reactor.

A gamma ray irradiation facility treated 4,700 group specimens of seeds, cuttings, pharmaceuticals, and micro-organisms, for research work in India.

Eleven seminars were held for scientists, science students, and members of the medical profession.

On June 13, the Government of India formally accepted a gift of the cobalt 60 gamma facility, the fly-rearing facility, and the fly sterilization model featured at the Commission's exhibit. Research work will continue in Indian research centers.

Cairo. The Commission exhibit at Cairo was viewed by 136,344 people. Scheduled for May 8–30, the exhibit was extended through June 9, upon a formal request from the United Arab Republic.

Nine UAR scientists received instruction in operating the American Standard UTR reactor; four engineers received certificates of competence after completing their training program. Commission scientists, in cooperation with those of the UAR, irradiated 20 samples in the reactor and performed 10 reactor experiments. Twenty-[illegible] students participated in a similar training program at the reactor simulator.

The cobalt 60 facility was used to irradiate 2,300 groups of samples, which included insects, seeds, chickens, chemical fungi, and yeast bacteria.

At the Technical Information Center, scientific publications were distributed in English and Arabic editions.

[illegible] patients underwent examination by the scintillation scanner at the request of a local physician. The scanner was being displayed in the Isotopes in Medicine section of the exhibit.

Rio de Janeiro. "Atoms at Work," a small nuclear energy exhibit, was presented in Rio de Janeiro, July 16–23, in conjunction with the Brazilian Nuclear Energy Exposition and shown simultaneously with the Third Inter-American Symposium on the Peaceful Applications of Atomic Energy.

Vienna. A three-panel display illustrating the scope of United States agricultural research with radioisotopes was displayed at the 1960 General Conference of the IAEA in September.

Lahore exhibit. The exhibit shown at Cairo in May was moved to Lahore, Pakistan, and displayed November 6–28.

Over 30 displays composed the exhibit, among which were an operating research and training reactor, a reactor simulator, mechanical manipulators, a technical information center, and demonstrations of radioisotope use in medicine, industry, and agriculture.

Pakistani and United States scientists conducted cooperative research programs at the reactor. Young scientists and engineers assigned by Pakistan received training in reactor installation and operation.

South American exhibit. A mobile exhibit that will travel to four South American countries opened November 1 in Buenos Aires, Argentina. Housing the exhibit was a duel envelope, portable, air-supported structure.

Films were used to present the benefits and potential services of nuclear energy. A technical area of the exhibit contained an operating research and training reactor manufactured by Lockheed Aircraft Corp., a gamma facility designed by Brookhaven National Laboratory, and a reactor simulator. A technical information center contained a complete unclassified library, a technical film library, and conference space.

Scientists and students of Argentina were invited to conduct demonstrations and experiments at the operating reactor and the gamma facility. Lectures and seminars were held for scientists, engineers, physicians, and advanced technical students; science demonstration programs were performed for groups of high school students.

After the exhibit closes at Buenos Aires on December 15, it will be shown in Rio de Janeiro in March 1961; in Lima, Peru in July; and in Caracas, Venezuela in November.

United Nations Cooperation

Committee on Effects of Radiation

The United Nations Scientific Committee on Effects of Atomic Radiation held its Seventh Session at United Nations Headquarters, New York, January 11–22, 1960. Dr. Shields Warren was United States representative; Dr. Austin Brues and Merril Eisenbud served

as alternates. Six Uni
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alternates. Six United Nations agencies directly interested in the work of the committee sent observers.

A major part of the Seventh Session was devoted to a detailed consideration of three problems: the occurrence, distribution, and movement of fallout from nuclear weapons tests; uptake of radioactive isotopes from soil through the food cycle to man; and effects of low doses of radiation on individuals. A panel of experts from the World Meteorological Organization reported on the current state of knowledge pertaining to the transport and distribution in the atmosphere of radioactive debris from weapons tests.

After discussion of General Assembly Resolution 1376 XIV, requesting the Committee, in conjunction with certain United Nations agencies, to study arrangements for disseminating information and data, two subgroups were established, one dealing with physical data and the other with biological information. They were given responsibility for recommending proposals to implement the General Assembly Resolution. As an interim measure, the Committee requested the Secretariat to communicate to governments of the member nations the Committee's need for certain specific information and data.

Major subjects for discussion at the Eighth Session of the Committee, September 19–30, in Geneva, were genetics, carbon 14, and dose computations.

Licensing, Regulation and Indemnification

LICENSING IN 1960

Facilities Licenses

During 1960, permits were issued authorizing construction of 5 power reactors, 13 research reactors, and 2 critical experiment facilities. One power reactor, 10 research reactors and 2 critical experiment facilities were licensed to operate. Licenses also were issued authorizing export of 3 research reactors (2 to Japan and 1 to Australia). Two companies filed applications for licenses to construct and operate developmental power reactors. Applications also were filed requesting authorization to construct and operate 10 research reactors, 2 critical experiment facilities and 1 production facility.

Following hearings held in April and May, the hearing examiner on June 14, 1960 issued his intermediate decision authorizing the operation of the Vallecitos Boiling Water Reactor with internal modifications, new fuel and control rod arrangements, and both turbine and electrically driven coolant pumps, and amending the procedure to be followed by the licensee in making changes in the reactor or its operation. On August 18, the Commission isssued a memorandum and order denying exceptions filed by General Electric Co. to the intermediate decision in regard to the procedure for operational or reactor changes incorporated in the license. Subsequently the Commission agreed to reconsider the memorandum and order, and oral argument on licensee's petition for reconsideration was heard on October. On November 2, the Commission issued a memorandum and order which directed the issuance of a license amendment incorporating a change procedure which had been jointly proprosed by Commission staff and the licensee. Under the amended license, the licensee has freedom to make changes within the limits of the technical specifications, provided no unreviewed safety question is involved. Any change involving unreviewed safety questions and all changes in the technical specifications must be referred to the Commission. The Director, Division of Licensing and Regulation, may authorize such changes if they present no significant new hazards considerations. Otherwise, referral to the Advisory Committee on Reactor Safeguards and scheduling of a public hearing is required.

As was reported last year, the Commission issued its opinion and final decision in the Power Reactor Development Co. (PRDC) case involving construction of the Enrico Fermi reactor near Monroe, Mich., on May 26, 1959; in July 1959, the intervenors in the matter (International Union of Electrical, Radio, and Machine Workers, AFL–CIO; United Automobile, Aircraft and Agricultural Implement Workers of America; and United Papermakers and Paperworkers) appealed the Commission's decision to the United States Court of Appeals for the District of Columbia Circuit. On June 1960, a two-judge majority of a panel of the Court of Appeals set aside the Commission's grant of a provisional construction permit to PRDC. The Government's and PRDC's petitions for rehearing *en banc* were denied on July 25. Petitions for *certiorari* were filed in the United States Supreme Court by PRDC and the Government on August 12 and September 29, respectively. The judgment of the Court of Appeals has been stayed. On November 14, the Supreme Court announced it would review the lower court's ruling. On November 18, the Commission granted PRDC's request for extension of the completion date specified in their construction permit. The Commission order specified July 15, 1961 as the new completion date, subject to such order as may be entered in the case by the Supreme Court.

The power reactor license issued by the Commission, the third issued far, authorized Yankee Atomic Electric Co. to operate its surized light water nuclear reactor at Rowe, Mass. A Second mediate Decision and Order dated July 9, 1960, directed the issu- of an interim license authorizing operation of the Yankee re- at power levels not in excess of 5 thermal megawatts, solely for purpose of initial fuel loading and low power testing. Pursuant Third Intermediate Decision of July 19, 1960, the limited license amended on July 29 to authorize steady state operation at power not to exceed 110,000 ekw, subject to another hearing to be held view operations at such power level. On August 8, 1960, Yankee an exception to the Third Intermediate Decision with respect to requirement that all proposed changes in the technical specifica- be subject to a public hearing. On August 18, 1960 the Commis- denied the exception and remanded the matter to the Hearing miner for further proceedings and appropriate decision with re- to the scope of the technical specifications, and other relevant ers. On November 15, 1960, Yankee filed a motion asking that aring be reconvened to conform the provisions of the license to ews expressed by the Commission in the Memorandum and Order November 2, 1960 in Docket No. 50–18 (General Electric- itos Boiling Water Reactor). A hearing was scheduled for ber 12, 1960, convened on that date and recessed to December 13, when it was reconvened. Proposed findings and conclusions have filed by Yankee and the Staff, and a decision by the Hearing ner is pending.

license amendment dated June 2, 1960, Commonwealth Edison authorized to operate Dresden nuclear power station at power up to 180,000 ekw, design capacity, but not in excess of, or at this state power level, without further order of the Commission. endment license authorizing steady-state capacity operation was October 14, after a public hearing was held September 26–27. mit investigation of control-rod difficulties in the Dresden plant, ommission, on November 23, 1960, granted a motion to extend December 16 the period within which the Commission might re- Third Intermediate Decision. When it became clear that the ation would extend beyond December 16, the AEC staff moved Commission further extend the review period until January . The motion was granted by the Commission on December

license amendment dated January 8, 1960, Westinghouse Elec- p. was authorized to operate the Westinghouse Test Reactor at power levels up to 60,000 thermal kilowatts; operation had previously been limited to 20,000 thermal kilowatts. Westinghouse subsequently reported an operating incident which occurred on April 3, involving partial destruction of a fuel element through overheating and subsequent melting. By Commission Order dated June 30, Westinghouse was ordered not to load or start up the reactor without prior approval pending filing of a report by Westinghouse of measures taken to prevent recurrence of the April operating incident. A Commission amendment to the June 30 Order was issued July 25 authorizing partial loading with instrumented experiments. On September 7, Westinghouse was authorized to load, start up, and operate the WTR with a modified venting system subject to specified power level, minimum coolant flow conditions, and also subject to fuel element inspection procedures. Westinghouse also was authorized to fuel and operate the WTR modified high-pressure experimental loop.

Permits were issued authorizing construction of five developmental power reactors by:

Saxton Nuclear Experimental Corp., on February 11, 1960, for construction of a 5,000 ekw light water-moderated and -cooled pressurized water reactor at Saxton Station, near Altoona, Pa.

Carolinas Virginia Nuclear Power Associates, Inc., on May 6, 1960, for construction of a 17,000 ekw vertical pressure tube nuclear reactor at Parr, S.C.

Northern States Power Co., on May 12, 1960, for construction of a 66,000 ekw Controlled Recirculation Boiling Reactor near Sioux Falls, S. Dak.

Consumers Power Co., on May 31, 1960, for construction of a 75,000 ekw, high power density, single cycle, boiling water reactor at Big Rock Point, Charlevoix County, Mich. (Initial output is estimated at 50,000 ekw.)

Pacific Gas and Electric Co., on November 9, for construction of a 50,000 ekw, direct cycle, internal circulation, boiling water nuclear reactor at the applicant's Humboldt Bay Plant near Eureka, Calif.

Prior to issuance of each permit, the application was reviewed by the Commission's Advisory Committee on Reactor Safeguards and was the subject of a public hearing before a Commission hearing examiner.

An application filed by *Philadelphia Electric Co.* for the proposed construction and operation of a 40,000 ekw, helium-cooled, graphite-moderated, developmental power reactor at Peach Bottom, York County, Pennsylvania, has not yet been scheduled for public hearing.

The year's licensing actions and hearings are summarized in Appendices 9 and 10, respectively.

Operator Licenses

For the period January 1 through November 30, there were 190 operator licenses issued authorizing manipulation of reactor controls. As of November 30, there were 538 operator licenses in effect.

Special Nuclear Material

For the period January 1 through November 30, 1960, there were new licenses issued authorizing the possession and use of special nuclear material; as of November 30 there were 356 special nuclear material licenses in effect.

As in two previous years, four companies were engaged during 1960 in conversion of uranium hexafluoride obtained from Commission plants to firms needed for fabrication of fuel elements and for research and development. They were the Davison Chemical Co., Erwin, Tenn.; Mallinckrodt Chemical Works, Hematite, Mo.; Nuclear Materials and Equipment Corp., Apollo, Pa.; and Spencer Chemical Co., Kansas City, Mo.

As of November 30, 17 concerns were 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. One new licensee, Olin Mathieson Chemical Co., was added during 1960. The licensed fabricators are:

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., Plainville, Mass.
General Dynamics Corp., General Atomic Div., San Diego, Calif.
General Electric Co., Atomic Power Equipment Dept., San Jose, Calif.
M & C Nuclear, Inc., Attleboro, Mass.
The Martin Co., Middle River, Md.
National Lead Co., Albany, N.Y.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Nuclear Metals, Inc., Concord, Mass.
Olin Mathieson Chemical Co., New Haven, Conn.
Sylvania Corning Nuclear Corp., Hicksville, N.Y.
Westinghouse Electric Corp., Blairsville, Pa., and Forest Hills, Pa.

One company, Combustion Engineering, Inc., Windsor, Conn., is manufacturing fuel elements under contract with the Commission, but has requested a license to authorize commercial fabrication.

The following companies continued to serve in their licensed ca- ities to reclaim unirradiated enriched uranium from scrap gener- in fuel fabrication and fuel material preparation:

Davison Chemical Co., Erwin, Tenn.
Engelhard Industries, Inc., Baker Platinum Div., Newark, N.J.
Mallinckrodt Chemical Works, Hematite, Mo.
Nuclear Materials and Equipment Corp., Apollo, Pa.
Spencer Chemical Co., Kansas City, Mo.

Source Material

Licenses issued for the period January 1 through November 1960, including renewals, authorizing possession and use of sou- materials totaled 1,653. This figure includes 644 licenses issued to porters. As of November 30 there were 1,175 source material lice- in effect (exclusive of export licenses).

Byproduct Material (Radioisotopes)

Nearly 7,000 byproduct licensing actions were taken during 19- Details are reported in the section on Radioisotopes and Radia- Development.

Waste Disposal Licensing

As of the end of 1960, there were nine organizations licensed to co- duct commercial disposal services involving the disposal of low ac- ity, packaged radioactive waste at sea. No new organizations we- licensed during 1960, current waste disposal services licensees are:

Crossroads Marine Disposal Corp., Boston, Mass.
California Salvage Co., San Pedro, Calif.
American Mail Line, Seattle, Wash.
The Walker Trucking Co., New Britain, Conn.
Isotopes Specialties Co., Burbank, Calif.
New England Tank Cleaning Co., Cambridge, Mass.
Nuclear Engineering Co., Pleasanton, Calif.
Coastwise Marine Disposal Co., Long Beach, Calif.
Ocean Transport Co., San Francisco, Calif.

In addition, eight organizations are authorized to dispose of the- own low-activity, packaged radioactive waste at sea. They are:

National Institutes of Health, Bethesda, Md.
U.S. Naval Radiological Defense Laboratory, San Francisco, Calif.
Socony Mobile Oil Co., Paulsboro, N.J.
California Research Laboratory, Richmond, Calif.

U.S. Naval Medical Research Laboratory, New London, Conn.
U.S. Fish & Wildlife Service, Beaufort, N.C.
University of Georgia, Sapelo Island, Ga.
University of Hawaii, Honolulu, Hawaii.

License amendments authorizing commercial waste disposal services involving land burial at Commission-owned sites near Oak Ridge, Tenn., and Idaho Falls, Idaho, were issued to Crossroads Marine Disposal Corp., Isotopes Specialties Co., and Ocean Transport Co. In addition, Industrial Waste Disposal Corp., Houston, Tex., and Nuclear-Waste Disposal Corp., Long Island, N.Y., were licensed to provide this type of service. The issuance of the license to Industrial Waste Disposal Corp. was appealed to the United States Court of Appeals for the Fifth Circuit on August 19, 1960, by Harris County, Tex., one of the intervenors in the licensing proceeding before the Commission. Radiological Services Co., Long Island, N.Y., was licensed previously to receive prepackaged radioactive wastes for transfer to Oak Ridge National Laboratory for land burial.

INDEMNITY AND REGULATIONS

Financial Protection and Indemnity

Two amendments to the Commission's financial protection and indemnity regulations in 10 CFR Part 140 became effective on May 7, 1960. Part 140 applies to reactor projects subject to licensing by the Commission.

The first effective amendment supersedes the original Part 140. In essence, this amendment (*a*) adds a population factor to the formula prescribed for computing amounts of financial protection required for the larger reactor projects; (*b*) provides fixed amounts of financial protection, according to power level, for the smaller reactors; (*c*) requires a holder of a reactor construction permit desiring to possess and store special nuclear material at his reactor site for subsequent use as reactor fuel to have financial protection in the amount of $1 million when the materials license is issued (indemnification is provided such licensees as of the date of issuance of the materials license); (*d*) clarifies information to be submitted by licensees relying on their own resources as financial protection; and (*e*) incorporates procedures for exemption of nonprofit educational institutions and Federal agencies from the financial protection requirement. In the latter two categories, Federal agencies are indemnified against all public liability, and nonprofit educational institutions are protected for public liability in excess of $250,000. Both cases, of course, are subject to the statutory limit of $500 million of indemnity protection per nuclear incident.

The second effective amendment to Part 140 approves, as proof of financial protection, the Nuclear Energy Liability Policy (Facility Form) currently offered by the stock and mutual insurance syndicates, Nuclear Energy Liability Insurance Association and Mutual Atomic Energy Liability Underwriters, respectively.

In addition to the two effective amendments, two proposed forms of Commission licensee indemnification agreements were published in the *Federal Register* for public comment on April 7, 1960. The forms are revisions of one proposed in August 1958 and republished May 1, 1959. Further opportunity for comment regarding the revised indemnity agreements was considered appropriate because of the importance and the significance of changes made in the form originally published for comment.

Prior to publishing the effective revision of Part 140, the Commission met in January 1960 with representatives of the insurance industry who proposed, among other things, a financial protection formula differing from that adopted by the Commission. In issuing the effective Part 140, the Commission requested comments regarding the proposal of the insurance industry and stated the Commission's intention to re-evaluate, no later than the end of 1960, the financial protection provisions of Part 140.

The Commission was completing a study on extension of Price-Anderson indemnification to licensees possessing and using substantial quantities of special nuclear material.

During 1960, the Commission entered into interim indemnity agreements covering operation of nuclear reactors by 2 private organizations, 5 nonprofit educational institutions, and 1 Federal agency. An additional 7 agreements protect holders of reactor construction permits also licensed to possess and store special nuclear material for ultimate use as reactor fuel when the Commission authorizes operation of the reactor.

New Regulations

New regulations and major amendments to existing regulations adopted by the Commission during 1960 were:

10 CFR Part 20—*Standards for Protection Against Radiation*

A comprehensive amendment to Part 20, effective January 1, 1961, prescribes numerical values and radiation exposure limits consistent both with the Radiation Protection Guides recommended by the Fe

Radiation Council, approved by the President on May 13, 1960, with the corresponding values recommended by the National Committee on Radiation Protection in National Bureau of Standards Handbooks 59 (revised) and 69.

A second amendment, also effective January 1, 1961, provides additional permissive methods of determining "calendar quarter;" amends the definition of "Restricted area" and "Unrestricted area;" modifies requirements for posting of Form AEC–3, "Notice to Employees;" and adds a concentration limit specifically applicable to uranium ore dust in air.

A third amendment, effective February 17, 1961, prohibits issuance of licenses authorizing receipt of radioactive waste materials from other persons for disposal on land not owned by the Federal or State governments.

10 CFR Part 30—*Licensing of Byproduct Material*

An amendment, effective September 16, 1960, exempts from Commission licensing requirements the possession and use of products containing small residual amounts of byproduct material not exceeding specified low concentrations. However, the person who introduces byproduct material into a product may do so only as authorized under a specific license. The products in which license-exempt concentrations would be introduced for quality control purposes include chemicals, plastics, petroleum products, and similar items where ingestion or inhalation is unlikely.

A further 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 luminescing agent.

In addition, an amendment, effective December 29, 1960, established detailed criteria for specific licenses for industrial radiography (nondestructive testing of materials to determine defects). This amendment was issued in conjunction with the adoption of the new regulation in 10 CFR Part 31, described below.

10 CFR Part 31—*Radiation Safety Requirements for Radiographic Operations*

Added as a new regulation, Part 31 becomes effective February 27, 1961. It 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—*Control of Source Material*

An amendment, effective July 8, 1960, exempts from licensing the receipt or possession of uranium contained in aircraft counterweights installed in aircraft.

10 CFR Part 50—*Licensing of Production and Utilization Facilities*

An amendment, effective March 7, 1960, added a definition of a "testing facility" and incorporated provisions concerning review by the Advisory Committee on Reactor Safeguards and formal hearings in power and testing reactor cases.

Two additional amendments, effective October 10, 1960, (*a*) clarify the extent of work permitted or prohibited prior to issuance of a reactor construction permit, and (*b*) add procedures and criteria whereby, under certain circumstances, a provisional operating license may be issued.

These amendments are two of the three proposed rules published in the *Federal Register* for public comment on February 11, 1960. The Commission has taken no action concerning the third proposal which would revise the criteria for issuance of provisional construction permits.

10 CFR Part 70—*Special Nuclear Material*

Two amendments added reporting requirements. The first, effective February 25, 1960, requires the semiannual reporting by licensees of the status of special nuclear material received, possessed or transferred. The second, effective January 12, 1961, provides for submission of reports of individual shipments and receipts of special nuclear material by licensees.

Proposed Amendments

A proposed amendment to 10 CFR Part 20, *Standards For Protection Against Radiation*, published in the *Federal Register* on August 16, would establish design and packing criteria for containers used for disposal into the sea of licensed low-level waste byproducts, source and special nuclear materials.

A proposed overall revision of 10 CFR Part 40, *Control of Source Material*, was published in the *Federal Register* for public comment on September 7, 1960. The proposed revision contains, among other things, procedures and criteria for the issuance of specific licenses and sets forth certain general licenses and exemptions from licensing requirements.

A proposed new rule, 10 CFR Part 72, *Regulations To Protect ... Accidental Criticality and Radiation Exposure in Ship... of Irradiated Fuel Elements* was published in the *Federal Regis...* March 17, 1960. The proposal would establish criteria for irradi... fuel element cask design and shipping procedures; it applies to ...mission special nuclear (fissionable) material licensees.

The proposed 10 CFR Part 115, *Procedures for Review of Certain ... Reactors Exempted From Licensing Requirements*, was pub... in the FEDERAL REGISTER for public comment on December 2, ... The proposed regulations would implement Commission policy ...ed in 1959 of providing for public hearings on safety aspects of ...mission-owned power reactors not located at Commission-owned

...tor Safety

...ring the first 11 months of the year, the Commission conducted ...views of the safety of licensee-and-Government-owned reactors. ...dition, advisory service was provided regarding reactors planned ...nstruction in Yugoslavia, Argentina, Indonesia, Republic of the ...ppines, Austria, Turkey, Iran, Israel, Tunisia, Pakistan, Colom... and the Euratom program.

...ring the same period, the Advisory Committee on Reactor Safe... held 10 meetings to consider and report on reactor projects ...ed to the Committee by the Commission.

...ance Actions

...rs were issued to 143 holders of source, byproduct, and special ... material licenses for revocation or modification of license, or ...ing that the licensee take specific actions to comply with Com... regulations. These included 134 orders amending licenses to ... that licensees possessing cobalt 60 teletherapy units make ... leak tests of the cobalt 60 sealed sources; and orders issued to ... Energy Waste Disposal Co., Dr. E. S. Gilifillen, Jr., University ...onsin, Specialty Steel Products Co., University of Pittsburgh ...enry N. Beets Co.

... Commission orders were contested by licensees as follows:

...e Matter of *Houston Gamma Ray Co.*, an order alleging willful ...ns was issued requiring the licensee to show cause why its ...aphy license should not be revoked. Following the filing of ...reliminary motions, and a prehearing conference, a stipulation between the licensee and the staff was filed agreeing to an order by the hearing examiner revoking the outstanding license, denying a pending application for license renewal, and providing that the licensee, after 1 year, could seek a new license upon showing its ability to fully comply with the Commission's regulations.

In the Matter of *Coastwise Marine Disposal Co.*, an order was issued requiring the licensee to show cause why its license authorizing the disposal of low-level radioactive wastes at sea should not be revoked. Subsequent alleged violations of the license led to the issuance of a further order suspending the company's operations pending a hearing. In December, the presiding officer issued an intermediate decision revoking the license.

In the Matter of *Sarnia Inspection Co.*, an order was issued requiring the company to conduct no further radiography operations except under specified conditions. After preliminary motions and a prehearing conference, the company stipulated that the order should be made effective by the presiding officer.

Resolution of Pending Cases

In the Matter of *X-Ray Engineering Co.*, an order alleging willful violations of the Commission's regulations and license conditions was issued requiring the licensee to show cause why its radiography license should not be revoked. The presiding officer delivered an intermediate decision in July 1960, which ordered revocation of the license. Exceptions were filed by the licensee. After review of submitted briefs, the Commission sustained the intermediate decision and directed that the company could file a new license application which would receive timely consideration contingent upon a demonstration that adequate provision for the public health and safety would be provided and maintained in complete compliance with Commission regulations. The applicant sought a stay of the order of revocation until such an application for license could be filed. The Commission denied the motion for stay.

In the Matter of *Mines Development, Inc.*, an order was issued to the operator of a uranium mill alleging the failure to conduct adequate surveys to determine compliance with the regulations. (The order

...er's intermediate decision ordered the licensee to institute a pro-...m which would assure that adequate surveys are made and other ...ective action taken. Exceptions were filed by the licensee in ...ember, and briefs were submitted by both parties.

...final decision in the Matter of *Advance Industrial X-Ray Labora-... Inc.,* delivered in January 1960, culminated proceedings in ...matter.[24] The decision permitted continuation of radiography ...ations but incorporated certain additional provisions in the ...se, including a monthly report of scheduled operations.

A full report on the status of compliance of the uranium mills ...the Commission's regulations was filed with the Joint Committee ...Atomic Energy.

Inspection and Compliance

AEC and Contractor Inspection

...inspection, audit and appraisal programs affecting the Commis-... and its contractor operations were monitored during 1960 through ...checks and reviews of their adequacy. Generally, inspection ...ms provided management with program evaluations and with ...formation necessary to determine whether or not contractors, ...es and employees complied with the Atomic Energy Act of 1954 ...with appropriate rules and regulations of the Commission. Sev-... improvements in the inspection systems provided responsible ...als with performance evaluation data in both administrative and ...rammatic areas.

...new program of formal evaluation of the performance of opera-... offices was initiated in September through a series of briefings of ...general manager. The evaluations were based largely on findings ... established Commission inspection and appraisal programs.

...mmary appraisals of the overall performance of 44 major cost-...ursable contractors were prepared by the operations offices which ...ister them.

...e responsibility for day-to-day inspection of licensed materials ...reactors was transformed from the Division of Inspection to the ... organized Division of Compliance on June 13 and August 1, ...respectively. Responsibility for evaluating the adequacy of the ...e inspection program remains in the Commission's Division of ...ction. Policies and standards governing the reporting and in-

[24] ...page 479, Annual Report for 1959.

vestigation of all incidents have been developed; and indepen- investigations of all serious incidents and independent inspe- of Commission operations have been carried out.

Licensee Compliance

Licensed Facilities

Inspection of licensed nuclear facilities, and those being constr- under construction permits, continued during 1960 with more freq- visits to sites of power and test reactors just coming into operati- Visits were made less frequently to facilities found generally - factory on previous inspections.

No substantial licensee noncompliance with rules and regula- were found. In a number of cases, inspection resulted in improve- of operational safety through relatively minor changes or addit- to equipment or procedures and organizations.

The Commission assigned to its Division of Compliance respo- bility for inspection of the N.S. *Savannah* and of power reac- under the second-round invitations of the Power Demonstra- Reactor Program, although these are Federal, not licensed, reac-

Licensed Materials

As of July 1, 1959, a changeover was made to establish a prior- system for scheduling inspections to assure adequate review of th- operations which experience showed were potentially the most haz- ous. The licenses in the highest priority constituted 7 percent of- total and 23 percent of all inspections reported to headquarters - ing the year were in this group. Eight field offices participated - this program (Albuquerque, Chicago, Hanford, Idaho, New Y- Oak Ridge, San Francisco, and Savannah River) and reported - inspections and 367 investigations and inquiries completed d- the year ended June 30, 1960. The number of active licenses incr- 7 percent during the fiscal year.

Professional personnel for this work in field offices was incr- from 39 to 59.

The Commission has streamlined reporting of inspections - noncompliance was not found. Formal reports are not prep- these cases, but form notices are issued to the licensees and supp- files of information are maintained.

C

Procurement Regulati-

The Federal Procuren- by the Administrator, Federal Property and - needless inconsist- -dures of Federal Gov- procurement regul- business representati- -ment Regulations -ation, and also the - which constitute imple- -essary and approve- -ulations to meet uni- The Commission is in- -ions System AEC pr- -dures (including tho- -) heretofore set for- -ual. They will be -ment Regulations (- Agreement has been -vices with respect t- -ulations, issued unde- -ces Act, and the spe- the Commission by th- agreement recogniz- Commission by the A- -racts under the Fed- and Federal Procu- -ty, are in addition to- -ission's statutory - -ic Energy Act of 19- Commission, in furth- procurement polici- will follow the Fe- those in which th- -wise.

The Federal Procurem- Commission Pro- -hed in the *Federal* - regulations will be Code of Federal Reg-

Contract Practices

...rement Regulations

...Federal Procurement Regulations System has been established ...the Administrator, General Services Administration, under the ...ral Property and Administrative Services Act of 1949 to elimi- ...needless inconsistencies between procurement policies and pro- ...res of Federal Government agencies, and to help make the agen- ...procurement regulations more readily available to the public and ...siness representatives. The system consists of the Federal Pro- ...ment Regulations (FPR) which are for Government-wide ap- ...tion, and also the policies and procedures of each Federal agency ...constitute implementation, supplementation or, in some cases, ...ary and approved deviations from the Federal Procurement ...ations to meet unique situations.

...The Commission is integrating into the Federal Procurement Regu- ...s System AEC procurement and contracting policies and pro- ...res (including those for construction and related engineering ...heretofore set forth in *Volume 9000—Contracting* of the AEC ...al. They will be designated Atomic Energy Commission Pro- ...ent Regulations (AECPR).

...ement has been reached with the Administrator of General ...es with respect to the relationship of Federal Procurement ...tions, issued under the Federal Property and Administrative ...es Act, and the specific authority to negotiate contracts granted ...Commission by the Atomic Energy Act of 1954, as amended. ...greement recognizes the principle that authority delegated to ...mmission by the Administrator of General Services to negotiate ...ts under the Federal Property and Administrative Services ...nd Federal Procurement Regulations pertaining to such au- ..., are in addition to and not a limitation or restriction upon the ...ssion's statutory authority to negotiate contracts under the ...Energy Act of 1954, as amended. With this understanding, ...mmission, in furtherance of the objective of establishing uni- ...rocurement policies and procedures throughout the Govern- ...ill follow the Federal Procurement Regulations in all areas ...hose in which the special nature of its programs requires ...se.

...Federal Procurement Regulations (FPR) and the Atomic ...Commission Procurement Regulation (AECPR), is being ...d in the *Federal Register*. An annual accumulation of both ...regulations will be published under Title 41—Public Contracts ...de of Federal Regulations.

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Cost Principles

The Commission's cost principles governing payments under cost-reimbursable contracts were revised and issued as a new Chapter 91.. of the AEC Manual effective March 22, 1960. Chapter 9111, Contract Forms and Provisions, was also revised and issued effective April 8, 1960, to provide standard contract language reflecting the cost principles. These two chapters were integrated into the Federal Procurement Regulations System as Atomic Energy Commission Procurement Regulations 9–15.50 and 9–7.50, respectively. They were published in the *Federal Register*, Vol. 25, No. 180, Thursday, September 15, 1960.

Small Business

The Commission's small business program emphasizes maximum practicable small business participation in the subcontracts of the Commission's prime contractors. In the fiscal year that ended June 30, 1960, small business' share of Commission subcontracts increased to 42.1 percent or $263 million out of $624 million total subcontract awards, as compared with 41.6 percent for fiscal year 1959 and the ... percent average for the 10-year period 1951–1960.

Classification and Declassification

A new "Classification Policy Guide" was made effective by the Commission in January 1960. It incorporates simplified broad statements of policy on classification of various phases of the atomic energy program agreed upon between the United States, the United Kingdom and Canada. This new guide, like previous guides, was prepared in line with the Commission's practice of continuously reviewing classification guides in view of the rapid pace of scientific progress and the wide scope of declassification activity.

Entire areas of information, previously classified in whole or part, were released from classification restrictions. The "Classification Guide for Use in the Civilian Application Program," for example, was greatly expanded and revised. Its list of unclassified reactors and critical experiments now includes 86 Commission Government-owned plants and 129 reactors owned privately in this country or built for other nations—an increase of 19 Commission reactors and 37 other reactors since June 1958. Another example of the Guide's effects was the declassification of the entire chemical engineering division of the Argonne National Laboratory which ...

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EXHIBITS A...

Exhibits

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comprehends every chemical engineering activity pertaining to nuclear energy. This step required review of 3,665 documents, of which nearly 3,000 were declassified.

The new Guide also permitted a reduction of the areas covered by the classified Access Permit Program. The number of classified categories was reduced from 37 to 2—"Nuclear Technology" and "Plutonium Production." The entire body of classified documents in the Civilian Application Program was reviewed again. Of 4,961 reports studied, nearly half were declassified and the remainder, by reason of subject matter, were placed in the two classified categories.

The Commission's review of classification policy included the weapons field and has resulted in adoption of a revised Atomic Weapons Classification Guide which better defines classification guidance and permits declassification of some additional information.

The Commission conducts a continuous review of the local classification and declassification programs in Commission and contractor organizations to insure that its policies with respect to release of the maximum amount of information are effectively carried out and to improve and strengthen the programs where possible. The appraisal has now run through its first cycle and has demonstrated that classification is, in general, being applied correctly and only where it is needed and that information is being reviewed and declassified promptly when its protection is no longer warranted. In this latter area an active and continued effort is being made in releasing information for publication.

Information

EXHIBITS AND EDUCATIONAL INFORMATION

Exhibits

Since the Commission established its traveling exhibits program 5 years ago, the exhibits have been viewed by 31,923,182 persons in the United States. Always shown under nonprofit sponsorship, the 27 manned and unmanned units were viewed by 8,873,837 persons in 48 States during the past 12 months.

The Commission's ten large, unmanned package exhibits titled "Summary of Atomic Energy," were withdrawn from tour in June after use since 1957. All were redesigned and reconstructed, retitled "Atoms in Action," and returned to tour in time for the fall county

Also renovated during the reporting period were the six manned "Atomic World" units used to demonstrate the basic principles

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of atomic energy before secondary school assemblies and science classes. The refurbished units were used in programs at summer camps in the Smoky Mountains area before starting the school-year tour in September.

Hawaii received its first traveling atomic energy exhibit in May, an extensive tour of "The Useful Atom" under the sponsorship of the Library of Hawaii. One of three package units designed specifically for library and school display, "The Useful Atom," was scheduled for showings in 11 different libraries on the three main islands.

The Commission's two large manned "You and the Atom" exhibits, which feature lecture demonstrations on fission principles, nuclear power, radioisotopes applications, and remote handling equipment, continued in heavy demand at State fairs and in large population centers. Five manned "Atoms at Work" mobile units, containing scaled-down versions of the larger exhibits and mounted in walk-through self-propelled vans, continued their tour of smaller U.S. communities under schedules sponsored jointly by the National University Extension Association and the United States Junior Chamber of Commerce.

In 1960, the Commission's American Museum of Atomic Energy at Oak Ridge, Tenn., had a record attendance of 95,707 visitors, bringing the attendance total during its 12 years of operation to 933,566 visitors from all of the States and from foreign countries. The Museum and traveling exhibits program are administered for the Commission by the Oak Ridge Institute of Nuclear Studies.

Information Exhibits

"Nuclear Information for Science and Industry," a manned exhibit featuring Commission technical information materials and services, was presented at the Atomic Exposition, New York, in April, and at the Western Atomic Industry Fair, San Francisco, in December.

The SNAP-3, a radioisotope-fueled thermoelectric generator, was demonstrated at the 1960 Aerospace Medical Assocation meeting in Miami, May 6–12, and at the Topsfield Fair, Topsfield, Mass., September 4–10. In the demonstrations, the device was used to power an amateur radio station and an apparatus to measure changes in heart-beat and respiration during physical activity—a simulated space application.

Educational Literature

Approximately 70,521 kits of atomic energy information literature were distributed during 1960 in response to requests from colleges,

...ndary school, and elementary school students, teachers, and guid-...e counselors; from adult study groups, teachers' institutes and ...inars; and from the general public.

FILMS

During the reporting period, the Commission's 10 domestic motion ...ture libraries, stocked with 160 popular and professional-level films, ...ed them for more than 68,000 showings viewed by an estimated ...,000 persons. The film libraries and the geographical areas they ...ply are listed in Appendix 7.

Approximately 65 professional-level films were on loan from the ...mission's liaison offices in London, Tokyo, Brussels, and Buenos ...res, with French and Spanish versions of about 45 films available ...ugh the latter two offices.

The Commission added 12 films to its motion picture libraries ...ing the reporting period. Motion pictures added were:

...fessional

FABRICATION OF PLUTONIUM DISKS, 13 minutes, black and white, ...duced by Los Alamos Scientific Laboratory; describes glove-box ...k in shaping toxic material.

...GONNE FAST SOURCE REACTOR, 9 minutes, color, produced by ...onne National Laboratory; describes the reactor's assembly and ...efulness in laboratory work.

...S COOLED REACTOR EXPERIMENT, 39 minutes, color, produced ...gh Idaho Operations Office by Lookout Mountain Air Force ...on for the Commission and U.S. Army Corps of Engineers; ...ribes design, development, component fabrication, assembly, test-... and initial criticality.

...MOTE MAINTENANCE OF MOLTEN SALT REACTORS, 20 minutes, ... produced by Oak Ridge National Laboratory; describes arrange-... of a mock-up fluid fuel reactor system and the remote use of ...alized equipment.

...sional and Popular

...E FIGHTING IN THE NUCLEAR AGE, 14 minutes, color, produced by ... Operations Office.

...USTRIAL APPLICATION OF RADIOISOTOPES, 57 minutes, color, pro-...d by the Army Pictorial Center for the Commission's Office of

Isotopes Development; describes the principles and techniques of dustrial gaging, radiography and radioisotope tracing.

SNAP–III: Operational Tests, 22 minutes, color, produced by Martin Nuclear for the Commission; describes operational tests of SNAP–III isotopic power unit.

Group Shelter, 10 minutes, color, produced by Department of Agriculture Motion Picture Service for the Commission; describes underground shelter for protection of 100 persons, and results of 19 nuclear effects tests at Nevada Test Site.

Technical Information Services of the AEC, 22 minutes, color, produced by the Department of Agriculture Motion Picture Service for the Commission.

Popular

Under Way, 20 minutes, color, produced by the U.S. Maritime Administration and the Commission; describes design and construction of the NS *Savannah* and its nuclear components and features.

Living With the Atom, 18 minutes, color, produced by the U.S. Information Agency. Explains in nontechnical terms the radiation safety devices and procedures that protect workers at atomic installations and communities.

The New Power, 39 minutes, color, produced by Lookout Mountain Air Force Station for Idaho Operations Office; describes the mission of the National Reactor Testing Station and some of its reactor and other facilities.

TECHNICAL INFORMATION ACTIVITIES

Technical Journals

Nuclear Science Abstracts

During the past 12 years the annual number of abstracts published in "Nuclear Science Abstracts" has increased from the 4,000 printed in 1948 to 26,000 in 1960. The steadily increasing volume is due primarily to expanded atomic energy activities at home and abroad, programs of exchange with foreign scientific sources, and of translations.

The Commission, in 1959, applied advanced machine techniques to preparation of this journal so that each issue now a subject index. Cumulative indexes now are published within weeks rather than several months later.[25]

"Nuclear Science Abstracts" and unclassified research and development reports published by the Commission are supplied to 706 organizations in 73 countries in return for monographs, research and development reports, and scientific journals from those sources. Publications received in exchange are abstracted for "Nuclear Science Abstracts" and made available through the Commission's depository libraries, Commission-contractors' libraries, or by inter-library loan from the library of the Oak Ridge Institute of Nuclear Studies. The Commission received 350 exchange research and development reports during 1960.

Technical Progress Reviews [26]

Cumulative indexes for the first 3 years of publication of the Commission's quarterly Technical Progress Reviews were published during 1960 and distributed as follows: September 1960 issue, "Power Reactor Technology;" October 1960 issue, "Reactor Fuel Processing;" November 1960 issue, "Reactor Core Materials." The first index of "Nuclear Safety" will be the index for Volumes I and II, available in the June 1961 issue. A three-year cumulative index will appear in the June 1962 issue—Vol. III, No. 4. "Nuclear Safety" entered its second year of publication in September.

Technical Symposia

During the reporting period the Commission published 24 collections of papers presented at scientific and technical symposia, meetings and conferences.

The Commission also issued during the past year, a catalog listing and describing proceedings of meetings of which the Commission or its contractors were sponsors or co-sponsors, or in which they were major participants. This 29-page catalog, "Proceedings of Technical Meetings, 1950–1958" is available on request to Office of Technical Information Extension, United States Atomic Energy Commission, P.O. Box 62, Oak Ridge, Tenn.

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[25] A brochure, "Technical Journals Published by the United States Atomic Energy Commission," describes the scope and content of the five technical periodicals published by the Commission: "Nuclear Science Abstracts" and four quarterly Technical Progress Reviews: "Power Reactor Technology," "Reactor Core Materials," "Reactor Fuel Processing," and "Nuclear Safety." Copies of the brochure are available on request from Office of Technical Information Extension, USAEC, P.O. Box 62, Oak Ridge, Tenn.

[26] Available by subscription (domestic, $2 a year; foreign, $2.50 a year), or by individual copy ($0.55), Superintendent of Documents, U.S. Government Printing Office, Washington

Technical Books

Under the Commission's program of preparing and arranging for the publication of handbooks, monographs, and other reference works on atomic energy subjects, four volumes were published during 1960:

"Volume 1, Materials," of the "Reactor Handbook" (2nd ed.).
"Management of Nuclear Materials".
"The Metallurgy of Hafnium".
"Controlled Thermonuclear Reactions".

As the year ended, five volumes were in press: "Metallurgy and Fabrication of Fuel Elements," "Rare Earth Alloys," and "Reactor Handbook," (2nd ed.), *Vol. 2, Fuel Reprocessing*, *Vol. 3 Physics and Shielding*, and *Vol. 4, Engineering*.

Contracts were awarded for revising and updating Samuel Glastone's "Principles of Nuclear Reactor Engineering;" for preparing a plutonium handbook, a sourcebook and a one-volume encyclopedia on atomic energy in the life sciences; for writing a text on vacuum technology, and for preparing a summary of special topics in electromagnetic radiation. A revision of the "Effects of Nuclear Weapons" was undertaken in cooperation with the Department of Defense. Arrangements also were made for the preparation and publication of the planned third edition of the "Reactor Handbook."

Distribution of Reports

A total of 4,400 copies of classified reports were sold during 1960 to those authorized to receive them, and 150,085 unclassified reports were sold to the public. A total of 5,328 new unclassified reports were placed on public sale through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

Engineering Materials

During 1960, the Commission signed a contract with Cooper-Trent Blueprint and Microfilm Corp. of Arlington, Va., for that firm to sell full-size blueline prints of engineering materials pertaining to the atomic energy program to industrial concerns, U.S. Government organizations and their contractors, and to the general public. Prices are 17 cents per square foot with substantial discounts for quantity orders. This service previously was provided from the Office of Technical Information Extension, Oak Ridge, Tenn.

The contractor[27] will prepare prints of drawings, specifications, photographs, and bills of materials as announced in "Engineering Materials List," (TID–4100)[28] and supplements, from reproducibles supplied by the Commission.

Depository Libraries

During 1960, a new depository collection of unclassified Commission reports was established at the Inter-American Nuclear Energy Commission, Pan American Union, Washington, D.C., for use by the Organization of American States. This brought to 85 the total depository libraries in the United States. Establishment of a depository library for the Euratom Research Center at Ispra, Italy (near Milan) raised the total in other countries to 85. (See Appendix 6 for listings.)

Translations

The Commission continued to expand its translation program during the reporting period. Over half of more than 600 translations announced in "Nuclear Science Abstracts" in the course of the year were produced under Commission sponsorship. These include 20 monographs on subjects such as "The Chemistry of Fluorine and Its Compounds", "Magnetic Emission of High Temperature Plasma", "Problems of Dynamic Theory in Statistical Physics", "Toxicology Problems of Radioactive Materials", and "Research in the Field of Dosimetry of Ionizing Radiation."

The Commission also participated in the translation program under Public Law 480, section (k), which authorizes use for this purpose of foreign currencies accruing to the United States from sale of surplus agricultural commodities. Under this program, which is coordinated by the National Science Foundation, translations of the Russian "Journal of Inorganic Chemistry", vol. 2, 1957, and the Russian "Advances in Physical Sciences", vol. 61, 62, and 63 (1957) were made in Israel. In Poland, translations were made of original Polish articles appearing in "Nucleonics", vol. 2, 1957, vol. 3, 1958.

Although emphasis was on publications from the Soviet Union, Japanese, Hungarian, and Serbo-Croatian publications also were translated and made available.

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[27] Inquiries concerning prices for this reproduction service should be addressed to Cooper-Trent Blueprint and Microfilm Corp., 2701 Wilson Blvd., Arlington 1, Va.; queries regarding materials not announced in "Engineering Materials List," (TID–4100), and its supplements should be addressed to Office of Technical Information Extension, USAEC, P.O. Box 62, Oak Ridge, Tenn.

[28] A catalog, "Engineering Materials List," (TID–4100, rev.), and periodic loose-leaf supplements, available on request, Office of Technical Information Extension, USAEC, P.O. Box 62, Oak Ridge, Tenn.

All these translations are announced in "Nuclear Science Abstracts" and placed on sale through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Photocopies may be obtained from the Library of Congress, Washington 25, D.C., and from the special Libraries Association Translation Pool maintained at the John Crerar Library, Chicago, Ill.

Education and Training

The findings of the survey of employment in the atomic energy field, described in Part One of this report, indicate a continuing demand for scientists, engineers, skilled workers, and technicians. This also is the general trend of American industry.

The Commission during 1960 extended through June 30, 1964, its programs of assistance for nuclear education in nonprofit educational and medical institutions in the United States. Some of these programs originally were scheduled to terminate on June 30, 1961.

Other aspects of the Commission's educational and training programs are described in sections of this report dealing with Radioisotope and Radiation Development, International Activities, and Health and Safety.

LIFE SCIENCES

Assistance to Schools

Faculty Training

Summer faculty training in radiation biology was conducted during 1960 through 8-week courses, 16 for high school teachers, 5 for college faculty, and 2 for high school and college faculties combined. Attendance of 347 high school and 113 college faculty members during 1960 brought the total, since the beginning of the program in 1958, to 1,087 high school teachers and 153 college teachers.

In September, two in-service sessions for 20 high school teachers each were inaugurated in the radiation biology institute program. These institutes consist of lectures and laboratory courses scheduled nights and Saturdays.

Equipment Grants

During 1960, 180 nonprofit educational institutions requested grants of funds for equipment to be used in radiation life science courses

The Commission awarded 122 grants for $1.128 million to 119 educational institutions.

Since the beginning in 1957 of the life science equipment grants program 352 grants totaling $3.7 million have been awarded to 213 schools.

Effect of Programs

Reports from schools receiving grants show that approximately 83 courses have been expanded to include instruction in aspects of nuclear technology related to medicine, public health, agriculture, pharmacy, veterinary medicine, and general biology. Twelve of 117 institutions enlarged laboratories and/or general teaching facilities for use of grant equipment and approximately 13 new faculty members have been added or assigned in the subsequent programs. Enrollment in courses relating to radiation biology during the academic year 1959–60 increased by 400 or 25 percent.

Fellowships

Industrial Fields

Four physicians were awarded fellowships for graduate training in *industrial medicine* for the academic year 1960–61. Three additional fellows were awarded a second year of training. The fellows are at the medical schools of Pittsburgh, Yale, Rochester and Harvard Universities.

Sixty fellowships have been awarded in this program since 1950.

Five *industrial hygiene* fellowships were awarded for the academic year 1960–61 bringing the total number of awards to fifty-four.

There are 62 *health physics* fellows for the coming academic year 1960–61. Thirteen of last year's fellows are continuing graduate study. More than 500 fellows have received this specialized graduate training since 1950 at one of the universities and one of the Commission's laboratories now cooperating in the program: Vanderbilt, Puerto Rico, Rochester, Harvard, Michigan, Kansas, Washington (Seattle), California (Berkeley), together with Oak Ridge, Brookhaven and Argonne National Laboratories, General Electric Co. (Hanford, Wash.), National Reactor Testing Station (Idaho), and E. O. Lawrence Radiation Laboratory, University of California (Berkeley and Livermore, Calif.).

The program for *advanced training in health physics*, to equip experienced health physicists for senior positions, was begun in academic year 1959–60, with five graduate fellows. One obtained his doctorate from the University of Michigan and fellowship renewals have been granted to the other four. Five new fellows will begin training in the academic year 1960–61.

The fellowship program is administered for the Commission by the Oak Ridge Institute of Nuclear Studies.

PHYSICAL AND ENGINEERING SCIENCES

Faculty Training

For five consecutive years summer institutes have been conducted under the joint sponsorship of the Commission and the American Society for Engineering Education to provide opportunities for faculty members to learn the latest developments in nuclear and nuclear-related technology. In 1960, 97 faculty members attended 6 institutes: 3 in basic nuclear technology—at North Carolina State College with Oak Ridge National Laboratory, at Pennsylvania State University with Argonne National Laboratory and at Purdue University with Argonne National Laboratory; intermediate reactor physics at North Carolina State College; specialized nuclear studies at Argonne National Laboratory; and radiation effects at University of Michigan. Since inception of the program a total of 581 enrollees have represented 154 institutions in 28 summer institutes.

Temporary Appointments at Laboratories

During the year, approximately 94 faculty and 197 graduate and undergraduate students were given temporary appointments at Argonne National Laboratory for periods of from 3 months to 1 year. At Oak Ridge National Laboratory there were 70 faculty participants in the summer of 1960. A similar program is carried on at Brookhaven National Laboratory.

Fellowships

A total of 177 graduate fellowships in nuclear science and engineering were in effect for the 1960–1961 academic year, bringing to [illegible] the total fellowships since the program began in 1957.

Equipment Grants and Materials Loans

In 1960, the Commission made grants totaling $1 million to universities and colleges for purchase of specialized nuclear equip-such as subcritical assemblies, pulsed neutron generators, reactor simulators, and instruments for radiation detection, monitoring, and counting. The Commission also approved loans to 74 schools, without charge, of neutron sources, natural uranium reject and enriched uranium for nuclear instructional purposes. Since the program was initiated in 1956, a total of $13.78 million has been awarded to 167 institutions and nuclear materials valued at $11.14 million have been loaned or authorized for loan to 154 institutions.

As stated in an August 16, 1960, announcement extending the educational assistance program, the Commission no longer will provide dollar grants for teaching reactors (grants were awarded for such reactors during the period 1956–58).

In addition, the emphasis of the training equipment grant program has been changed from furnishing equipment for use in the education of reactor engineering specialists to furnishing equipment needed for general nuclear education in colleges of arts and sciences as well as engineering schools.

University Research Reactor Assistance

In 1960, the Commission agreed to lend enriched uranium and heavy water and pay fuel fabrication costs for the Georgia Tech research reactor now under construction, bringing to nine the number of universities assisted in this manner. Under this program the Commission assists reactor projects at nonprofit educational and medical institutions by loaning special nuclear material and heavy water without charge for use and normal loss, and by providing funds or services without charge for the fabrication of fuel elements and neutron sources and reprocessing of fuel after use. The program is carried out in cooperation with the National Science Foundation which provides grants toward the construction of university research reactor facilities.

INDUSTRIAL PROGRAMS

Contractors Training Programs

The training and education requirements at Commissioned-owned establishments—as in industry generally—are determined largely by two considerations.

First, keeping up with a changing technology by expansion of employees' scientific knowledge.

Second, recruitment and training of new personnel and upgrading or retraining of employees to meet shifting requirements.

Third, adequately trained replacements for work force loss. Turnover is relatively low at Commission-owned establishments; however, those leaving Commission employment do help staff pri-vate atomic energy activities.

The training programs reported in this section, based on a study during 1959 of Government-owned plants operated by contractors on a cost reimbursable basis for the Commission, assist both employees and non-employees. Training of employees is authorized when the training is directly related to the operations of the contractor. Non-employees' training is authorized to assist in the Commission's task of helping to develop a pool of trained personnel for the future atomic energy industry.

Training Contractor Employees

The following tabulation estimates the number of employees given training during 1959 through different systems, not including specialized training in radiation safety which is required in various degrees for all employees:

System	No. of employees
Tuition Assistant Plans	2,[illegible]
Selected Vocational Level Training Activities	2,[illegible]
Undergraduate Level Training Courses	1,[illegible]
Graduate Level Courses Given on Site	1,[illegible]
Graduate Level Special Outside Training Courses	[illegible]
Combined Work-Study Graduate Plans	[illegible]
Professional Research, Advanced Study and/or Teaching Leave	[illegible]
Total	8,[illegible]

Tuition assistance plans. The tuition assistance plan is offered at all educational levels. In general, the scientific and engineering subjects are covered, although the plans may be extended as part of employee improvement and upgrading programs. All school work under these plans is on the employee's own time, usually off hours, although leave without pay is sometimes granted.

Vocational level training. The added nuclear specialties required at the vocational level are frequently interwoven in basic craft skill training. Apprentice programs and related skill development for workers and technicians are general throughout Commission installations. The Department of Labor has estimated that current apprentice programs throughout all industry are adequate to meet not more than 10 per cent of the need for skilled workers. Accordingly, Commission contractors, like other industrial operators, have established a variety of skill training programs of which a portion cover specialized nuclear skills. This is essentially on-the-job training.

Undergraduate level training. Relatively little undergraduate level technical training is carried on directly by Commission contractors. Most of the courses are a part of programs to help upgrade technicians to professional positions. Assistance is provided chiefly through tuition aid.

Graduate training. The greatest amount of training by contractors at the graduate level is on site and pointed to particular subjects closely related to the employee's work assignment. Courses may be given either during work hours or afterward. If during work time, the employee draws regular salary. If after hours, no pay is received for time in class.

Each year a number of contractor employees are sent to outside courses and seminars of greater than 16 hours duration. The studies are directly related to jobs and frequently cover subjects needed for new programs. The cost of this type of training includes salaries, transportation, living expenses, tuitions, books, etc.

Three contractors have combined work and study graduate plans under which young engineers and scientists with outstanding records in undergraduate work are provided stipend or other assistance in graduate work while employed on Commission work.

Leave for advance study or teaching. This type of training activity, rare among Commission contractors, is designed to allow a few selected senior members of the professional staffs an opportunity to spend a period of time—not to exceed one year—in professional research advanced study or teaching. The objective is broad professional development and stimulation of creative abilities.

Contractor Training for Others

The following tabulation shows categories and number of participants in training programs for others not its own employees:

System	*Total No. of participants*
Cooperative Education Participation by AEC Contractors	140
Summer Employment Activities Among AEC Cost-Reimbursed Contractors	178
Formal Research and Engineering Participation Activities Carried on by AEC Contractors	632
Training of Employees of Other Organization by AEC Contractors	578
Total	1,528

Cooperative educational participation. Under these plans, two undergraduate students who take similar courses in engineering schools with established cooperative programs alternate between school and work, thereby providing continuous coverage of a single position. Employment of these students provides practical engineering experience; increases student interest and knowledge in fields of atomic energy technology; and provides a source of prospective employees upon graduation. All the students are given actual work assignments and their productive work compensates in large part for the salaries paid.

Summer employment. A number of Commission contractors offer summer employment to students and faculty members at various educational levels. Work assignments vary with capacity and participants join actual work groups. At secondary school level, the objective of summer employment is vocational guidance.

Formal research and engineering participation. Somewhat formalized arrangements to provide for participation by college students and faculty in Commission research and engineering projects have been established at a number of installations. Those participating in these programs are teaching faculty or students working for a degree rather than part-time employees. The general purpose of these programs is to develop superior graduate students into well-qualified nuclear scientists, and to assist universities in strengthening their programs in nuclear courses by providing research opportunities. The work assignments involve actual work on projects within approved Commission programs. Most participants are compensated like regular employees on similar assignments. This program either combines part-time university attendance with part-time laboratory assignments, or provides alternate periods of university attendance and Commission research.

Training for other organizations. Upon request of the Commission, contractors provide opportunities for specialized work experience at Government-owned facilities for: (*a*) scientific, engineering and other employees of private firms and institutions and of other Government agencies; (*b*) foreign nationals; and (*c*) fellows in approved Commission fellowship programs. Salaries are paid by the sponsoring organization, and administrative costs are absorbed in contractor operating funds.

Industrial Courses

During the year,
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* Publications for sale by S
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Maintenance Personnel in Nu
Survey of Nuclear Energy a
Nuclear Energy Training
Preparation for Nuclear En
Radiation Safety Training P
"Instructor's Guide: Radiati
Hazard," $0.35; "Develop
Industry," $0.75; "Instructo
Applications in Industry," $0

Assistance To Vocational Schools

Industrial Courses

During the year, Stanford Research Institute completed under 3 Commission contracts development of three 32-hour basic adult education courses covering: (*a*) radiation safety training; (*b*) training for radioisotope workers in industry; and (*c*) training for operating and maintenance personnel in nuclear power generating systems. The Institute also drew up general plans for more advanced courses consistent with training needs.

In its research to develop these courses, Stanford assessed the scope and magnitude of training needs that now exist or that may be expected to arise as a consequence of the development of nuclear power generation systems and the increasing use of radioisotopes in industry. The effectiveness of the courses was tested in trial presentations conducted in adult vocational educational programs and the courses were modified to incorporate results of the trial presentations. Instructors' guides were developed to cover nuclear energy and power plant applications; radiation safety and, nuclear fundamentals and radioisotope applications in industry.[29]

The courses for operating and maintenance personnel in nuclear power generation systems was distributed to Directors of Vocational Education of the 50 States, to all utility companies interested in nuclear power generation, to companies interested in production of components of nuclear power generation systems, to the labor unions who will represent employees of nuclear power generation stations, of the 50 States and to approximately 250 industrial companies interested in atomic energy.

Public Safety Courses

To expand and integrate nuclear energy training courses for firemen into vocational education systems of the States, the Commission and the Office of Education have jointly consulted with the National Professional Curriculum Materials Committee for Trade and Industrial Education, for State Directors of Vocational Education, and four trainers of firemen. Acting as a working committee, this group reviewed course material in use and recommended development of courses for vocational schools and methods for encouraging use of the material. The committee proposed development of a 4-hour orientation course for all firemen, and a 12-to-15-hour basic course for firemen selected because of their specific assignments. Using the Stanford Research Institute "Instructor's Guide: Radiation Safety" and other material, the two courses recommended by the committee are being prepared for distribution early in 1961 to the 50 States and to larger cities and fireman organizations that operate independently of State vocational training systems.

This training, an integral part of the Commission's Radiological Assistance Program, replaces the earlier training program for public safety personnel carried out directly by the Commission.

To date, over 2,000 public safety instructors from State and municipal organizations across the country have attended Commission courses. Sampling inquiries indicate that thousands of firemen and police have attended classes conducted by these instructors.

In addition, seminars have been conducted for executives in industry, fire protection engineers, safety engineers, personnel of other Federal agencies, and others with an interest in obtaining a layman's understanding of the relationship of the radiation problem to their specific field of interest.

Two publications growing out of this work have been placed on sale at the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. More than 17,000 copies have been sold of "Living With Radiation" Part I, Fundamentals ($0.45), a basic publication for laymen. "Living With Radiation" Part II, Fire Service Problems ($1.00), was published just before the end of the year.

"Living With Radiation" Part I is being made into a motion picture for distribution through the Commission's film libraries (see Information Section of this report).

Health and Safety

Under its organization for directing its health and safety programs, the Commission during 1960:

Inaugurated a program of regular reports by Commission contractors operating major installations to provide data to the public on environmental radiation levels.

Completed most of the preliminaries, in cooperation with States and interested organizations to assist States that wish to share in regulation and enforcement of radiation safety.

Received requests from 8 States for comments on proposed State legislation or regulations, and held discussions with 4 States interested in assuming regulatory responsibility.

Continued and expanded academic and on-the-job training for State officials and orientation of local employees who might have to deal with radiation hazards.

Responded to 60 requests for radiological assistance in suspected radiation incidents, and broadened its capability for meeting requests. A map has been published establishing service points for geographical areas.

Reviewed the radiation protection guides established by the President on the basis of Federal Radiation Council recommendations and determined their impact on Commission and licensee operations.

Conducted an annual survey of industrial exposures to radiation in Commission installations, broadened to include 12,000 additional workers with results that showed the number of people exposed to more than 5 rems during 1959 was 60 percent below the number exposed to this amount in 1958.

This report includes a table listing radiation incidents during the 2 years beginning July 1, 1958, and extending through June 30, [illegible] in both Commission installations and in licensed operations.

A prime function of the Commission's Office of Health and Safety, established September 12, 1959, is to accomplish continuous review and evaluation of health and safety programs within Commission's facilities, and to assist in developing appropriate health and safety policies, [illegible] and criteria.

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Immediate responsibility for health and safety in the operation of Commission facilities lies with the operator, generally a contractor, who must maintain a staff of competent, professional industrial health and safety specialists. This staff has the first responsiblity for anticipating and solving health and safety problems.

Responsibility for contractor performance lies with the Operations Office Manager. His staff provides the data used by the contract administrator to determine that prescribed standards and policies are being followed.

Staff evaluations of the overall program are made by Commission headquarters staff on the basis of periodic visits, routine and special reports, and other exchanges of information.

This triple surveillance of safety and health protection problems within Commission contract activities has helped to maintain the Commission's health and safety record as one of the best in the country.

Commission submissions for Hearings on Radiation Protection Standards and Criteria: Their Basis and Use, held in May and June by the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy of the Congress, included several appendices dealing with the application of radiation protection standards at major production plants, and a report on the economics of radiation protection for reactors.

PUBLIC REPORTING ON RADIOACTIVITY

In view of increased public interest in levels of radiation exposure, the Commission has undertaken to publish periodically full information on environmental radioactivity resulting from Commission operations. Beginning July 1, environmental data were reported quarterly from all Commission installations where radioactivity reaches the environs in amounts sufficient to justify environmental monitoring or surveys. In the past, data of this kind usually have been made available on request.

Under the Commission's new arrangements, each prime contractor operating a Commission installation prepares, on a quarterly basis, a summary report of all available data on environmental levels of radioactivity resulting from the operations of the particular installation. With the first quarterly report each year, the contractor also will issue summaries of data for the preceding calendar year.

These reports are distributed to local news media, to State and municipal public health officials, and to the U.S. Public Health Service

STATE-FEDERAL RADIATION COOPERATION

Cooperation between the Federal Government and the States in arranging for States to share responsibility for assuring safe atomic energy operations was carried forward during 1960 jointly by the Commission and the States and interested organizations with these results:

Criteria were developed for guidance of the Commission and States in determining compatibility of regulatory programs, and after review by State representatives, these are being used as a basis in negotiating agreements.

A draft of suggested legislation prepared by the Commission cooperatively with the Council of State Governments, was adopted by the Council as part of the legislative program it will sponsor in 1961.

Suggested radiation control and licensing regulations for States were drafted as a cooperative project with the Council of State Governments, and the U.S. Public Health Service, and are being circulated for public comment.

Training programs for State personnel were continued and are being expanded.

During 1960, nine States requested comments on proposed regulations and legislation.

The first formal proposal by a State for an agreement to assume regulatory responsibility was submitted on September 20, 1960, by Kentucky at which time informal discussions had been under way with New York for several months. Preliminary discussions were held with New Jersey and Maryland about entering into agreements.

A study on the community impact of atomic energy was completed by the American Municipal Association, and discussions have been held with representatives of municipalities: for example, Cincinnati, Los Angeles Harbor, and New York City, officials.

Preliminary work started on a draft of a model Commission-State agreement.

Criteria For Regulatory Programs

As an initial step in preparing for negotiation of agreements, criteria were developed for guidance of the States and the Commission in determining the compatibility of the regulatory programs of the States with that of the Commission. Under Public Law 86–373 amending the Atomic Energy Act of 1954, the agreements may cover the control of (*a*) byproduct materials (radioisotopes), (*b*) source materials (uranium and thorium), and (*c*) special nuclear material (uranium 233, uranium 235 and plutonium 239) in quantities less than a critical mass.

On April 11, President Eisenhower wrote the Governors pointing out that the law was enacted in response to recommendations by the Joint Federal-State Action Committee, and stressing the need to increase the functions and responsibilities of the States. On April 12 the Commission forwarded copies of the proposed criteria to the State Governors requesting their comments. The proposed criteria also were circulated for comment to interested Federal agencies, and other public and private groups and individuals.

To provide a more detailed explanation of the proposed criteria, the Commission conducted four regional meetings: Atlanta, May 19, sponsored by the Regional Advisory Council on Nuclear Energy of the Southern Governors' Conference, and in Chicago June 23, New York City June 24, and San Francisco July 11, sponsored by the Council of State Governments. The four regional meetings were attended by approximately 150 persons representing 37 States.

In addition, at the request of State coordinators, advisory commissions, committees and officials, meetings were held in 13 States (California, Connecticut, Illinois, Kansas, Massachusetts, Missouri, Nevada, New York, New Jersey, Rhode Island, South Dakota, Oregon and Arizona) and the District of Columbia, to discuss the proposed criteria and problems related to various aspects of the program. At Commission headquarters in Germantown, Md., similar discussions were held with representatives of Hawaii, Kentucky and Maryland. Follow-up conferences were held with representatives of a number of States. Additional conferences were held with representatives of industry, labor and other interested groups.

Commission staff also discussed the proposed criteria before the Committee on Atomic Energy of the National Association of Attorneys General, the Conference of State Sanitary Engineers, the Middle States Public Health Association, the Atomic Energy Committee of the National Conference of Commissioners on Uniform State Laws and the National Legislative Conference, as well as at a hearing before a committee of the California legislature.

Prior to drafting the proposed criteria, informal discussions were held with State health officials in meetings sponsored by the U.S. Public Health Service at Las Vegas, Nev., on December 5, 1959, and Montgomery, Ala., on February 12, 1960.

On August 22 and 23, the Commission's Advisory Committee of State Officials met in Washington, D.C. to assist in evaluating comments on the proposed criteria, which then were rewritten in part. They now are being used in negotiating agreements with the States.

Suggested Control Act

Through a cooperative effort between the staffs of the Council of State Governments and the Commission, a suggested State Radiation Control Act was drafted. The purpose of the act is to provide suggested basic enabling legislation for radiation control programs compatible with the Commission program, as well as for other radiation problems within the States. Primarily through the mechanism of the Council of State Governments, this draft of a suggested act was presented for comments and criticism to representatives of the National Association of Attorneys General, the State and Territorial Health Officials, the American Public Health Association, Federal agencies, municipal organizations, industry, labor and other interested groups. This act, also reviewed by the Advisory Committee of State Officials, has been included in suggested State legislation sponsored by the Council of State Governments for 1961.

Suggested Regulations

To aid States in developing radiation safety regulations compatible with the Federal program, the Commission is working with the Council of

Training courses include both one-year and 10-week training cours[es] in health physics and on-the-job training and orientation in the Com[-] mission's licensing and inspection programs. In the past 2 years, State employees have attended the one-year courses which include months at the University of Michigan or Harvard University, fol[-] lowed by 3 months experience in Commission facilities. The Commis[-] sion formerly paid stipends in addition to tuition, but stipends no longer are authorized.

A 10-week pilot course in health physics was initiated by Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies in January 1960. The pilot course was attended by 16 State and munici[-] pal health officers and 4 Federal personnel. It will be repeated in the spring of 1961.

Similar courses have been developed at the Commission's Health and Safety Laboratory, which presented its first course in New York City in October. Argonne National Laboratory at Argonne, Ill., and the University of California plan to start courses in March and sum[-] mer of 1961, respectively.

On-the-job training in licensing activities and orientation in inspec[-] tion is provided at Commission headquarters; detailed training in inspection is provided by operations offices. Operations offices have expanded their programs to include orientation in general aspects of inspection.

The State of New York was the first State to send personnel for orientation. Other States which have taken advantage of this train[-] ing include New Jersey and Connecticut.

RADIOLOGICAL ASSISTANCE PLAN

During 1960, the Commission's operations offices and headquarters responded to about 79 requests under its Radiological Assistance Plan in connection with incidents that were believed to involve radio[active] materials. Of these incidents, 54 were found actually to involve radio[-] active materials. Commission offices replied to about 126 addi[tional] requests for information, advice and guidance on emergency radio[-] logical assistance matters.

The Radiological Assistance Plan provides for nation-wide emer[-] gency radiological monitoring teams including an appro[priate] organization [30] "to make available, upon request from an AEC li[censee] ...

[30] See p. 268–70, Annual Report to Congress for 1959.

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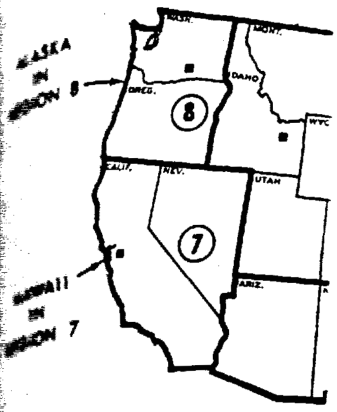
AEC REGIONAL A[...]
IN INCIDENTS

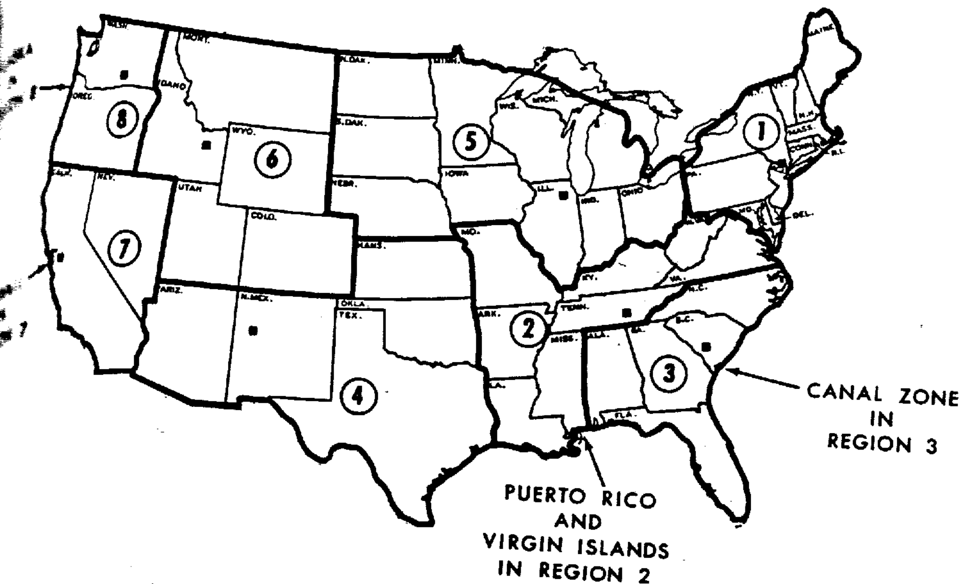


New York Operations O[...] YUkon 9–1000.
Oak Ridge Operations O[...] Ridge 5–7486, ext. 760[...]
Savannah River Operati[...] 9–6211, ext. 3333 (thro[...] Augusta, Ga.).
Albuquerque Operations [...] ALpine 6–4411, ext. 382[...]
Chicago Operations Office [...] water 7–7711, ext. 2111 [...]
Idaho Operations Office, [...] 2–6640.
San Francisco Operations [...] THornwall 1–5620.
Hanford Operations Offic[...] hall 2–1111, ext. 6–5441.

[...] AEC contractor, Federa[...] person cognizant of [...] material, such advice an[...] may be appropriate [...] property damage, to cop[...] health and safety.

[...] AEC Manual Chapter 05[...]

AEC REGIONAL AREAS FOR RADIOLOGICAL ASSISTANCE
IN INCIDENTS INVOLVING RADIOACTIVE MATERIALS



York Operations Office, 376 Hudson St., New York 14, N.Y., phone: ...tkon 9-1000.

...Ridge Operations Office, P.O. Box E, Oak Ridge, Tenn., phone: Oak ...idge 5-7486, ext. 7607; or Oak Ridge 5-8611, ext. 7607.

...annah River Operations Office, P.O. Box A, Aiken, S.C., phone: MIdway ...6211, ext. 3333 (through Aiken, S.C.), or PArk 4-6311, ext. 3333 (through ...ugusta, Ga.).

...querque Operations Office, P.O. Box 5400, Albuquerque, N. Mex., phone: ...pine 6-4411, ext. 38267.

...go Operations Office, 9800 South Cass Ave., Argonne, Ill., phone: CLear- ...ater 7-7711, ext. 2111 or 541.

... Operations Office, P.O. Box 2108, Idaho Falls, Idaho, phone: JAckson ...040.

... Francisco Operations Office, 2111 Bancroft Way, Berkeley, Calif., phone: ...ornwall 1-5620.

...ord Operations Office, P.O. Box 550, Richland, Wash., phone: WHite- ...all 2-1111, ext. 6-5441.

...ontractor, Federal, State or local official, private organization ...on cognizant of an incident suspected to involve radioactive ... such advice and radiological assistance from AEC resources ... be appropriate to minimize injury to people, to minimize ... damage, to cope with radiological hazards and to protect the ...ealth and safety.[31]

[31] ...EC Manual Chapter 0526, Radiological Assistance Program.

Information is made available to interested organizations on a routine basis which identifies Commission offices that will provide emergency radiological assistance, advice, or information and should receive reports of radiation accidents believed to be of interest to the Commission or to the Department of Defense.[32] More than 30,000 copies have been distributed of a map showing geographical areas of responsibility for radiological assistance activities of Commission operations offices.

Through the operations offices, 584 personnel are routinely available for radiological assistance team work. The teams include specialists in administration, radiation safety, public information, and radiation medicine. These specialists are sent out in teams or individually in accordance with requirements of the particular situation. It is estimated that 80 requests for radiological assistance could be served simultaneously with three-man teams of appropriate specialists. A reserve of more than 300 persons would remain available as needed.

It is intended to increase total capability for areas that now have limited coverage so that teams could arrive at the incident site in not more than 2 to 3 hours.

The Interagency Committee on Radiological Assistance (ICRA) approved a final draft of the proposed Interagency Radiological Assistance Plan (IRAP). The thirteen agencies currently participating on the ICRA have received the IRAP for consideration and approval. Each agency that finds the IRAP acceptable will officially become a participating agency under the plan on the date of approval.

FEDERAL RADIATION COUNCIL

On May 13, 1960, the President approved seven recommendations concerning radiation exposure to persons contained in the first memorandum submitted by the Federal Radiation Council, established by Executive Order 10831, August 14, 1959, and made a statutory body by amendment of the Atomic Energy Act of 1954 in Public Law 86-373.[33] (See Appendix 8.) Also on May 13, the Council issued its Staff Report No. 1 on background information for the memorandum.

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[32] See p. 270, Annual Report to Congress for 1959, Joint Nuclear Accident Coordinating Center and basic agreement.

[33] See p. 268, Annual Report to Congress for 1959.

The memorandum views the setting of radiation protection standards as the making of a judgment on the extent to which the risks of exposure to radiation may be accepted in order to realize the benefits associated with incurring the exposure. The Council emphasizes that there should be no single "permissible" or acceptable exposure level set without regard to the reasons for permitting the exposure. Then, the memorandum recommends adoption for Federal use of the term "Radiation Protection Guide" to designate an exposure dose level resulting from application of this principle. Values to be used as Radiation Protection Guides are given for normal peacetime operations.

Radiation protection guides developed so far pertaining to whole body and special organ exposure under industrial conditions, and to somatic (whole body) genetic exposure to individuals, and as an average for large populations. The rem-dose values given by the guides differ very little from the most recent values recommended or suggested by the National Committee on Radiation Protection and Measurements, and the International Commission on Radiological Protection. To that extent, no immediate effect on Commission activity is expected.

The new radiation protection guides were promulgated for official use by agencies of the Federal Government. The Commission will look to the recommendations of the memorandum for its primary guidance.

Radioactivity concentration guides for radioactive materials that might be inhaled or ingested are being developed by the Federal Radiation Council. Pending their issuance, the Council recommends that Federal agencies continue to follow the recommendations of the NCRP, which the Commission has followed for some years.

SAFETY AWARD

The Atomic Energy Commission has established a new safety award for the contractors or operations offices achieving the best all-time Commission record for prevention of occupational injury—the greatest number of injury-free man-hours. A trophy will be held by the winner until the record is superseded.

Sandia Laboratory at Albuquerque, N. Mex., accumulated an all-time AEC safety record total of 14,936,169 man-hours before its record was broken on September 6, 1960, by a disabling injury. Sandia exceeded the old AEC record of 11,175,509 man-hours achieved by the General Electric Co. at the Commission's plant at Evendale, Ohio, in 1957. This places Sandia Laboratory among the National Safety Council's best records known in industry.

Radiation Exposure Of AEC Contractor Personnel

The Commission's annual survey of rates of exposure to external radiation among workers in Commission installations, designed to check on adequacy of safeguards and enforcement, showed that of more than 75,000 contractor personnel, some 99.9 percent were exposed from none to less than 5 rems per year, and only 5.17 percent had exposures of between 1 to 5 rems. This compares to 99.73 percent in the 0 to 5-rem range during 1958 for some 66,000 employees, and 9.52 percent in the 1- to 5-rem range. The number of people exposed to more than 5 rems in 1959 was reduced by more than 60 percent despite the greater number of people involved.

The following table gives details for the 2 years:

TABLE 1—EXPOSURES OF CONTRACTOR PERSONNEL TO PENETRATING RADIATION, SUMMARIZED FOR 1958 AND 1959

Range of annual total exposure in rem [a]	1958 Number of workers	1958 Percent of total number of workers	1959 Number of workers	1959 Percent of total number of workers
0–1	59, 455	90. 21	71, 630	[illegible]
1–5	6, 271	9. 52	3, 912	[illegible]
5–10	159	. 24	66	[illegible]
10–15	10	. 01	2	[illegible]
15	12	. 02	[b] 1	[illegible]
	65, 907	100. 00	75, 611	100. [illegible]

[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] This overexposure is noted in table 5.

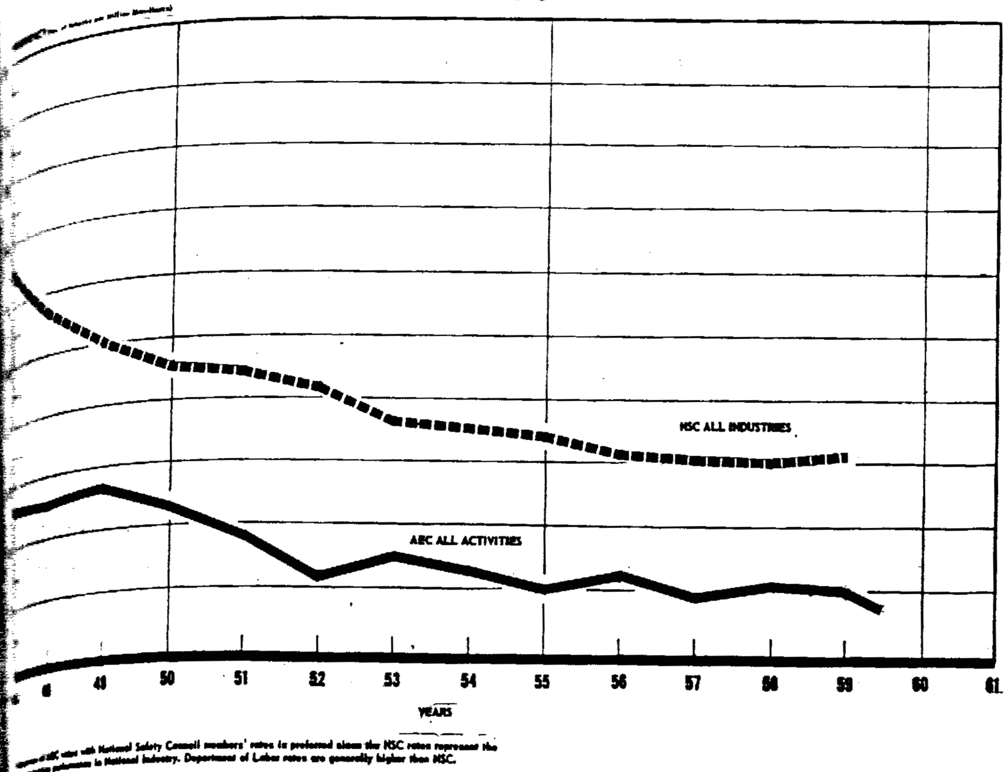
Industrial Safety And Property Protection

Industrial Safety

The Commission's 1960 record in safety and fire protection was surpassed by the 1959 record (the latest available) of only one of the industries in the United States as reported to the National Safety Council, which compiles and publishes annually the average injury

...quency rates. The one having the best record was the communica-...ns industry.

PERSONNEL INJURY RATES 1947-1960



...e Commission showed a reduction of 24 percent in its injury rate ...m 1959 to 1960. Based on number of injuries per million man-...s of employment, the over-all rate dropped from 2.11 to 1.70 ...own in the following table:

AEC INDUSTRIAL INJURY FREQUENCY RATES [a]

Type of work	1959	Jan. thru November 1960	Percent increase or decrease
...ction	1. 07	0. 73	−32
...rch	1. 94	1. 57	−19
...	2. 88	2. 24	−22
...us Construction	4. 32	3. 85	+11
...um Construction	16. 72	14. 10	−16
...ct-Engineering	2. 05	1. 64	−20
...ment	2. 14	0. 76	−65
...	2. 11	1. 70	−24

...ber of lost time injuries per million man-hours.

Fire, Explosion and Property Damage

Fire and explosion have been the principal causes of Commission property damage and loss during each of the 17 years the Government's industrial nuclear facilities have been in operation. Approximately 11 percent of total damage resulted from hazards classed as specific to nuclear activities.

Serious Accidents

Thirty-seven serious accidents occured in atomic energy facilities January 1 to November 1, 1960 inclusive, and are summarized in Table 1. A "serious accident" means an accident required to be reported immediately to Commission headquarters, and includes any of the following: (*a*) fatalities, (*b*) Government property damage of $5,000 or more, (*c*) an external radiation exposure greater than [illegible] rems received over a short period of time, (*d*) other injury or industrial illness, no matter how slight, of five or more persons in one accident, and other defined accidents. (AEC Manual Chapters 0502–04 and 0523–052 give full definitions of immediately reportable accidents.) Four workers were killed in accidents that did not involve radiation.

TABLE 1.—SERIOUS ACCIDENTS [a]

January 1—November 1, 1960

HS No. [b]	Date	Operations Office	Injury and loss	Remarks
60–3	1–16	COO	$30,000	Two boilers in a reactor power house exploded due to [illegible] of fumes in firebox while an attempt was being [illegible] start unit manually.
60–4	1–29	ALOO	1 killed	Professional skin diver drowned while performing [illegible] duties at the Eniwetok Proving Ground.
60–5	2–12	COO	13,115 2 injured	A reactor vessel holddown plug assembly dropped [illegible] being lifted and moved by means of a hand [illegible] riggers injured.
60–7	3– 3	SAN	12,500	During the pressing of an experimental high [illegible] detonation occurred.
60–8	3– 8	OROO	1 exposed	An employee was exposed to radiation from Ce 144 [illegible] cleaning up a cell. The exposure was 5,550 rads to the [illegible] (beta dose).
60–9	1–26	OROO	20,000	Explosion occurred in a uranium sintering furnace.
60–10	3–18	SROO	170,000	A hydrogen-sulfide gas release from a process [illegible] condenser caused a fire.
60–11	3–30	SROO	6,000	During an electrical storm, lightning struck two [illegible] pump motors.
60–12	3–18	ALOO	1 killed	While a kitchen employee, helping to pour 15 [illegible] soup into a kettle, slipped and spilled the soup on his [illegible] Died 20 days later from first and second degree burns.

[a] In Compliance with AEC Manual Chapters 0502 and 0523.
[b] Office of Health and Safety, USAEC Headquarters, File Number.

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TABLE 1.—SERIOUS ACCIDENTS—Continued

January 1—November 1, 1960—Continued

No.[b]	Date	Operations Office	Injury and loss	Remarks
	4-13	NYOO	1 killed	20-foot fall.
…-13	4-17	HOO	$250,000	A fire of pyrophoric metal and excess pressurization of equipment in a chemical dissolver caused damage and contamination.
…-14				
…-15	4-26	OROO	39,500	While an irradiated graphite-clad reactor fuel element was being dry cut inside a hot cell with a remotely operated saw, a change in air pressure forced contaminated graphite dust from the cell. No overexposures.
…-16	4- 5	SROO	216,285	A leak in an outlet nozzle on a reactor was caused by cracks around the circumference of the nozzle.
[illegible]	6-15	ALOO	9,950	Breaking of sling in removal of astrodome from a 20-foot camera tower dropped dome 10 feet.
…-19	6-11	LARO	6,000	Failure of overload switches during a severe electrical storm caused burnout of transformer.
…-20	6-24	IDOO	1 injured	Employee seriously injured while using an explosive powder-actuated power tool.
…-21	6-28	OROO	12,000	The stainless steel lining of a new liquid nitrogen storage tank collapsed during an acceptance test.
…-22	7-11	ALOO	12,000	A 15 kilovolt switchgear damaged by fire.
…-23	7-15	OROO	5,000	Hydrogen gas explosion in gas furnace enclosure in metal plant; one employee injured.
…-24	7- 6	ALOO	$31,360	The accidental discharge of radioactive material into a room as a result of pressure buildup in a drybox. This was due to an inlet solenoid being locked in the open position and a venting solenoid being closed due to a malfunction. The pressure built up to a point that one of the drybox gloves blew out, thereby releasing radioactive particulate material into the room. Eleven persons received minor exposures.
[illegible]	8-31	IDOO	1 killed	Employee killed in fall while painting handrails around a silo.
[illegible]	9-13	SROO	250,000	Contaminated cooling water was discharged from canyon onto floor. No overexposures.
[illegible]	9-29	SROO	8,300	Water leaking through roof during heavy rainstorm damaged transformer.
[illegible]	6/2-6/6	SROO	24,000	During shipment, of irradiated fuel elements, 30 to 40 gallons of contaminated water leaked from the cask.
[illegible]	8- 4	OROO	18,132	During violent storm, severe power system disturbance caused oil circuit breaker failure.
[illegible]	10- 7	ALOO	16,500	Beechcraft Drone Aircraft, which was to be used for air sampling, crashed in desert when radio control was lost.
[illegible]	9-13	LAROO	12,000	During an electrical storm lightning damaged transformer.
[illegible]	7-12	HAOO	6,000	15-mile per hour breeze spread a grass fire over 3,000 acres of AEC property.

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Radiation Incidents

Radiation incidents occurring in the atomic energy program, both in Commission and licensee operations, during fiscal years ended June 30, 1959 and 1960 are summarized in Tables 2 and 3.

For Commission operations, the criteria for inclusion in the listing are as follows:

a) A dollar cost of recovery (decontamination, repair, etc.) or damage or loss associated with the incident of $5,000 or more.

b) Radiation exposures to one or more persons of several rems or more, usually delivered in a short time.

c) Potential radiation exposure as in (b) which did not in fact occur (for example, an incident involving the spillage of curie quantities of plutonium).

d) An incident which, for reasons of possible public interest, has been reported previously to the public.

For licensee operations, the criteria for inclusion in the listing are those given in AEC Regulations as stated in 10 CFR Part 20 which defines incidents requiring (*a*) immediate or (*b*) 24-hour notification of Commission, plus criterion (*d*) as stated above for Commission activities.

10 CFR Part 20 requires immediate notification to the Commission of any incident 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."

It is also required by 10 CFR Part 20 that:

"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:

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(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."

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TABLE 2.—INCIDENTS INVOLVING RADIATION IN AEC OPERATIONS

July 1, 1958—June 30, 1960

Date	Location	Number of persons involved	Extent of exposure	Nature of incident
Dec. 4, 1958	Miamisburg, Ohio	1	Estimated 3.5 times the maximum continuous body burden for polonium 210.	An employee inhaled polonium 210 during the handling and counting of a polonium-alpha source. The source was odd-sized, and it was being counted in an unorthodox manner.
Dec. 30, 1958	Los Alamos, N. Mex.	3	1—Died 35 hours later from the effects of a radiation dose estimated to be several thousand rems to the midportion of the body. 2—Received whole body radiation doses ranging up to 118 rems.	As the result of certain chemical operations, the plutonium suspended in an emulsion in a 225-gallon tank assumed a critical configuration. The results of the accident have been the subject of several technical and scientific reports.
Jan. 6, 1959 HS-59-103	Livermore, Calif.	7	1—Received exposure dose of 41 rems. 1—Received exposure dose of 400 millirems. 5—Received less than 50 millirems.	Malfunction of remote controls on an electron accelerator caused exposure to personnel.
Mar. 31, 1959 HS-59-7	Richland, Wash.	6	Negligible	While two employees were doing experimental machining with plutonium in a glove box, an explosion occurred inside the box, spreading plutonium. The principal cost was the replacement of alpha monitoring instrument, $1,449.
Apr. 2, 1959 HS-59-8	Aiken, S.C.	0	None	While solvent containing radioactivity was being transported to underground storage tanks in the burial ground, a small volume (estimated at less than one gallon) of the solvent leaked from the forward hatch of the solvent trailer and dripped onto the plant roadway. Cleanup cost, $8,700.
July 3, 1959 HS-59-18	Berkeley, Calif.	0	None	Overpressurization of a box for helium cooling at an accelerator installation blew out a thin experimental foil, containing about 0.05 curies of curium 244, causing it to disintegrate. The cost was $58,500 for cleanup and lost time of operation.
July 15, 1959 HS-59-[illegible]	Los Alamos, N. Mex.	0	None	A unit filtering system was in process of revision when the filter caught fire from sparks or hot metal from a welding torch. Alpha radiation emitters were spread, and resulted in approximately $1,[illegible] to $1,[illegible] decontamination costs.
[illegible]	[illegible]	[illegible]	Negligible	[illegible] gas was inadvertently released through the exhaust system. Loss of tritium gas amounted to $10,300.
Aug. 8, 1959 HS-59-24	Miamisburg, Ohio	0	None	A spontaneous explosion occurred in a dry box, causing 39 curies of polonium to be spread into the room and corridor. The cost of the accident was $1,900.
Aug. 21, 1959 HS-59-27	Aiken, S.C.	0	None	During an attempt to locate the source of stoppage in a chemical separations plant, hot liquid in an evaporator vaporized through an open connection. A remotely operated crane was contaminated with high level radioactive solution. Decontamination costs amounted to $130,000.
Oct. 16, 1959 HS-59-[illegible]	Idaho Falls, Idaho	21	7—Received whole body exposures ranging	A nuclear reaction in an underground waste collection tank resulted

				of the solvent trailer and dripped ... cost, $8,700.
July 3, 1959 HS-59-18	Berkeley, Calif.	0	None	*Overpressurization of a box for helium cooling at an accelerator installation blew out a thin experimental foil, containing about 0.05 curies of curium 244, causing it to disintegrate. The cost was $58,500 for cleanup and lost time of operation.*
July 15, 1959 HS-59-134	Los Alamos, N. Mex.	0	None	*A unit filtering system was in process of revision when the filter caught fire from sparks or hot metal from a welding torch. Alpha radiation emitters were spread, and resulted in approximately $1,000 to $1,500 decontamination costs.*
				... gas was inadvertently released through the exhaust system. Loss of tritium gas amounted to $10,300.
Aug. 6, 1959 HS-59-24	Miamisburg, Ohio	0	None	A spontaneous explosion occurred in a dry box, causing 39 curies of polonium to be spread into the room and corridor. The cost of the accident was $1,900.
Aug. 21, 1959 HS-59-27	Aiken, S.C.	0	None	During an attempt to locate the source of stoppage in a chemical separations plant, hot liquid in an evaporator vaporized through an open connection. A remotely operated crane was contaminated with high level radioactive solution. Decontamination costs amounted to $130,000.
Oct. 16, 1959 HS-59-33	Idaho Falls, Idaho	21	7—Received whole body exposures ranging up to 6 rems. Of these, two received skin exposures of 50 rems and 32 rems. 14—Negligible.	A nuclear reaction in an underground waste collection tank resulted from the accidental transferring of fissionable material into the tank.
Nov. 11, 1959 HS-59-259	Oak Ridge, Tenn.	0	None	Particles of radioactive elements, principally ruthenium 106 and rhodium 106 were accidentally released from a stack and settled to the ground in the immediate vicinity.
Nov. 20, 1959 HS-59-37	Oak Ridge, Tenn.	0	No persons were directly affected by the explosion. In subsequent survey and cleanup operations employing several hundred people, several persons had sufficient exposure to plutonium to result in measurable excretion of 1 percent of the maximum permissible body burden.	As the result of an explosion in a processing vessel during a cleanup procedure, about six-tenths of a gram of plutonium was blown out of a concrete cell onto nearby buildings, vehicles, roadways and grounds in an area of about 4 acres. Cost of cleanup was $350,000.
Nov. 30, 1959 HS-59-272	Miamisburg, Ohio	2	1—3.9 times the permissible body burden of polonium 210. 1—2.05 times the permissible body burden of polonium 210.	Routine monitoring of two employees servicing radioactive equipment disclosed exposure to polonium. Detailed circumstances of exposure could not be determined.
Nov. 30, 1959 HS-59-267	Idaho Falls, Idaho	0	None	Rupture in a reactor core section of an inpile tube caused spread of highly contaminated liquid (approximately 25 rep at 1 foot). Cost for cleanup of contaminated area and replacement of damaged instruments was $4,720.
Dec. 12, 1959 HS-59-40	Aiken, S.C.	0	None	During railroad transportation of a burial box containing pipe jumpers, radioactive particulate matter was shaken loose from the box, resulting in spread of contamination along the railroad right-of-way within site. The diesel locomotive and several spacer cars were also contaminated. Cost for cleanup $5,200.

TABLE 2.—INCIDENTS INVOLVING RADIATION IN AEC OPERATIONS—Continued
July 1, 1958—June 30, 1960

Date	Location	Number of persons involved	Extent of exposure	Nature of incident
Mar. 8, 1960 HS-60-8	Oak Ridge, Tenn.	1	5,550 rads to the hand (beta dose)	Personnel exposure. See table of "Serious Accidents" for description.
Apr. 5, 1960 HS-60-16	Aiken, S.C.	0	None	Reactor leak. See table of "Serious Accidents" for description.
Apr. 17, 1960 HS-60-14	Richland, Wash.	2	Negligible	Dissolver explosion. See table of "Serious Accidents" for description.
Apr. 26, 1960 HS-60-17	Richland, Wash.	1	Survey indicated 90,000 disintegrations per minute in the wound.	The right forefinger was pricked by a splinter of plutonium through the rubber glove employee was wearing while arranging equipment in a hood.
Apr. 26, 1960 HS-60-15	Oak Ridge, Tenn.	8	Highest exposure was 120 millirems of penetrating radiation.	Ventilation change. See table of "Serious Accidents" for description.
June 2-6, 1960 HS-60-28	Baltimore, Md. & Corning, N.Y.	0	None	Shipping cask leak. (See table 4, Serious Accidents, for description.)

[illegible] INCIDENTS INVOLVING RADIATION—LICENSEES
July 1, 1958—June 30, 1960

Date	Location	Number Persons Involved	Extent of Exposure [b]	Nature of Incident
Aug. 1958	Vallejo, Calif.	1	Film badge exposure 4.8 rems during month	Engaged in radiography work.
Aug. 5-6, 1958	Portsmouth, N.H.	4	Film badge exposures ranging 600 millirems to 7.5 rems.	Exposures occurred as a result of mechanical failure of a radiographic camera containing a 7 curie iridium 192 source.
Sept. 5, 1958	St. Louis, Mo.	0	None	Two phosphorus 32 spills occurred, one when an employee placed an open-top lead shield holding a bottle containing 10 cc of precipitate

Date	Location	Number Persons Involved	Extent of Exposure b	Nature of Incident
Aug. 1958	Vallejo, Calif.	1	Film badge exposure 4.8 rems during month	Engaged in radiography work.
Aug. 5-6, 1958	Portsmouth, N.H.	4	Film badge exposures ranging 600 millirems to 7.5 rems.	Exposures occurred as a result of mechanical failure of a radiographic camera containing a 7 curie iridium 192 source.
Sept. 5, 1958	St. Louis, Mo.	0	None	Two phosphorus 32 spills occurred, one when an employee placed an open-top lead shield holding a bottle containing 10 cc of precipitate wash water on a hotplate. The liquid boiled over onto the hot-plate. The loss was estimated to be from 5 to 10 millicuries of phosphorus 32. Secondly, about 30 minutes later, a centrifuge tube containing approximately 100 millicuries of end product turned over in the water bath and resulted in a loss of 2.58 millicuries of phosphorus 32.
Sept. 15-29, 1958	Ithaca, N.Y.	1	Calculated exposure of 10 rems	It was mistakenly believed that a cobalt 60 source consisting of 5 metal slugs of 5 curies each was no longer present in a stack of bricks and the shield was removed while realigning some furniture.
Sept. 22, 1958	Houston, Tex.	2	1—Film badge exposure of 3.6 rems 1—Film badge exposure of 1.5 rems	The exposures occurred when the employees were retaping the extension cable of a radiographic device.
Oct. 29, 1958	Arlington, Mass.	1	Film badge exposure of 1.435 rems whole body and a calculated hand exposure of 1,000 rems.	Individual was engaged in experiment with one 200-curie cobalt 60 source and one 400-curie iridium 192 source. Malfunction of equipment resulted in failure of iridium 192 source to return to shielded position.
Oct. 29, 1958	Cambridge, Mass.	1	Negligible	A spill of approximately 5 millicuries of polonium 210 occurred in a laboratory when a glass ampule containing polonium solution exploded while being opened.
Nov. 6, 1958	Boston, Mass.	0	Calculations showed the average 24-hour concentration of effluent discharged through the stack amounted to 6.6 x 10^{13} microcuries per milliliter.	During the transfer of several hundred curies of tritium from a shipping container to a vacuum manifold, a valve was inadvertently left open and 200 curies of tritium were lost.
Nov. 12, 1958	Bronx, N.Y.	0	None	A leak in a 1,000 curie cobalt 60 sealed source contained in a teletherapy unit. Contamination confined to unit head. Unit was decontaminated, and leaking source replaced.

See footnotes at end of table.

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TABLE 3.—INCIDENTS INVOLVING RADIATION—LICENSEES [a]—Continued

Date	Location	Number Persons Involved	Extent of Exposure [b]	Nature of Incident
Nov. 14, 1958	Houston, Tex	8	Radiation doses calculated from 130 millirems to 1 rem whole body and 4 rems to 560 rems (hand).	A radioactive sealed source was found at the head of a filter casing near a pump on a pipeline. Before the source identified, eight individuals were exposed. All employees were given medical examination and no biological effects were noted.
Nov. 17, 1958	Pittsburgh, Pa	1	Film badge exposure of 9.975 rems for week beginning Nov. 15, 1958.	Employee had been conducting industrial radiography activities using a 17-curie iridium 192 source. Exposure probably caused by failure to close and lock camera between shots.
Nov. 21, 1958	Tonawanda, N.Y	0	None	Leaking source caused contamination of equipment in a hot cell. Hot cell decontaminated.
Dec. 3, 1958	Cambridge, Mass	1	Film badge exposure of 6 rems whole body	A radiographer apparently became confused in his routine, neglected to crank the source back into the camera, and walked into the radiation area where the 52-curie iridium 192 source was exposed.
Feb. 4, 1959	Shrewsbury, Mass	8	Negligible	Approximately 35 millicuries of carbon 14 lost when a beaker containing 80 millicuries of sodium acetate in alcohol boiled over.
Feb. 9, 1959	Waltham, Mass	0	None	Flask shattered containing approximately 50 millicuries of carbon 14. Investigation revealed smears on the order of 1,000 counts per minute outside the laboratory, smears taken in the immediate vicinity of the accident were in excess of 10,000 counts per minute, while those on the surface of overhead pipes and ducts were between 500 and 1,000 counts per minute.
Mar. 2, 1959	Albany, N.Y	0	None	While uranium was being melted, a mold fractured, allowing molten normal uranium to flow into a mold tank and onto the floor of the furnace area. Property damage amounted to about $7,000.
Mar. 19, 1959	Durango, Calif	0	None	A fire occurred in a uranium refinery (yellow cake preparation only) caused by a momentarily unattended open flame used for drying the final mill product. Damage amounted to $5,000.
Mar. 31, 1959	New York, N.Y	1	Calculated upper limit of exposure to approximately 300 square centimeters; of skin was approximately 1.50 rad.	*Spill of 0.1 millicurie of phosphorus 32 as a result of filling centrifuge tubes too full. Licensee's clothing was contaminated and disposed of.*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr. 17, 1959	Bloomsburg, Pa	[illegible]	1 Film badge exposures of [illegible] rems to [illegible] rems and 2.9 rems during three successive quarterly periods.	[illegible] X-rays. [illegible] employees were exposed.
May 5, 1959	Hempstead, N.Y	1	Calculated whole body dose of approximately 9 rems. Urine was found to contain 668 microcuries of tritium per liter.	While transferring defective tritium gas-filled tubes into closed containers, an employee was exposed.
July 23, 1959	Syracuse, N.Y	1	Negligible	An employee spilled between 100 and 200 microcuries of iodine 131.
Sept. 10, 1959	Fort Worth, Tex	0	None	A process loss of approximately 25 curies of krypton 85 up an exhaust stack.
Oct. 1, 1959	Vallecitos, Calif	6	Calculated exposures ranged from 800 millirems to 11 rems.	While setting up a camera, a 28-curie iridium 192 source was blown out of end of tube.
[illegible]		2	1 calculated exposure of 70–100 [illegible]	[illegible]

				furnace area. Property dam[illegible]
Mar. 19, 1959	Durango, Calif.	0	None	A fire occurred in a uranium refinery (yellow cake preparation only) caused by a momentarily unattended open flame used for drying the final mill product. Damage amounted to $5,000.
Mar. 31, 1959	New York, N.Y.	1	Calculated upper limit of exposure to approximately 300 square centimeters; of skin was approximately 1.50 rad.	*Spill of 0.1 millicurie of phosphorus 32 as a result of filling centrifuge tubes too full. Licensee's clothing was contaminated and disposed of.*
			[illegible] terly periods.	
Apr. 17, 1959	Bloomsburg, Pa.	1	Calculated whole body dose of approximately 9 rems. Urine was found to contain 668 microcuries of tritium per liter.	While transferring defective tritium gas-filled tubes into closed containers, an employee was exposed.
May 5, 1959	Hempstead, N.Y.	1	Negligible	An employee spilled between 100 and 200 microcuries of iodine 131.
July 23, 1959	Syracuse, N.Y.	0	None	A process loss of approximately 25 curies of krypton 85 up an exhaust stack.
Sept. 10, 1959	Fort Worth, Tex.	6	Calculated exposures ranged from 800 millirems to 11 rems.	While setting up a camera, a 28-curie iridium 192 source was blown out of end of tube.
Oct. 1, 1959	Vallecitos, Calif.	2	1-calculated exposure of 70–100 rems to one hand; 100–300 millirems to the whole body. 1-calculated exposure of 7–17 rems to one hand, 90 rems to the other hand and 200–400 millirems to the whole body.	The exposures occurred when the employees removed radioactive sample holders from a pool which was loaded with irradiated samples of europium.
Oct. 27, 1959	Azusa, Calif.	0	None	Due to a malfunction during the loading of a sample into an irradiator containing a 10,000-curie cobalt 60 source, the sample was released prematurely and dropped onto the irradiator. The sample rack directly above the source was damaged to the extent of more than $1,000.
Oct. 28, 1959	Burlington, Mass.	1	Film badge exposures of 1.4 rems whole body, and a calculated 100–700 rems exposure to tips of fingers of right hand.	Employee pushed accidentally protruding source back into its container with his bare hand.
Dec. 18, 1959	Oak Ridge, Tenn.	1	Calculated total integrated dose of 106 rems to the thyroid.	Due to mechanical failure of a hood during the preparation of material containing iodine 131, an employee was exposed and a laboratory contaminated.
Dec. 21, 1959	Jamaica, N.Y.	1	Film badge exposure 170 millirems beta (whole body), 13.25 rems to hand (over 13-day period).	Employee exposed while dismantling and removing heavy mechanical apparatus from a glove box contaminated with strontium 90.
Jan. 5, 1960	Dayton, Ohio	1	Film badge exposure 4 rems beta (Dec. 15 to 29, 1959); and 23 rems beta (Oct. 6, 1959 to Jan. 5, 1960).	Making instrument calibration checks with a cobalt 60 source.
Jan. 29, 1960	Everett, Mass.	1	Calculated exposure of 130 rems to one hand.	An employee performing radiographic shots was exposed to radiation when he neglected to return source to shielded position.
Mar. 10, 1960	Pleasanton, Calif.	7	1-dose to thyroid at 48 rads 6–1.875 rems to 7.06 rems dose to the thyroid (calculated).	Exposed to gaseous iodine 131 and iodine 133 from a fission gas bubble released from a defective loop element.

See footnotes at end of table.

TABLE 3.—INCIDENTS INVOLVING RADIATION—LICENSEES [a]—Continued

July 1, 1958—June 30, 1960

Date	Location	Number Persons Involved	Extent of Exposure [b]	Nature of Incident
Mar. 14, 1960	Portsmouth, N.H.	1	Film badge exposure of 6.515 rems	An employee while performing industrial radiography, using a 40-curie iridium 192 source, was exposed when a malfunction of the camera occurred.
Mar. 29, 1960	Madison, Wis.	12	1-estimated 80-100 rems 11-estimated 200 millirems to 25 rems.	A student removed some samples from an irradiator unaware that a 200-curie cobalt 60 source had become detached and had fallen into the flask holding the samples.
Apr. 3, 1960	Pittsburgh, Pa.	0	None	A release of mixed fission products to the primary coolant of reactor caused by rupture of fuel element.
Apr. 10, 1960	do.	1	Film badge exposure of 120 rems	Exposure occurred while making radiographic shots with 5.2-curi iridium 192 source. Exposure resulted from use of faulty camera.
Apr. 27, 1960	St. Louis, Mo.	0	None	A 174-curie cobalt 60 sealed source contained in a teletherapy unit leaked.

[a] A & B type incidents plus all other incidents receiving press notices.

[b] Exposures of less than 1 rem are expressed in millirems (1,000 millirems=1 rem).

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SPECIAL HAZARDS UNDER STUDY

Contamination Containment in Glove Boxes

Glove boxes are widely used in atomic energy activities to prevent spread of contamination. Glove boxes are closed, ventilated compartments with rubber gloves sealed into the side into which worker inserts his hands. Experience has shown that the protection afforded by glove box containment is substantially reduced in case of accidents involving fire and explosion. During 1959, a committee was formed for the purpose of collecting the best Commission experience and practices on glove box design. A draft guide on glove box design, construction and use, will be prepared for publication during 1961.

High Efficiency Filters

In many cases, high efficiency filters on air ventilating systems serve as the final means for preventing inadvertent spread of radioactive contamination to external environment. The occurrence of several unexpectedly severe filter fires made it necessary to develop filters that are more nearly noncombustible. Such filters have been developed during the past 3 years and have found widespread acceptance and use throughout Commission installations.

Arrangements were made during 1959 so that Commission contractors could have the performance characteristics of filters checked before installation at one of two testing facilities. A simple, economically practicable means for checking banks of filters as a unit remains to be developed. Other areas currently being studied include methods for further increasing filter heat resistance, and development of more efficient dry filters to remove radioactive iodine.

Metal Pyrophoricity

In research to obtain improved understanding and means for more effective prevention or control of fires and explosions caused by pyrophoric metals (such as plutonium, uranium, thorium and zirconium), Argonne National Laboratory found that certain mixed halogen organic derivatives appear effective in retarding or preventing zirconium combustion in air. Stanford Research Institute found that uranium foils could be ignited by exposure to shock waves. A. D. Little, Inc. tests to evaluate the relative effectiveness of various metal extinguishants are nearing completion.

Air-Oil Explosions

Under certain conditions, air-oil mixtures explode. Four accidents of this kind occurred in Commission installations during 1959, the most serious at West Milton on October 30, 1959, in a hydraulic system for a prototype reactor. A survey failed to reveal the West Milton type of hazard in any other Commission location. The causes and means for preventing such accidents have been studied and the results published by the Commission.

Electronic Computer Fire Protection

A fire in the Department of Defense Pentagon headquarters in Washington, D.C. in 1959 resulted in national recognition of fire risks associated with computer systems. A Commission engineer is surveying this type of risk in Commission installations where many computers are in use, and is representing the Commission on the National Fire Protection Association Committee on Electronic Computers. The survey is to be concluded in 1961.

Liquid Hydrogen Hazards

Bubble chambers used in research work with particle accelerators contain relatively large quantities of liquid hydrogen under great pressure. Hazards of these devices have been studied at Commission-supported laboratories—Lawrence Radiation Laboratory, University of California, Argonne National Laboratory, and Brookhaven National Laboratory. These findings, with that resulting from extensive liquid hydrogen hazard work performed under contract to the U.S. Air Force, are being studied by the Commission with a view to strengthening safety precautions covering this area.

Nuclear Materials Management

Review of Nuclear Materials Control System

The Commission's system for controlling source and special nuclear materials was established in 1947, and since that time has been subject to continuing critical review by staff. Late in 1960, the Commission requested proposals from private consultant firms for an objective evaluation of the system and procedures.

The purpose of the review is to assure the public, the Congress, and the Commission that proper administration is being maintained over source and special nuclear materials. The review is designed to ensure the suitability of the existing system of control to present conditions. In addition, the review should provide assurance, or recommend corrective measures to assure, that the system will detect significant diversions of source and special nuclear materials, and that the system is sufficiently flexible to permit development of peaceful applications of atomic energy. The study should provide advice and guidance on such problems as ascertaining the special nuclear material content of unirradiated fuel elements, and of irradiated fuel elements returned by licensees for chemical reprocessing and subsequent payment.

Recommended Measurement Methods

Through a special advisory committee and through seminars, the Commission is establishing suitable methods for measuring the properties and quantities of source and special nuclear materials transferred between the Commission and private industry or foreign governments. Measurement methods now in use for atomic energy operations are being reviewed and evaluated at a series of seminars among recognized authorities in various fields of measurement. The seminars, divided into six sections, were held during 1960 as follows:

Mass Spectrometry Section, February 9–10, Argonne National Laboratory.

Uranium Chemistry Section, February 25–26, and September 15, New Brunswick Laboratory.

Emission Spectroscopy Section, February 29–March 1, Pittsburgh, Pa., and November 1, New York, N.Y.

Plutonium Chemistry Section, March 24–25, Los Alamos Scientific Laboratory and August 17–18, Dow Chemical Co., Rocky Flats Plant, Denver, Colo.

Radiochemistry Section, May 9, Oak Ridge National Laboratory and October 13, Gatlinburg, Tenn.

Sampling Section, June 7–8, Washington, D.C.

Standard Reference Materials

The Commission-National Bureau of Standards cooperative program, which has provided 15 uranium isotopic standards, was continued. Preliminary investigations for preparation and certification of a uranium 236 isotopic standard and of isotopic plutonium standards are underway.

Samples of high purity plutonium metal are being prepared at the Los Alamos Scientific Laboratory for distribution to six laboratories for analysis. These results will be used for certification of this material when made available as a plutonium chemical standard from the National Bureau of Standards.

Non-destructive Analysis of Reactor Fuels

A program was initiated to develop techniques for non-destructive analysis of reactor fuel materials. Primary emphasis was placed on gamma ray scintillation spectrometry, which has been proved feasible.

A portable gamma ray spectrometer has been developed and after final field trials, all the Commission's operations offices will be furnished instruments for inventory verification, for quality control in core manufacture, and for other uranimum measurement problems which may arise.

Meetings

The annual meeting of Commission and contractor personnel concerned with nuclear materials management was held in Columbus, Ohio, June 22–24, in conjunction with the first annual meeting of the Institute of Nuclear Materials Management.

Construction and Supply

Construction Costs

As of December 31, 1960, the Nation's investment in atomic energy facilities was $7.4 billion before depreciation reserves.

Costs incurred by the Commission for additional plant and equipment during fiscal year 1960 amounted to $332 million, an increase of about 11 percent over similar costs incurred in the previous fiscal year. The following table shows capital costs incurred during the previous 5 years:

Fiscal year	Plant construction (In millions)	Equipment (In millions)
1960	$231	$101
1959	212	87
1958	210	80
1957	260	57
1956	264	38

Design Criteria for Shelters

Design criteria for Commission structures were expanded during 1960 by the addition of Chapter 6316 to the AEC Manual with accompanying Handbook Parts I, II, and III establishing guidelines for design of fallout resistant personnel shelters and blast resistant emergency relocation centers, when these are authorized by the Congress. The criteria include such factors as space allocations in relation to number of personnel, living and sanitary facilities, ventilation, strength of structure and radiation attenuation.

Mobilization Planning

The Commission continued its full participation in the activities of the Office of Civil and Defense Mobilization (OCDM). Assistance was provided to OCDM in development and review of annexes and appendixes to the National Plan for Civil Defense and Defense Mobilization and in modifications to Federal Emergency Plan D-Minus.

The Commission carried out a comprehensive program of exercises during Operation Alert 1960. Emergency operating plans were successfully followed in simulating conduct of postattack functions from the Headquarters Relocation Center and from field relocation centers. Commission representatives also were active at the OCDM Main Relocation Site and at OCDM regional locations.

As part of Operation Alert 1960, the Commission's entire succession of command was briefed on headquarters emergency planning and facilities, and on postattack responsibilities.

A high-speed, especially-designed teletype printer was installed at the Commission's Headquarters Emergency Relocation Center. This teletype is capable of quickly receiving information about the postattack condition of facilities directly from the National Resources Evaluation Center computer.

Radiation Seminars for Transportation Industry

With the increase in the number of shippers of radioactive materials which has accompanied the growth of the atomic energy industry, the Commission has embarked on a program to provide transportation associations of motor and rail carrier groups with detailed information concerning the transportation characteristics of atomic energy materials and products. Radiation protection seminars were sponsored and conducted, and carrier groups were encouraged to conduct similar training sessions, or to develop other means to instruct operating personnel. The seminars also provide a means of informing the transportation industry concerning the Radiological Assistance Plan (see section of this report on Health and Safety).

Records Management

During fiscal year 1960, the Commission and its cost-reimbursable contractors disposed of 98,000 cubic feet of records having no further value, or 9,000 feet more than in 1959. At the end of the fiscal year, 228,000 cubic feet, or about 39 percent, of Commission records were housed in low-cost records centers or storage areas.

Community Activities

OAK RIDGE AND RICHLAND

During 1959 and 1960, the Government completed turning over to designated entities all municipal services and facilities of the former Commission-operated atomic energy communities of Oak Ridge, Tenn., and Richland, Wash. The sale of all Government-owned buildings for residential, commercial, and nonprofit use was largely completed. Built during the war to provide homes and facilities for employees of the atomic energy enterprises at Oak Ridge and the Hanford plant, the communities for years were operated as Government towns, with municipal services and administration supplied by contractors and with all buildings either rented or leased by concessionaires. Until February 1949, there was a security fence around the Oak Ridge Community and public access was restricted.

Public Law 84–221 was enacted August 4, 1955, and on August [illegible] 1955, the Commission requested the Federal Housing Administration (FHA) to make the necessary appraisals. Assistance in the organization of local government and the classification of property for sale began immediately after the passing of the enabling legislation in 1955. Except for some 100 leased residential lots in Oak Ridge, the first of which was sold in December 1955, all properties classified for sale were placed under the jurisdiction of the Housing and Home Finance Administration (HHFA). The first offering of houses was made in Oak Ridge on September 7, 1956, and in Richland on June [illegible] 1957. Sale of property, up to November 30, returned a total of $

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million to the Government, compared with original costs of $119.5 million minus depreciation of $46.0 million.

Municipal installations with a book value of $60 million have been transferred, and the Commission is now making annual assistance payments as provided in the Atomic Energy Community Act of 1955. Most of the Community operating costs incurred at Oak Ridge and Richland during fiscal year 1960 were in the form of assistance payments to local municipal entities. At Oak Ridge, assistance payments for organization and establishment of city government and for operation of the city government (including the schools) totaled $1,453,746. At Richland, assistance payments for organization and establishment of the city government, as well as operation of the city government, the hospital, and the school district totaled $1,354,799. It is estimated at this time that steady-state annual assistance payments to the entities, as required, in the future might approximate the following:

City of Oak Ridge (including schools)	$1,400,000
City of Richland	425,000
Richland School District	700,000
Total	2,525,000

Chapter 8 of the Community Act, authorized the Commission to cooperate with and assist residents of the communities in preparation for, and establishment of, local self-government and to transfer municipal installations and responsibilities to local entities. This authority expired as of August 3, 1960, the purpose thereof having been fulfilled.

Oak Ridge

As of November 30, the only remaining Government property offered for sale but remaining unsold were some 313 out of 1,741 vacant lots and parcels, and one commercial property reclassified from Government use and offered for sale. All buildings for residence (including apartments), and nonprofit uses, except as indicated, had been sold. Five commercial properties remained to be sold. Sales of property returned a total of $26.5 million as of November 30.

	Dec. 31, 1959		Nov. 30, 1960	
	Units offered	Percent sold	Units offered	Percent sold
... and duplex houses	4,360	99	4,360	100
...ments (4 or more family units)	257	99	257	100
... lots and parcels	1,585	66	1,741	82
...rcial properties	103	97	115	97
...fit	33	100	33	100

School facilities and real property were transferred to the city of Oak Ridge on January 1, 1960, and all remaining municipal functions, facilities, and utilities, together with operational responsibility, were transferred to the city of Oak Ridge on June 1, 1960. Construction of the new Oak Ridge Hospital at Federal expense was completed and accepted by the Commission on January 22, 1960. Transfer of the new building to the Oak Ridge Hospital of the Methodist Church, Inc., was effective June 1, 1960, and on July 1, 1960, the hospital began operation independent of the Commission.

The population of Oak Ridge, as of 1960, was placed by the Census Bureau at 27,009.

Richland

All residential properties, except apartments and certain Wherry Act developments, have been sold in Richland, as have 89 percent of all residential lots. However, some 86 commercial properties remain to be sold as do several nonprofit properties. Sales of property returned a total of $33.7 million as of November 30.

	Dec. 31, 1959		*Nov. 30, 1960*	
	Units offered	*Percent sold*	*Units offered* [a]	*Percent sold*
Single and duplex houses	4, 806	99	4, 806	[illegible]
Apartments (4 or more family units)	17	00	17	[illegible]
Residential lots	205	75	292	[illegible]
Commercial properties	151	32	232	[illegible]
Nonprofit	7	42	13	[illegible]

[a] All properties offered except two which are held up by court action.

The transfer of municipal facilities to the city of Richland was completed during 1960. Population in 1960, according to the Census Bureau, was 23,521.

LOS ALAMOS AND SANDIA

Los Alamos

Development and sale by the Commission of residential lots for privately owned homes continued at Barranca Mesa in Los Alamos, N. Mex. The original 72 lots offered have been increased by development of 47 additional lots during the year. Twenty-five homes were occupied during 1960, 27 more were under construction, and 51 additional lots have been sold for home construction. Engineering for a additional 72-lot development, provided for in the 1960–1961 construction program, is underway.

The $1 million housing modification project authorized in 1958 was completed during 1960, and another similar $1 million program is underway. Approximately 240 Government-owned houses will have been modified when the programs are complete.

Several long-term leases on unimproved commercial real estate were awarded on the basis of competitive bids, and construction is underway at some sites. Included in the new commercial activities are a privately owned trailer court, and three multi-purpose sites with a variety of commercial enterprises proposed such as a grocery store, barber shop and laundry.

The Los Alamos Planning Committee, an official advisory group to the Manager of Albuquerque Operations, submitted a report recommending that the Commission, its contractors, and the residents, increase their activities toward the goals of greater local self-government, increased commercial enterprise, and elimination of the housing shortage.

Sandia Base Housing

Housing constructed at the Sandia base, Albuquerque, N. Mex., in the early 1950's to provide homes, not otherwise available, for Commission and contractor employees, was determined, during 1960, to be excess to Commission needs. This fact was reported to the General Services Administration with the information that the Department of Defense is interested in obtaining the housing.

Industrial Relations

Developments during 1960 in Commission contractor employment, patterns of earnings, collective bargaining, and related matters included the following:

Average employment for the first 11 months of 1960 for 29 prime cost-reimbursable contractors operating 38 Government-owned installations, employing 50 or more persons, and engaged in operations, research, development, maintenance and service, continued at about the same level (91,126) as in 1959 (91,304).

The proportion of exempt salaried workers [34] in the work force of

[34] Exempt salaried workers includes all personnel "employed in a bonda-fide executive, administrative or professional capacity" who are exempt from the overtime provisions of the Fair Labor Standards Act.

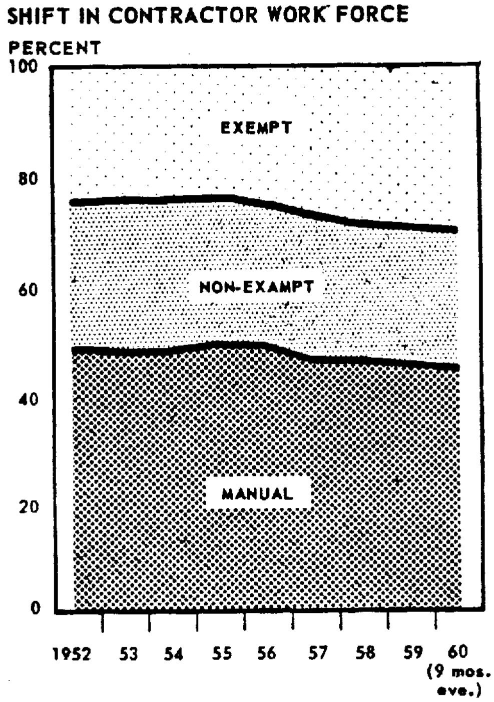
these contractors, the segment that includes scientists and engineers, continued to increase during 1960. This group constituted about one-fourth (24.7 percent) in 1952, approached one-third (30.2 percent) in 1959, and continued in 1960 with the percentage at 32.0 percent.

A 1960 occupational survey of contractors operating Government-owned facilities revealed that scientists and engineers comprise about one-fifth (18.8 percent) of the work force; skilled trades one-fifth (20.7 percent); clerical and office workers 15.2 percent; technicians and related occupations 15.1 percent; and managerial and administrative about one-tenth (10.3 percent). The remaining workers are in production and service occupations.

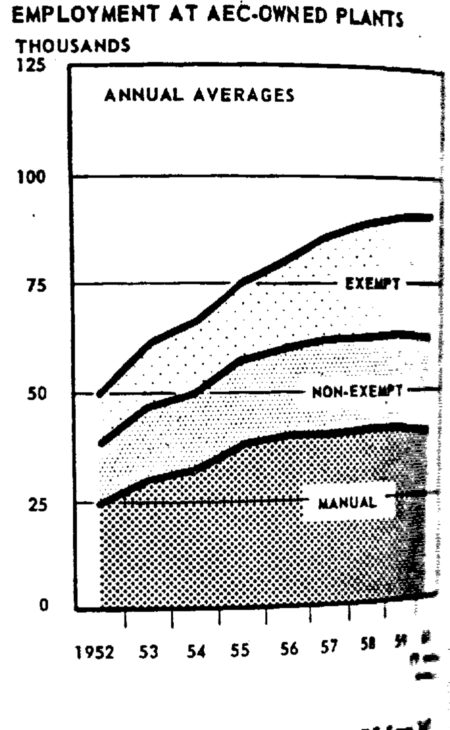
Earnings of contractor exempt salaried employees (consisting primarily of scientists and engineers) have increased at about the same rate as national averages since 1952, based on the limited industry information available.

Earnings of production (manual) workers in the Petroleum and Coal Industry and the Industrial Inorganic Chemical Industry—generally similar in process and equipment to Commission installations—have more or less paralleled earnings for comparable Commission contractor employees from 1952 through June 1960. However, in October 1960, contractor manual employee earnings for the first time rose above the $2.83 gross earnings less overtime preliminary figure reported for the petroleum industry.

SHIFT IN CONTRACTOR WORK FORCE



EMPLOYMENT AT AEC-OWNED PLANTS



Source: AEC

Earnings of contractor nonmanual nonexempt salaried employees,[35] which bear a relationship to manual workers in the timing and amount of wage adjustments, have advanced since 1952 at a rate of 4.9 percent compared to 5.0 percent per year for contractor manual workers.

Contractor fringe benefit expenditures for nonexempt manual employees[36] amounted to 19.7 percent of gross payroll in 1959, compared with 19.3 percent in 1958.

EMPLOYMENT AND EARNINGS

Contractors[37] Work Forces

Increase in Scientists and Engineers

The shift toward an increasing proportion of exempt salaried workers in the work force of contractors operating Commission facilities continued during 1960 (see chart, Shift in Contractor Work Force Composition). Offsetting this increase are declines in the nonexempt salaried component from 26.9 percent in 1952 to 24.1 percent in 1959, and in the nonexempt manual sector from 48.4 percent to 44.6 percent over the same period.

This trend parallels a similar development observed by the Bureau of Labor Statistics in both manufacturing and nonmanufacturing sectors of the U.S. economy.[38] In Commission establishments, this shift reflects in part the increasing emphasis placed on research and development activities, with a consequent increase in scientific and engineering workers. The reduced percentage in manual and nonexempt salaried segments of the contractor work force may be attributed in part to technical improvements, ranging from installation of electronic data processing equipment for payroll preparations to the modifications in plant and machinery and improved methods.

All three work force groups have increased from 1952 through 1959 (see chart, Employment in AEC-owned Plants). Total employment of 91,126 in 1960, based on a 11-month average continued at about the same level as in 1959 when the total was 91,304.

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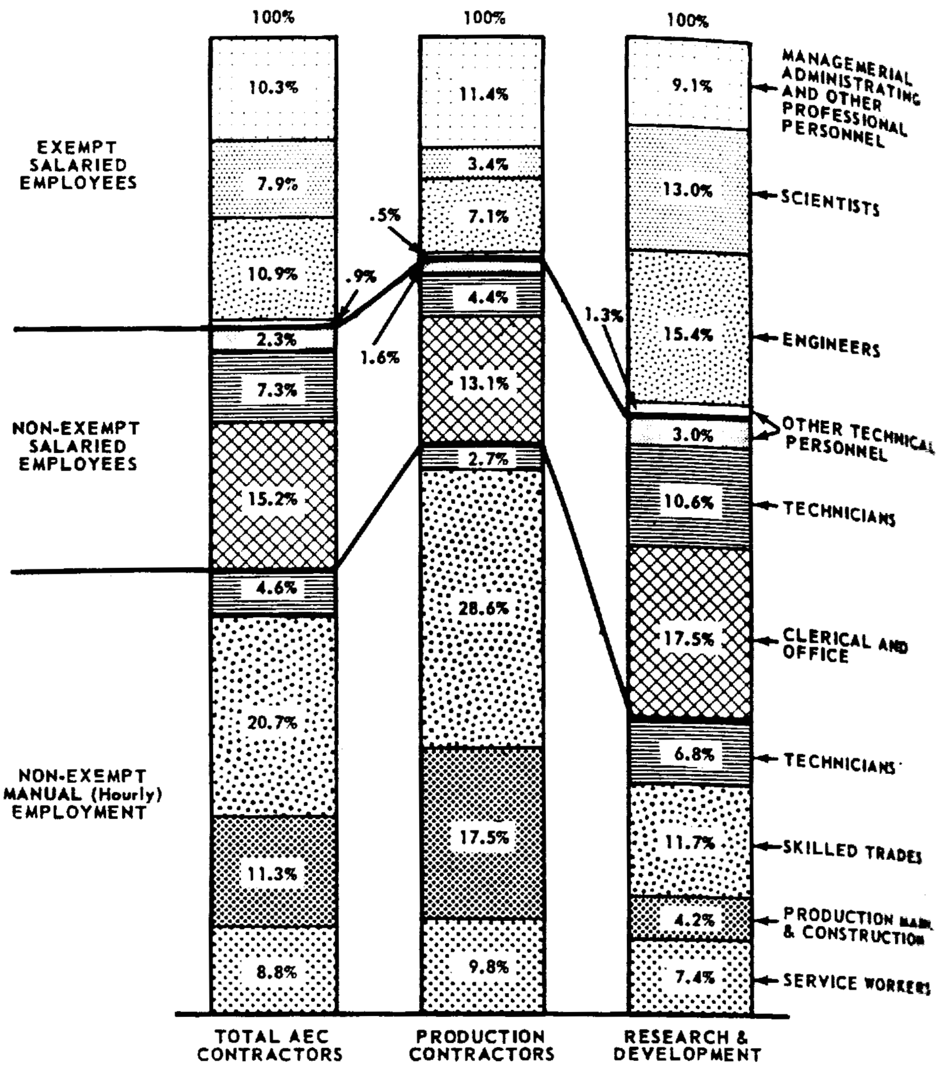
[35] Nonmanual nonexempt salaried employees include all personnel performing essentially nonmanual duties who are subject to the minimum wage and overtime provisions of the Fair Labor Standards Act.

[36] Nonexempt manual employees include all personnel performing essentially manual duties who are subject to the minimum wage and overtime provisions of the Fair Labor Standards Act.

[37] These include prime cost-type operations, research, development, maintenance and service contractors employing 50 or more persons at AEC installations. Excluded are employees of construction and architect-engineering firms. The number of contractors from whom reports are obtained has increased from 26 in 1952 to 29 in 1960 with the number of establishments reported in 1960 standing at 38.

[38] "Employment and Earnings," Sept. 1958, published by the Bureau of Labor Statistics, Department of Labor.

CONTRACTOR WORK FORCE BY OCCUPATIONAL GROUPS*
(JANUARY 1960)



*The graph views the work force from two frames of reference, viz., an occupational viewpoint and a Fair Labor Standards Act viewpoint. The latter is directed at determining the degree of manual and routinized content to an occupation which in turn determines, along with other criteria, whether minimum wages and overtime payments are legally required.

Source: Based on Bureau of Labor Statistics Survey of "Employment in the Atomic Energy Field," January 1960.

Occupational Groups

When divided between production contractors and research and development contractors,[39] total AEC employment reveals a slightly larger production contractor work force, 46,045 workers, compared

[39] *Production Contractors* include the following industrial segments: production of feed materials; production of special materials for use in reactors; fuel element fabrication and recovery activities and atomic energy defense production facilities. *Research and development contractors* include the following industrial segments: reactor and reactor component design and manufacturing; private research labs and centers engaged in atomic energy work and Commission laboratory and research facilities.

with 42,538 workers employed by research and development contractors (see chart, Contractor Work Force by Occupational Groups). The occupational composition of these two contractor groupings is sharply different. Among production contractors 58.6 percent of manpower is found in the blue collar segment of the work force consisting of technicians, skilled trades, production, maintenance and construction, and service workers, compared with 30.1 percent among research and development contractors.

The research and development work force included 28.4 percent scientists and engineers compared with 10.5 percent among production contractors.

The emergence of technicians as an important sector of the work force is clearly apparent. Approximately 12 percent of total AEC employment is in this category; production contractors employ about 9 percent compared with 17.5 percent in research and development establishments. The proportion of clerical and other office workers is similarly higher—17.5 percent—among research and development contractors than the 13.1 percent for production contractors.

Among production contractors, 11.4 percent of the work force consists of managerial, administrative and other professional employees compared to 9.1 percent among research and development contractors.

Contractor Employee Earnings

Salaried Employees

Base monthly earnings of contractor exempt and nonexempt salaried employees since 1952 are shown in the chart, AEC Contractor Base Monthly Earnings of Salaried Personnel.[40] In the exempt salaried group approximately 66 percent are scientific, engineering and related technical employees. The scientific and engineering payroll has dominated the exempt earnings average since 1952. The exempt group includes also the payroll of executive, administrative and other nonscientific professional personnel.

Based on the Los Alamos Scientific Laboratory annual national survey of average scientific and engineering salaries in research and development, salary levels for this group since 1952 have advanced at a rate of approximately 5.5 percent a year. This parallels the 5.5 percent average annual rate of increase observed for the Commission's

[40] Applicable to prime cost type operating, research, development, maintenance and [illegible] contractors employing 50 or more persons at Commission-owned installations.

contractor exempt salaried group. The actual level of base pay for Commission contractor exempt employees was $805 a month in November 1960.

In the nonmanual nonexempt salaried group, base monthly earnings have increased from $310 in 1952 to $471 in November 1960 (see same chart). The average annual rate of increase of salaries for this group from 1952 through 1959 was 4.9 percent. The average 4.9 percent a year increase in base pay for nonmanual nonexempt salaried workers compares favorably with the 5.0 percent a year increase for nonexempt manual employees.

Manual Work Force

The contractor average from 1952 until June 1960 for nonexempt manual work force earnings has fallen between the higher rate in the products of petroleum and coal industrial sector and the lower industrial inorganic chemicals industrial sector which use generally similar processes and equipment. In August 1960, Commission contractor earnings for the first time rose above the $2.83 figure for petroleum workers (see chart, Straight-time Average Hourly Earnings, Manual Workers). However, wage negotiations within the petroleum industry are scheduled for late 1960 and early 1961.

Fringe Benefits

The Commission's annual survey of "fringe" benefit expenditures by contractors operating AEC-owned plants covers a number of categories of supplementary remunerations considered as paid to, or for the benefit of nonexempt manual employees.[41] These fringe benefit expenditures amounted to 19.7 percent of gross payroll in 1959, the last year for which information is available, compared with [illegible] percent in 1958 (see Table 1—Contractor Fringe Payments as Percent of Payroll—1959).

The figures in the following table are necessarily an approximation, but help provide an estimate of the total cost to the contractor of an hour of manual labor, compared with those in other segments of industry:

[41] Based on "Fringe Benefits 1959" by the Economic Research Dept. of Chamber of Commerce of the United States, Washington 6, D.C., 1960.

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ᵃ Pay for time not worked
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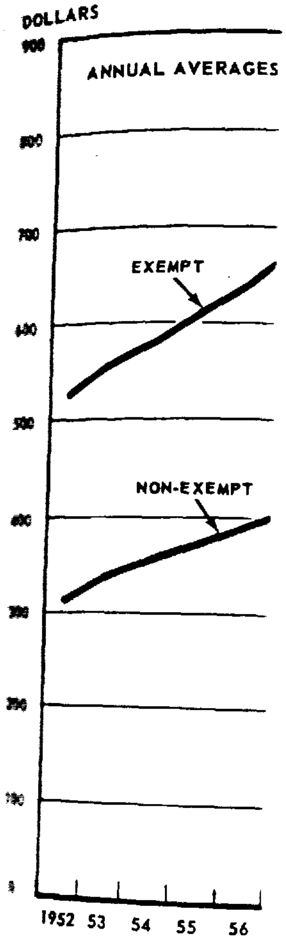


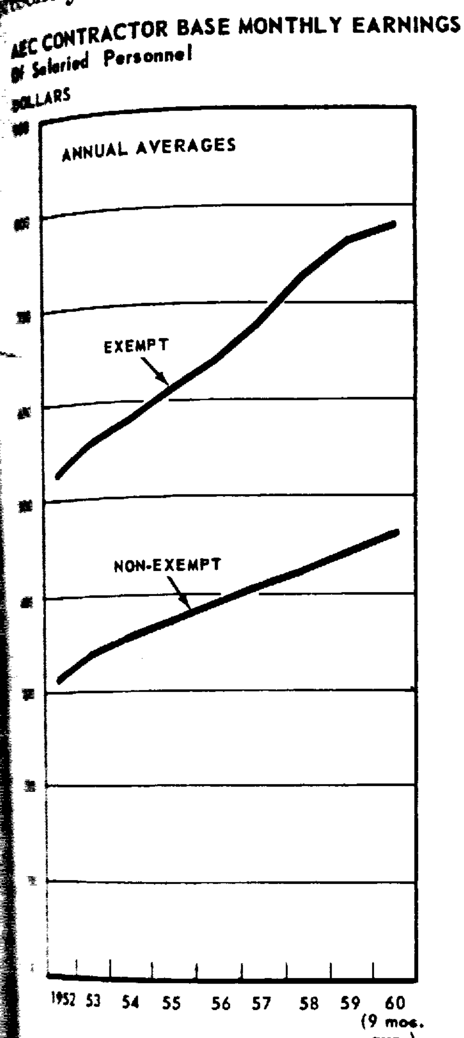
*Comparing AEC contractor ear
inorganic chemicals industrie

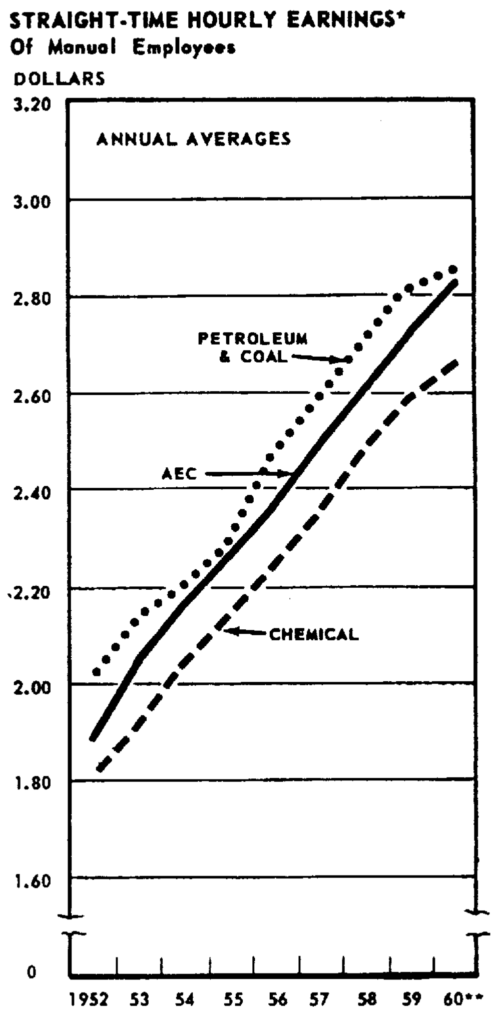
**AEC earnings (Source: AEC
Source: Bureau of Labor Sta

	Total AEC contractors	*All manufacturing*	*Petroleum industry*	*Chemicals and allied*
Gross average hourly earnings	$2.819	$2.454	$2.954	$2.464
Fringe cost (less pay for time not worked)[a]	.261	.300	.508	.345
Estimated total hourly labor cost	$3.080	$2.754	$3.462	$2.809

[a] Pay for time not worked consisting of paid rest periods, lunch periods, washup time, travel time, clothes change time, get ready time, paid vacations, paid holidays, paid sick leave and similar payments is contained in gross average hourly earnings and therefore has been deducted from the "Fringe Cost" category shown to avoid double counting in the total.

The Commission as a matter of policy recognizes that contractor white collar employees including Clerical and Professional Groups are entitled to fringe benefits of the same kind and level as prevail across industry. There is substantial evidence that those employees presently enjoy the fringe benefits that prevail generally in industry.





*Comparing AEC contractor employee earnings with those in the products of petroleum and coal, and industrial inorganic chemicals industries.

**AEC earnings (Source: AEC Form 341) based on average through September; petroleum and coal, and chemical (Source: Bureau of Labor Statistics) earnings based on average through August.

TABLE 1.—CONTRACTOR FRINGE PAYMENTS AS PERCENT OF PAYROLL—1959

Type of payment	Total AEC	Chamber of Commerce data [d]: All manufacturing	Chemicals and allied products	Petroleum industry
	Percent	*Percent*	*Percent*	*Percent*
TOTAL FRINGES AS PERCENT OF PAYROLL	[c] 19.7	21.6	25.0	[illegible]
1. *Legally required payments:*				
a. Old-age Survivors and Disability Insurance	1.8	2.3	2.2	[illegible]
b. Unemployment compensation	.7	1.2	1.1	[illegible]
c. Workmen's compensation	.5	.9	.7	[illegible]
d. Railroad Retirement Tax: R.R. Unemployment Ins.; State Sickness Benefits Ins., etc	.5	.1	.1	(b)
Total	3.5	4.5	4.1	[illegible]
2. *Pension and other agreed-upon payments:*				
a. Pension plan premiums and noninsurance type pension plans	3.3	3.3	4.3	[illegible]
b. Life insurance premiums; death benefits, etc	1.4	2.4	2.4	[illegible]
c. Contributions to privately financed unemployment benefit funds	(a)	.1	(b)	
d. Separation or termination pay allowances	.1	(b)	.1	(b)
e. Discounts on goods and services, etc	(a)	.1	.1	[illegible]
f. Miscellaneous payments	.8	.2	.3	[illegible]
Total	5.6	6.1	7.2	[illegible]
3. *Paid rest periods, lunch periods, washup time; travel time; clothes-change time, etc*	1.9	2.7	3.4	[illegible]
4. *Payments for time not worked:*				
a. Paid vacations and bonuses in lieu of vacation	4.3	4.0	4.2	[illegible]
b. Payments for holidays not worked	2.6	2.3	2.4	[illegible]
c. Paid sick leave	1.4	.3	.8	[illegible]
d. Payments for State or National Guard Duty, jury, witness and voting allowances, payments for time lost due to death in family or other personal reasons, etc	.3	.1	.2	[illegible]
Total	8.6	6.7	7.6	[illegible]
5. *Other items:*				
a. Profit-sharing payments	(b)	.9	1.4	[illegible]
b. Christmas or other special bonuses, service awards, suggestion awards, etc	.1	.5	.9	[illegible]
c. Special wage payments ordered by courts, payments to union stewards, etc	(b)	.2	.4	[illegible]
Total	.2	1.6	2.7	[illegible]

[a] Indicates no expenditures reported.
[b] Less than 0.05 percent.
[c] Not additive due to rounding.
[d] From a study of "Fringe Benefits 1959" conducted by the Chamber of Commerce of the [illegible] States.

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LABOR-MANAGEMENT ACTIVITIES

Collective Bargaining Units

ion Representation

Of 39,565 nonexempt manual employees reported in August, 1960 the 29 Commission's cost reimbursable contractors engaged in oper- ions, research, development and maintenance and service activities ploying 50 or more workers at Commission-owned facilities, ap- ximately 70 percent are represented by unions under collective gaining agreements. The great majority of these employees are liated with the AFL–CIO.

The following table gives representation in the nonexempt manual k force by selected labor organization groupings:

	Approximate representation	*Percent*
al Trades Councils (AFL–CIO)[a]	12, 823	46. 4
national Association of Machinists (AFL–CIO)	6, 087	22. 0
Chemical and Atomic Workers International Union (AFL–CIO)	5, 072	18. 4
ellaneous unions (excluding guards, but including ts, etc.) (AFL–CIO)	2, 488	9. 0
ellaneous guard unions (independent unions)	1, 166	4. 2
	27, 636	100. 0

[a] al Trades Councils are local bargaining units, consisting of two or more local chartered affiliated of cooperating International Unions, which negotiate as a unit with an employer over the terms ditions of employment.

ly about 6 percent of approximately 22,300 office and related al workers are represented by unions as follows:

	Approximate representation
Employees International Union (AFL–CIO)	1, 349
tady Draftsmen's Association (Indep.)	84
	1, 433

General Industrial Relations Problems

Stoppages and AEC Programs

ain Commission programs and projects during 1960 were de- for varying periods by labor-management disputes. The strike steel producers and disruption in supply and scheduled de- of components were somewhat noticeable in reactor projects.

The 5-month strike of the Marine and Shipbuilding Workers (AFL-CIO) against Bethlehem Shipbuilding Corp. slowed naval reactor projects considerably.

Work stoppages in industrial establishments or among Commission contractors may affect Commission programs in various ways. These range from a clearly direct impact measurable in quantitative terms where physical units of end-product must be foregone until work resumes, to more indirect and less measurable effects, such as loss of scientific skills in research and development programs due to a strike affecting an experimental tool (i.e., a research reactor). During a strike of reactor operators at Brookhaven National Laboratory and another strike of maintenance and auxiliary operators at the ETR-MTR facilities operated by Phillips Petroleum Co. at the National Reactor Testing Station, it was necessary for professional and technical personnel to operate these reactors to maintain continuity of experimentation.

Through November, bargaining activity affected approximately 21,600 employees in the course of 55 negotiated settlements resulting from initial contracts, renewals or reopeners. Most settlements were reached without a work stoppage.

Policies on Contracting Out Work

Problems have arisen between labor representatives and Commission contractor management over placing work with outside contractors in three types of situations: (*a*) Situations where work is contracted out to commercial suppliers, particularly in the reactor field in order to help develop a private source of supply for the private reactor program; (*b*) Situations in which Government policy calls for using commercial facilities where feasible in preference to Government plants; and (*c*) Situations in which normal methods and expectations relating to the application of the Davis-Bacon Act affect certain types of work that is border line between construction activity and operational activities in Government plants.

With respect to the first category, the problem seems well understood by employees and their representatives and not likely to be a source of misunderstanding if the contracting out does not result in reductions in employment.

No strikes have occurred over actions in the second category, but there have been serious threats of such action. Difficulties arose over publicity given the application of the policy in some Government-owned, Government-operated plants.

The third category involving application of the Davis-Bacon Act s received much attention during the year. This act requires the yment of wage rates determined by the Secretary of Labor for all rk classed as construction. In general, it has been the practice f the Secretary to use rates paid by construction contractors as a sis for his determination. The line is not easily drawn between intenance work, which is not covered, and minor construction work hich is covered. Similarly, in a field of changing technologies such atomic energy, it is difficult to distinguish between construction a facility for experimentation, which is covered by the Act, and the ting up of an experiment which normally is not covered. The eral practice of the Commission has been to contract out to conuction contractors work covered by the Davis-Bacon Act. Work t covered by the Davis-Bacon Act normally is assigned to an operatg contractor. On a variety of work items conflict frequently arises to which contractor, which employees and which union will thus ain cognizance of the work.

During 1960 a joint project between the Department of Labor and Commission was directed toward development of criteria to be d in distinguishing construction work items from research, mainance or other operative items. Labor unions, the Commission, and actors participated in the project, and the final document, when oved by the Labor Department, will be issued as part of the mic Energy Commission Procurement Regulation.

Consultant Policy Revised

During 1960 the Commission revised its policy regarding the use s contractors of consultants who are regularly employed by other mission contractors.

Prior to this revision there were instances where employees of one actor were employed by a second contractor through private cong agreements at rates which, at times, exceeded the individual's lar salary.

e new policy recognizes the desirability of utilizing the special-kills possessed by contractor employees within the Commission's am. To facilitate the use of these specialists, Managers of Comon Operations Offices may authorize cost-reimbursable contracto enter into agreements with other contractors for consultation qualified specialists who are primarily identified as regular Comon contract work employees. These agreements will be either on bursable cost or nonreimbursable loan basis. In the first case, the consultant's regular employer would be reimbursed for the time he spends on consultant activities; under the second, the regular employer would loan the services of the employee to the contractor requesting specialized service.

Panel Activities

During 1960 the Atomic Energy Labor-Management Relations Panel continued to keep fully informed on collective bargaining developments in the Commission program. Where disputes arose over contract terms, the Panel had frequent consultations with the Commission, the Federal Mediation and Conciliation Service and, when necessary, with the parties involved in the dispute. The Panel took jurisdiction in three cases during 1960, involving Federal Services, Inc., (NTS) and Independent General Association of Nevada; and Zia Company, Los Alamos and nine craft unions, General Electric-Hanford and the Hanford Atomic Metal Trade Council.

In February, the President designated Charles O. Gregory, Professor of Law, University of Virginia, as an additional member of the Panel.

AMENDMENTS TO STATE WORKMEN'S COMPENSATION LAWS

During calendar year 1960 less than half the State Legislatures met in regular session. Some important changes in State laws were enacted. Additional coverage affecting radiation injury or disease occurred in three States.

An amendment to the Rhode Island Law recognized the possible latent characteristics of injury or disease induced by radiation. The 1960 revision provides that the time limit (two years) for filing claims in such cases does not begin until the claimant knew, or should have known, of the existence of an impairment and the casual relationship to employment or until after disablement, whichever is later.

A similar amendment to the Virginia Law provides that the time limit (one year) does not begin until a diagnosis is communicated to the worker.

Kentucky broadened its coverage under the second injury provisions of its law by making them applicable to occupational disease.

Second or subsequent injury arrangements—usually funds—exist within a workman's compensation system to insure that a handicapped

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Personnel Changes

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Robert E. Wilson, fo
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Commissioner John
Loren K. Olson, for
President and confirme
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that will end June 30, 1
Commissioner John
Dr. Willard F. Libby
Energy Commissioner,
General Advisory Com
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Philip Hauge Abelso
Advisory Committee for th
effective July 14, 1960 a
that will expire August
Dr. Paul W. McDani
search, was appointed I

worker suffering a second injury or disease on the job will receive full compensation to cover the resultant disability, and at the same time ensuring that the employer need pay only the benefits due for the second injury. The "second injury" fund pays the difference between what the worker actually receives from the employer and what he would have received for his resulting condition if there had been no prior disability.

During 1960, the Council of State Governments established a workmen's compensation subcommittee of the State Legislative Advisory Committee. A group of experts in the field has also been appointed as an advisory body to the subcommittee. These groups are expected to conduct a comprehensive review of the radiation injury coverage of State workmen's compensation law and to make recommendations to various States.

Organization and Personnel

Personnel Changes

During the January–December 1960 reporting period, the following major personnel changes took place:

Robert E. Wilson, formerly a member of the General Advisory Committee, was appointed Commissioner by the President on March 18, confirmed by the Senate, and sworn in March 22, 1960 for the unexpired term of Commissioner Harold S. Vance (deceased August 31, 1959) that ended June 30, 1960 and for a 5-year term that will end June 30, 1965.

Commissioner John F. Floberg resigned effective June 23, 1960.

Loren K. Olson, formerly General Counsel, was appointed by the President and confirmed by the Senate, and sworn in on June 23, 1960 as Commissioner for the unexpired term of Commissioner Floberg which will end June 30, 1962.

Commissioner John H. Williams resigned effective June 30, 1960.

Dr. Willard F. Libby, University of California, and former Atomic Energy Commissioner, was appointed on June 13, as a member of the General Advisory Committee for the unexpired term of Robert E. Wilson that will end August 1, 1962.

Philip Hauge Abelson was appointed as a member of General Advisory Committee for the unexpired term of the late James W. McRae, effective July 14, 1960 and ending August 1, 1960, and for a new term which will expire August 1, 1966.

Dr. Paul W. McDaniel, formerly Deputy Director, Division of Research, was appointed Director, effective May 20, 1960.

Morse Salisbury, formerly Director, Division of Information Serv-ices, was appointed Assistant to the General Manager, effecti May 27, 1960.

Duncan C. Clark, formerly Assistant Director for Public Infor-mation Service, Division of Information Services, was appointed Di-rector, Office of Public Information, effective May 27, 1960.

Melvin S. Day, formerly Assistant Director for Technical Infor-mation Service, Division of Information Services, was appointed Di-rector, Office of Technical Information, effective May 27, 1960. H left the Commission effective August 27, to the National Aeronauti and Space Administration.

Lawrence D. Low, formerly Chief, Materials Inspection Branc Division of Inspection, was appointed Director, Division of Compli ance, effective May 27, 1960.

Neil D. Naiden, formerly Deputy General Counsel, was appoin Acting General Counsel, effective July 12, 1960, and General Couns effective December 19.

Harry Gorman, formerly Manager, Lockland Aircraft Reacto Operations Office, resigned June 5, 1960, to go to the National Aer nautics and Space Administration, Marshall Space Flight Cente Huntsville, Ala. He was succeeded by John L. Wilson, former Deputy Manager at Lockland.

Robert H. McCulloh, Manager, Portsmouth Area Office, retir effective July 29, 1960. He was succeeded by Robert H. Thalg formerly Chief, Operations Branch, Portsmouth Area Office, effecti July 30, 1960.

Donald F. Musser, formerly Director, Division of Nuclear Materia Management, was appointed Technical Advisor of the United Sta Delegation to the Conference of the Ten-Nation Committee on Di armament, Geneva, Switzerland, effective March 7, 1960.

Douglas E. George was designated Acting Director of the Divis of Nuclear Materials Management.

Amasa S. Bishop, Scientific Representative at Brussels, Belgiu resigned effective March 18, 1960. He was succeeded by Nelson Sievering, who had been serving as Reactor Technology Advisor the Brussels Office.

Edward J. Brunenkant was designated Acting Director, Office Technical Information, effective August 29, 1960.

John R. Moore, formerly Director, Office of Contract Policy, tra ferred to Oak Ridge Operations Office as Assistant Manager for A ministration, effective September 18, 1960. He was succeeded by Jo V. Vinciquerra, formerly Assistant Director for Safeguards, Divis of International Affairs, effective October 31.

Organization

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Organization

Effective February 24, the titles "Assistant General Manager" and "Assistant General Manager for Administration" were exchanged, each for the other, to cover more suitably the functions of the two positions. The change was one of title only.

Effective May 27, the Division of Information Services was reorganized into two new organization elements. Public information functions were assigned to a newly established Office of Public Information, responsible to the General Manager. Technical information functions were assigned to a newly established Office of Technical Information, responsible to the Assistant General Manager for Administration.

Effective August 1, the activities involving the direct inspection of facility licenses were transferred to the Division of Compliance.

APPENDIX 1

ORGANIZATION AND PRINCIPAL STAFF OF U.S. ATOMIC ENERGY COMMISSION

Atomic Energy Commission	JOHN A. McCONE, *Chairman* JOHN S. GRAHAM LOREN K. OLSON ROBERT E. WILSON *Vacancy*
General Manager	ALVIN R. LUEDECKE
Special Assistant to General Manager (Congressional)	RICHARD X. DONOVAN
Assistant to the General Manager	MORSE SALISBURY
Deputy General Manager	ROBERT E. HOLLINGSWORTH
Assistant General Manager	DWIGHT A. INK
Assistant General Manager for Administration	HARRY S. TRAYNOR
Assistant General Manager for International Activities	JOHN A. HALL
Assistant General Manager for Manufacturing	E. J. BLOCH
Assistant General Manager for Regulation and Safety	WILLIAM F. FINAN
Assistant General Manager for Research and Industrial Development	A. TAMMARO
Hearing Examiner	SAMUEL W. JENSCH
Controller	DON S. BURROWS
General Counsel	NEIL D. NAIDEN
Secretary to the Commission	W. B. McCOOL
Director, Office of Contract Policy	JOHN V. VINCIGUERRA
Director, Office of Headquarters Services	EDWARD H. GLADE
Director, Office of Health and Safety	NATHAN H. WOODRUFF
Director, Office of Industrial Relations	OSCAR S. SMITH
Director, Office of Isotopes Development	PAUL C. AEBERSOLD

[1] John A. McCone was chairman during period covered by this report. He resigned, effective January 20, 1961. Glenn T. Seaborg was nominated to succeed him.

...ctor, Office of Operations Analy-...and Forecasting	PAUL C. FINE
...ctor, Office of Personnel	ARTHUR L. TACKMAN
...ctor, Office of Plans	JOHN L. MCGRUDER
...ctor, Office of Public Informa-...ion	DUNCAN C. CLARK
...ctor, Office of Special Projects	EDWARD R. GARDNER
...ctor, Office of Technical Informa-...ion	EDWARD J. BRUNENKANT, *Acting*
...ector, Division of Biology and Medicine	CHARLES L. DUNHAM, M.D.
...ector, Division of Classification	C. L. MARSHALL
...ector, Division of Compliance	LAWRENCE D. LOW
...ector, Division of Construction and Supply	JOHN A. DERRY
...ector, Division of Inspection	CURTIS A. NELSON
...ector, Division of Intelligence	C. H. REICHARDT
...ector, Division of International Affairs	ALGIE A. WELLS
...ctor, Division of Licensing and Regulation	HAROLD L. PRICE
...ctor, Division of Military Appli-...ation	MAJ. GEN. ALFRED D. STARBIRD
...ctor, Division of Nuclear Mate-...als Management	DOUGLAS E. GEORGE, *Acting*
...ctor, Division of Production	GEORGE F. QUINN
...ctor, Division of Raw Materials	JESSE C. JOHNSON
...ctor, Division of Reactor Develop-...ent	FRANK K. PITTMAN
...ctor, Division of Research	PAUL W. MCDANIEL
...tor, Division of Security	JOHN A. WATERS, Jr.

MANAGERS OF OPERATIONS OFFICES AND AREAS

...querque (N. Mex.) Operations ...ice	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	PAUL A. WILSON

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
Chicago (Ill.) Operations Office	KENNETH A. DUNBAR
Canoga Park, (Calif.) Area	JOEL V. LEVY
Grand Junction (Colo.) Operations Office	ALLAN E. JONES
Hanford (Wash.) Operations Office	J. E. TRAVIS
Idaho (Idaho Falls) Operations Office	ALLAN C. JOHNSON
Lockland (Ohio) Aircraft Reactors Operations Office	JOHN L. WILSON
Hartford (Conn.) Area	CLIFFORD E. McCOLLEY
New York (N.Y.) Operations Office	JOSEPH C. CLARKE
Brookhaven (Long Island, N.Y.) Area	E. L. VAN HORN
Princeton (N.J.) Area	ENZI DE RENZIS
Oak Ridge (Tenn.) Operations Office	S. R. SAPIRIE
Fernald (Cincinnati, Ohio) Area	CLARENCE L. KARL
New Brunswick (N.J.) Area	C. J. RODDEN
Paducah (Ky.) Area	KENNEDY C. BROOKS
Portsmouth (Ohio) Area	ROBERT H. THALGOTT
Puerto Rico (Mayaguez) Area	JOHN I. THOMAS
St. Louis (Mo.) Area	FRED H. BELCHER
Pittsburgh, (Pa.) Naval Reactors Operations Office	LAWTON D. GEIGER
San Francisco (Calif.) Operations Office	ELLISON C. SHUTE
Savannah River (Aiken, S.C.) Operations Office	ROBERT C. BLAIR
Schenectady (N.Y.) Naval Reactors Operations Office	STANLEY W. NITZMAN

APPENDIX 2

Membership of Committees

STATUTORY COMMITTEES AND BOARD

Joint Committee on Atomic Energy—Eighty-seventh Congress

committee was established by the Atomic Energy Act of 1946, and con-d under the Atomic Energy Act of 1954, to make "continuing studies of activities of the Atomic Energy Commission and of problems relating to development, use, and control of atomic energy." The committee is kept and currently informed with respect to the Commission's activities. Legis- relating primarily to the Commission or to atomic energy matters is red to the committee. The committee's membership is composed of 9 Mem- of the Senate and 9 Members of the House of Representatives.

Representative CHET HOLIFIELD (California), *Chairman.*
Senator CLINTON P. ANDERSON (New Mexico), *Vice Chairman.*
Senator RICHARD B. RUSSELL (Georgia).
Senator JOHN O. PASTORE (Rhode Island).
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

Section 27 of the Atomic Energy Act of 1954, "there is hereby estab- Military Liaison Committee consisting of—*a.* a Chairman, who shall be thereof and who shall be appointed by the President, by and with the ad- consent of the Senate, who shall serve at the pleasure of the President, shall receive compensation at the rate prescribed for an Assistant Secre- Defense; and *b.* a representative or representatives from each of the ents of the Army, Navy, and Air Force, in equal numbers as determined Secretary of Defense, to be assigned from each Department by the Secre- of, and who will serve without additional compensation. The Chairman ommittee may designate one of the members of the Committee as Acting 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. Herbert B. Loper, *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 T. Snodgrass, United States Army.
Capt. John N. Shaffer, United States Navy.

General Advisory Committee

This committee was established by the Atomic Energy Act of 1946 (Sec. 2 [illegible]) and is continued by Section 26 of the Atomic Energy Act of 1954. The [illegible] 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;* professor of chemistry, University of California, Berkeley, Calif.
- 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. J. C. Warner, president, Carnegie Institute of Technology, Pittsburgh, Pa.
- Dr. Eugene P. Wigner, Palmer Physical Laboratory, Princeton University, Princeton, N.J.
- (*Two vacancies*)
  - Dr. Robert A. Charpie, *secretary;* Oak Ridge National Laboratory, Oak Ridge, Tenn.

Patent Compensation Board

zard was established in April 1949 pursuant to Section 11 of the Atomic gy Act of 1946, and is the Board designated under Section 157a of the Atomic gy Act of 1954. Section 157 provides that upon application for just compen- or awards or for the determination of a reasonable royalty fee certain edings shall be held before such a board.

Casper W. Ooms, chairman; firm of Ooms, McDougall, Williams & Hersh, Chicago, Ill.
Lawrence E. Kingsland, Kingsland, Rogers & Ezell, St. Louis, Mo.
George Sipkin, Barr Building, Washington, D.C.
vacancy.

Advisory Committee on Reactor Safeguards

mmittee reviews safety studies and facility license applications referred and makes reports thereon, advises the Commission with regard to the ds of proposed or existing reactor facilities and the adequacy of proposed safety standards, and performs such other duties as the Commission may The committee's reports on applications for facility licenses become a of the record of the application and available to the public, except for se- material. Members are appointed by the Commission for a term of 4 each, and one member is designated by the committee as its chairman. statutory committee replaced the former Advisory Committee on Reactor ards in 1957.

Leslie Silverman, chairman; professor of engineering in environ- mental hygiene, director of radiological hygiene program, Harvard Uni- versity, School of Public Health, Boston, Mass.
R. L. Doan, vice chairman; manager, atomic energy division, Phillips Petroleum Co., Idaho Falls, Idaho.
Harvey Brooks, dean of engineering and applied physics, Harvard University, Cambridge, Mass.
Willard P. Conner, Jr., technical assistant to director of research center, research department, Hercules Powder Co., Wilmington, Del.
William K. Ergen, principal physicist, Oak Ridge National Laboratory, Oak Ridge, Tenn.
Franklin A. Gifford, Jr., meteorologist in charge of the Oak Ridge Office, U.S. Weather Bureau, Oak Ridge, Tenn.
C. Rogers McCullough, director of reactor safeguards (for foreign reactors) and scientific adviser to board of directors, Nuclear Utility Services, Washington, D.C.
Henry W. Newson, professor of physics, Duke University, Durham, N.C.
R. Osborn, chief engineer, general chemical division, Allied Chemical Corp., New York, N.Y.
A. Rogers, manager of project analysis, Central Research Laboratory, Allied Chemical & Dye Corp., Morristown, N.J.
H. C. Stratton, consulting engineer, Hartford, Conn.
Abel Wolman, consulting engineer and professor emeritus, sanitary engineering, The Johns Hopkins University, Baltimore, Md.

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.

J. B. GRAHAM, executive secretary; U.S. Atomic Energy Commission, Washington, D.C.

Dr. THEOS J. THOMPSON, director, MIT nuclear reactor, Massachusetts Institute of Technology, Cambridge, Mass.

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.

GEORGE FRANKENTHALER, attorney, firm of Frankenthaler and Kohn, New York, N.Y.

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, Johns 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 Chemistry, 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.

Dr. Henry I. Kohn, scientific secretary; clinical professor of experimental radiology, University of California Medical Center, San Francisco, Calif.

Historical Advisory Committee

Historical Advisory Committee was established by the Commission in ...ary, 1958, to advise the Commission and its historical staff on matters ...ing to the preparation of the history of the Atomic Energy Commission.

Dr. James P. Baxter, III, chairman; president, Williams College, Williamstown, Mass.

Dr. John M. Blum, department of history, Yale University, New Haven, Conn.

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.

Don K. Price, Jr., Dean, Graduate School of Public Administration, Harvard University, Cambridge, Mass.

Dr. Glenn T. Seaborg, chancellor, University of California, Berkeley, Calif.

Dr. Richard G. Hewlett, AEC representative; chief historian, U.S. Atomic Energy Commission, Washington, D.C.

Advisory Committee on Industrial Information

...mittee, formed in 1949, advises and assists in the planning and execution ... Atomic Energy Commission's industrial information program.

... A. Tucker, chairman; publications business manager, American Society of Mechanical Engineers, New York, N.Y.

...nard M. Fry, deputy head, Office of Science Information Service, National Science Foundation, Washington, D.C.

... Allen G. Gray, editor, *Metal Progress*, American Society for Metals, Cleveland, Ohio.

...ne J. Hardy, National Association of Manufacturers, Washington, D.C.

...th Henney, consulting editor, *Nucleonics and Electronics*, McGraw-Hill Publishing Co., Inc.; American Institute of Radio Engineers, New York, N.Y.

...man H. Jacobson, *Electric Light and Power*, Haywood Publishing Co., Chicago, Ill.

...ew W. Kramer, editor, *Atomics*, The Technical Publishing Co., Barrington, Ill.

... W. Landis, assistant manager, atomic energy division, The Babcock & Wilcox Co., representing American Nuclear Society, Chicago, Ill.

...ric A. Pawley, research secretary, American Institute of Architects, Washington, D.C.

Karl T. Schwartzwalder, director of research, A-C spark plug div., General Motors Corp., representing The American Ceramic Society, Columbus, Ohio.

George F. Sullivan, editor, *The Iron Age*, Chilton Publication, Inc., Phila-delphia, Pa.

E. E. Thum, editor-in-chief, *Metal Progress*, American Society for Me..., Cleveland, Ohio.

Oliver H. Townsend, Office of Atomic Development, State of New Y..., New York, N.Y.

John W. Wight, vice president McGraw-Hill Book Co., Inc., New Y..., N.Y.

Edward J. Brunenkant, secretary; acting director, office of technical in...mation, 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 ... means of encouraging widescale industrial use of radioisotopes and ... radiation.

Dr. Paul C. Aebersold, chairman; director, office of isotopes develop..., U.S. Atomic Energy Commission, Washington, D.C.

Dr. James F. Black, products research division, Esso Research and Engi-neering Co., Linden, N.J.

Samuel E. Eaton, Arthur D. Little, Inc., Cambridge, Mass.

Dr. Henry J. Gomberg, director, Memorial-Phoenix Project, University of Michigan, Ann Arbor, Mich.

Dr. Thorfin R. Hogness, director, Chicago Midway Laboratories, Univer-sity of Chicago, Chicago, Ill.

John L. Kuranz, vice president, Nuclear-Chicago Corp., Des Plaines, Ill.

John J. McMahon, manager, marketing research, American Machine & Foundry Atomics, Greenwich, Conn.

Homer S. Myers, vice president for marketing, Tracerlab, Inc., Waltham, Mass.

Dr. Leonard Reiffel, director of physics research, Armour Research Foun-dation, Illinois Institute of Technology, Chicago, Ill.

Dr. Glenn T. Seaborg, chancellor, University of California, Berkeley, Calif.

Dr. Lauriston S. Taylor, chief, atomic and radiation physics div..., National Bureau of Standards, Washington, D.C.

Advisory Committee on Medical Uses of Isotopes

This committee was established in 1958 and replaces the Subcommittee on Hu-man Applications of the Advisory Committee on Isotope Distribution. The committee will advise the Commission on policies and standards for the regula-tion and licensing of medical uses of radioisotopes in humans.

Dr. Wallace D. Armstrong, professor, 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.

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

Plowshare Advisory Committee was established in September 1959. The ...ittee's function is to advise the Commission and the General Manager on ...ing and carrying out particular Plowshare Projects; developing and making available various applications of Plowshare; and determining the general ...ation and policies of the Plowshare program.

Dr. SPOFFORD G. ENGLISH, chairman; special assistant to the General Manager, 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

...mittee is appointed to consider the status of the development of reactor ... information required for the development of reactor concepts and the ...nd construction of reactors. Nuclear physics data and reactor physics ...required for the design and development of reactors are reviewed and .... The committee's recommendations and advice are used in planning ...ch and development work in the field of reactor physics.

...RA F. ZARTMAN, chairman; chief, reactors physics branch, division of ...ctor development, U.S. Atomic Energy Commission, Washington, D.C.
... E. RICHARD COHEN, research adviser, Atomics International, North ...erican Aviation, Inc., Canoga Park, Calif.
...NDE DE BOISBLANC, director, reactor physics and engineering, Phillips ...roleum Co., Idaho Falls, Idaho.

Dr. GEBHARD DESSAUER, director, physics section, E. I. du Pont de Ne
& Co., Inc., Aiken, S.C.

Dr. MILTON EDLUND, manager, physics and mathematics department, B
cock & Wilcox Co., Lynchburg, Va.

Dr. RICHARD EHRLICH, Knolls Atomic Power Laboratory, General E
Co., Schenectady, N.Y.

Dr. PAUL F. GAST, manager, physics and instrument research and de
ment, General Electric Co., Richland, Wash.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N.

Dr. IRVING KAPLAN, professor of nuclear engineering, Massachusetts I
tute of Technology, Cambridge, Mass.

Dr. HERBERT J. C. KOUTS, experimental reactor physics group le
Brookhaven National Laboratory, Upton, Long Island, N.Y.

Dr. SIDNEY KRASIK, Astronuclear Laboratory, Westinghouse Electric C
Pittsburgh, Pa.

Dr. F. C. MAIENSCHEIN, Oak Ridge National Laboratory, Oak Ridge, Te

Dr. THEODORE MERKLE, associate director, Pluto Project, "R" division, La
rence Radiation Laboratory, Livermore, Calif.

Dr. JOHN W. MORFITT, manager, nuclear development laboratory, Ge
Electric Co., Cincinnati, Ohio.

Dr. THOMA M. SNYDER, manager, physics—APED, Vallecitos Atomic La
ratory, General Electric Co., Pleasanton, Calif.

Dr. BERNARD I. SPINRAD, director, reactor engineering division, Ar
National Laboratory, Lemont, Ill.

Dr. JOHN J. TAYLOR, Westinghouse Electric Corp., Bettis Atomic P
Div., Pittsburgh, Pa.

Dr. PAUL F. ZWEIFEL, professor of nuclear engineering, Univers
Michigan, Ann Arbor, Mich.

Dr. ALVIN RAKOWSKY, secretary; division of reactor development,
Atomic Energy Commission, Washington, D.C.

Advisory Committee for Standard Reference Materials and Me of Measurement

The committee was originally established by the Commission in March 19 the Committee for Uranium Isotopic Standards. The Commission approved reconstitution in January 1958 under its present title to reflect the broa scope of its activities. The committee reviews, evaluates and recommends for providing standard reference materials (i. e., certified chemical and standards for uranium, plutonium, etc.) and approved methods of measur for materials of special importance to atomic energy activities.

Dr. SAMUEL C. T. MCDOWELL, chairman; chief, chemistry and ph
branch, division of nuclear materials management, U.S. Atomic E
Commission, Washington, D.C.

RALPH J. JONES, division of nuclear materials management, U.S. A
Energy Commission, Washington, D.C.

Dr. CHARLES F. METZ, group leader, analytical chemistry group, ch
and metallurgical research division, Los Alamos Scientific Labor
Los Alamos, N. Mex.

Dr. HORACE W. NORTON III, professor of statistical design and an
University of Illinois, Urbana, Ill.

Dr. EDWIN F. ORLEMANN, professor of chemistry and chemical engineering, University of California, Berkeley, Calif.
Dr. LEONARD P. PEPKOWITZ, vice president, Nuclear Materials and Equipment Corp., Apollo, Pa.
C. J. RODDEN, area manager, New Brunswick Area Office, Atomic Energy Commission, New Brunswick, N.J.
CHARLES M. STEVENS, Argonne National Laboratory, Lemont, Ill.
C. D. W. THORNTON, vice president, ITT Laboratories, International Telephone & Telegraph Corp., Fort Wayne, Ind.
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. BRECKINRIDGE, attorney general of Kentucky, Frankfort, Ky.
Dr. BERNARD BUCOVE, director of health, State Department of Health, Seattle, Wash.
Dr. R. L. CLEERE, executive director, State Department of Public Health, Denver, Colo.
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.
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.
T. LINTON, executive director, water pollution control authority, South Carolina State Board of Health, Columbia, S.C.
M. MARX, coordinator, Atomic Development Activities, Greenwich, Conn.
M. MASON, director, bureau of environmental health, Pennsylvania Department of Health, Harrisburg, Pa.

Dr. JAMES E. PEAVY, commissioner of health, State Department of H Austin, Tex.

WILLIAM J. PIERCE, University of Michigan Law School, Ann Arbor,

B. A. POOLE, director, bureau of environmental sanitation, Indiana Board of Health, Indianapolis, Ind.

RAYMOND I. RIGNEY, coordinator of atomic development, The Commonwealth of Massachusetts, Boston, Mass.

D. P. ROBERTS, chief industrial hygiene section, Tennessee Department Health, Nashville, Tenn.

ROBERT H. SOLOMONS, III, executive secretary, Regional Advisory Co on Nuclear Energy, Atlanta, Ga.

OLIVER TOWNSEND, director, Office of Atomic Development, New York,

JAMES T. VOCELLE, chairman, Industrial Commission of Florida, Tallahassee, Fla.

Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect the rules and guides for the control of scientific and technical information. 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 Scien Laboratory, Los Alamos, N. Mex.

Dr. JOHN P. HOWE, chief research department, Atomics International, N American Aviation, Inc., Canoga Park, Calif.

Dr. FRANK C. HOYT, Missiles System Division, Lockheed Aircraft C Palo Alto, Calif.

Dr. WARREN C. JOHNSON, vice president, University of Chicago, Chica Ill.

Dr. WINSTON M. MANNING, director, chemistry division, Argonne Nati Laboratory, Lemont, Ill.

Dr. J. REGINALD RICHARDSON, professor of physics, University of Califor at Los Angeles, Calif.

Metallurgy and Materials Advisory Panel

This panel was established in October 1955 to advise on the Commission research program on metallurgy, solid state physics, and ceramics.

Dr. HARVEY BROOKS, dean, division of engineering and applied phy Harvard University, Cambridge, Mass.

Dr. MORRIS COHEN, department of metallurgy, Massachusetts Institute Technology, Cambridge, Mass.

Dr. MAXWELL GENSAMER, department of metallurgy, Columbia Univer New York, N.Y.

Dr. JOHN P. HOWE, chief, research department, Atomics International division of North American Aviation, Inc., Downey, Calif.

Dr. ALBERT R. KAUFMANN, vice president, Nuclear Metals, Inc., Cambri Mass.

Dr. FREDERICK SEITZ, head, department of physics, University of Illi Urbana, Ill.

Dr. JOHN C. SLATER, department of physics, Massachusetts Institute of Technology, Cambridge, Mass.
Dr. DONALD K. STEVENS, division of research, U.S. Atomic Energy Commission, Washington, D.C.

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 1959 to July 1960.

Dr. JOSEPH L. FOWLER, chairman; Oak Ridge National Laboratory, Oak Ridge, Tenn.
Dr. GEORGE L. ROGOSA, vice chairman; division of research, U.S. Atomic Energy Commission, Washington, D.C.
Dr. JACOB BENVENISTE, Lawrence Radiation Laboratory, Livermore, Calif.
Dr. LOWELL M. BOLLINGER, Argonne National Laboratory, Lemont, Ill.
Dr. TOM W. BONNER, department of physics, Rice Institute, Houston, Tex.
Dr. LAWRENCE CRANBERG, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. BENJAMIN C. DIVEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. JOHN E. EVANS, Phillips Petroleum Co., Idaho Falls, Idaho.
Dr. REX G. FLUHARTY, Phillips Petroleum Co., Idaho Falls, Idaho.
Dr. HERBERT GOLDSTEIN, Nuclear Development Corp. of America, White Plains, N.Y.
Dr. BOWEN R. LEONARD, General Electric Co., Richland, Wash.
Dr. HENRY W. NEWSON, department of physics, Duke University, Durham, N.C.
Dr. JACK M. PETERSON, Lawrence Radiation Laboratory, Livermore, Calif.
Dr. L. JAMES RAINWATER, department of physics, Columbia University, New York, N.Y.
Dr. VANCE L. SAILOR, Brookhaven National Laboratory, Upton, Long Island, N.Y.
Dr. ALAN B. SMITH, Argonne National Laboratory, Lemont, Ill.
Dr. JOHN A. HARVEY, secretary; Oak Ridge National Laboratory, Oak Ridge,

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, Brown, Jackson, Boettcher & Dienner, Chicago, Ill.
CASPER W. OOMS, firm of Ooms, McDougall, Williams & Hersh, Chicago, Ill.
JOHN C. STEDMAN, Universitay 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. 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. J. A. LIEBERMAN, division of reactor development, U.S. Atomic Energy Commission, Washington, D.C.

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 resources, The Johns Hopkins University, Baltimore, Md.

APPENDIX 3

MAJOR RESEARCH AND DEVELOPMENT INSTALLATIONS OF THE U.S. ATOMIC ENERGY COMMISSION

…mes *Laboratory* (Iowa State University of Science and Technology, contractor), Ames, Iowa

…ector	Dr. FRANK H. SPEDDING
…ciate Director	Dr. H. A. WILHELM
…sistant to Director	Dr. ADOLF F. VOIGT
…sistant to Director	MORTON S. SMUTZ
…iness Manager	ALEX E. EDWARDS

…gonne *Cancer Research Hospital* (University of Chicago, contractor), Chicago, Ill.

…ector	Dr. LEON O. JACOBSON
…ciate Director	Dr. ROBERT J. HASTERLIK

…gonne *National Laboratory* (University of Chicago, contractor), Lemont, Ill.

…ector	Dr. NORMAN HILBERRY
…y Director	Dr. LOUIS A. TURNER
…ciate Director for Education	Dr. FRANK E. MYERS
…ciate Director for High Energy Physics	Dr. ROGER H. HILDEBRAND
…stant Director	Dr. JAMES R. GILBREATH
…ess Manager	JOHN H. MCKINLEY
…ger, Technical Services	JOHN T. BOBBITT

…iated Midwest Universities:

- …telle Memorial Institute
- …negie Institute of Technology
- … Institute of Technology
- …ois Institute of Technology
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- …a State University
- …sas State University
- …ola University (Chicago, Ill.)
- …quette University
- … Foundation
- …igan College of Mining and …hnology
- …igan State University
- …hwestern University
- … State University
- …homa State University
- …e University
- St. Louis University
- State University of Iowa
- University of Chicago
- University of Cincinnati
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Mississippi State College	University of South Carolina
North Carolina State College	University of Tennessee
North Texas State College	University of Texas
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Assistant Director	T. G. Hennessy
Project Manager	H. B. Thompson

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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	Dr. Luis W. Alvarez
Associate Director	Dr. Donald Cooksey
Associate Director	Dr. Isadore Perlman
Associate Director	Dr. Glenn T. Seaborg
Associate Director	Dr. Harold Brown
Associate Director and Director, Livermore Laboratory	Dr. Edward Teller
Associate Director	Dr. Robert L. Thornton
Associate Director and Director, Donner Laboratory of Medical Physics	Dr. J. H. Lawrence
Business Manager and Managing Engineer	Wallace B. Reynolds

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Director	Dr. Henry A. Blair
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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
Sr 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

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, 1959		Jan. 1, 1960–Nov. 30, 1960		Total to Nov. 30, [illegible]	
	Activity (Curies)	Shipments	Activity (Curies)	Shipments	Activity (Curies)	Shipments
Carbon 14	85	3,135	23	300	108	[illegible]
Cesium 137	93,239	1,306	29,626	202	122,865	[illegible]
Cobalt 60	678,565	2,038	141,037	146	819,602	[illegible]
Hydrogen 3	92,900	1,008	5,203	115	98,103	[illegible]
Iodine 131	6,590	44,031	503	2,327	7,093	[illegible]
Iridium 192	30,862	763	8,538	109	39,400	[illegible]
Krypton 85	6,636	284	3,290	116	9,926	[illegible]
Phosphorus 32	1,656	26,453	141	1,957	1,797	[illegible]
Promethium 147	1,270	332	2,285	64	3,555	[illegible]
Strontium 90	561	745	302	107	863	[illegible]
All others	1,541	51,510	173	6,330	1,714	[illegible]
Total	913,905	131,605	191,121	11,773	1,105,026	[illegible]

NOTE.—This table does not include several thousand curies of radioisotopes produced and [illegible] directly from other AEC facilities such as Mound Laboratory or Brookhaven National Laboratory [illegible] from reactors owned by private industrial firms and universitils. Radioisotopes made in other [illegible] and imported into United States are also not included.

RADIOISOTOPE SALES FROM OAK RIDGE NATIONAL LABORATORY

Type of sales	Aug. 2, 1946–Dec. 31, 1959	Jan. 1, 1960–Nov. 30, 1960	Total to Nov. 30, [illegible]
Domestic	$11,533,508	$1,272,983	[illegible]
Foreign	1,492,812	246,782	[illegible]
Total commercial sales	13,026,320	1,519,765	[illegible]
Project transfers	1,752,713	172,439	[illegible]
Medical subsidy	3,216,763	213,117	[illegible]
Technical cooperation program; Local sales to ORNL; Civilian defense	714,383	70,289	[illegible]
Subtotal	5,683,859	455,845	[illegible]
Total	18,710,179	1,975,610	[illegible]

NOTE.—This table does not include sales by private commercial firms who act as secondary [illegible] other AEC facilities such as Mound Laboratory and Brookhaven National Laboratory, private [illegible] universities who own reactors, nor imports into the United States from other countries.

LOCAT[illegible]

Nov[illegible]

States

Total ... 357

P.P.—Private practice.

I.R.—Industrial radiogra[illegible]

C.D.—Civil defense.

LOCATION AND TYPE OF NEW LICENSEES

November 30, 1959—December 1, 1960

States	Medical Institutes and Physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutes	Other	Total
		P.P.*			I.R.†		C.D.‡			
[illegible]	4	4	0	3	1	3	1	0	0	10
[illegible]	0	0	0	0	0	3	1	0	0	3
[illegible]	4	1	1	2	0	5	4	0	0	12
[illegible]	3	3	0	1	0	1	1	0	0	5
[illegible]	57	39	0	39	3	10	0	1	2	109
[illegible]	4	2	1	6	0	7	5	0	1	19
...ut	11	8	2	9	0	1	1	0	0	23
[illegible]	2	1	0	0	0	2	2	0	0	4
... of Columbia	0	0	2	3	0	3	1	0	0	8
[illegible]	15	13	1	1	1	6	3	0	0	23
[illegible]	9	6	0	1	0	8	5	0	0	18
[illegible]	1	1	0	1	0	1	0	0	0	3
[illegible]	0	0	1	0	0	0	0	0	0	1
[illegible]	10	7	1	20	2	5	3	1	1	38
[illegible]	9	6	2	5	2	3	1	0	0	19
[illegible]	8	3	0	1	0	5	4	0	1	15
[illegible]	1	1	0	6	1	5	5	0	0	12
[illegible]	5	3	1	3	0	8	5	0	0	17
[illegible]	3	3	1	3	2	2	1	0	0	9
[illegible]	6	5	0	0	0	1	0	0	0	7
[illegible]	3	2	1	1	0	9	6	0	0	14
...etts	18	10	6	8	1	3	3	0	0	35
[illegible]	11	7	1	9	2	15	12	0	0	36
[illegible]	2	2	2	0	0	8	8	0	0	12
[illegible]	2	0	1	2	2	0	0	0	0	5
[illegible]	12	10	0	3	0	3	1	0	0	18
[illegible]	1	1	0	0	0	0	0	0	0	1
[illegible]	5	3	0	2	0	3	0	0	0	10
[illegible]	1	1	0	2	0	0	0	0	0	3
...ampshire	0	0	0	0	0	0	0	0	0	0
...ey	14	8	0	15	3	5	2	0	0	34
...exico	3	3	0	2	0	1	0	0	0	6
...rk	30	20	2	36	3	10	7	2	1	81
...arolina	1	1	1	3	0	7	6	0	0	12
...akota	0	0	0	2	1	3	3	0	0	5
[illegible]	19	11	2	22	4	12	8	0	1	56
[illegible]	3	3	1	4	1	4	2	0	0	12
[illegible]	8	8	0	1	1	14	13	0	0	23
[illegible]	0	0	0	0	0	0	0	0	0	0
...ania	19	9	3	22	7	11	6	0	1	56
...ico	1	0	0	2	0	0	0	0	0	3
...sland	0	0	0	0	0	1	1	0	0	1
...arolina	4	3	0	3	2	8	1	0	0	15
...akota	3	3	1	0	0	0	0	0	0	4
[illegible]	3	2	0	6	0	3	2	0	0	12
[illegible]	19	15	4	15	6	9	4	0	0	47
[illegible]	0	0	0	4	0	0	0	0	0	4
[illegible]	4	1	0	0	0	0	0	0	0	4
[illegible]	3	2	1	3	0	4	1	0	0	11
[illegible]	6	5	2	3	2	14	13	0	0	25
[illegible]	4	4	0	4	0	17	16	0	0	25
[illegible]	6	5	0	4	1	7	7	0	1	18
[illegible]	0	0	0	2	0	2	2	0	0	4
Total	357	245	41	284	48	252	167	4	9	947

* —Private practice.
† —Industrial radiography.
‡ —Civil defense.

LOCATION AND TYPE OF LICENSEES

February 10, 1956 through November 30, 1960

States	Medical Institutes and Physicians		Colleges and universities	Industrial firms		Federal and State laboratories		Foundations and institutues	Other [illegible]
		P.P.*			I.R.†		C.D.‡		
Alabama	31	16	3	21	11	14	9	1	[illegible]
Alaska	1	1	1	0	0	12	8	0	[illegible]
Arizona	17	11	3	6	0	13	12	0	[illegible]
Arkansas	22	17	1	7	0	4	4	0	[illegible]
California	300	189	15	226	49	62	23	4	[illegible]
Colorado	32	10	6	26	3	29	24	1	[illegible]
Connecticut	35	16	7	47	12	12	9	1	[illegible]
Delaware	4	1	1	11	2	5	5	0	[illegible]
District of Columbia	21	6	4	4	2	30	13	2	[illegible]
Florida	81	52	4	17	7	17	11	0	[illegible]
Georgia	40	17	5	11	8	20	16	0	[illegible]
Hawaii	14	10	1	5	2	4	1	1	[illegible]
Idaho	5	2	2	2	2	1	1	0	[illegible]
Illinois	119	34	7	121	19	37	29	4	[illegible]
Indiana	50	23	7	42	15	20	19	0	[illegible]
Iowa	47	25	11	10	3	24	23	0	[illegible]
Kansas	26	10	2	16	5	12	11	0	[illegible]
Kentucky	29	16	4	13	3	20	17	0	[illegible]
Louisiana	39	18	4	28	14	8	8	1	[illegible]
Maine	14	6	2	8	2	10	9	0	[illegible]
Maryland	33	15	7	23	7	31	21	2	[illegible]
Massachusetts	77	27	20	99	16	16	11	5	[illegible]
Michigan	95	37	10	62	18	49	42	0	[illegible]
Minnesota	39	15	10	22	7	107	106	0	[illegible]
Mississippi	10	3	3	8	4	9	8	0	[illegible]
Missouri	80	37	6	31	8	27	25	0	[illegible]
Montana	13	5	2	1	0	1	1	0	[illegible]
Nebraska	21	9	1	4	1	26	25	0	[illegible]
Nevada	6	3	1	3	1	4	3	0	[illegible]
New Hampshire	12	2	3	6	2	9	8	0	[illegible]
New Jersey	89	48	1	125	20	25	21	1	[illegible]
New Mexico	16	8	4	13	1	5	1	0	[illegible]
New York	313	151	32	180	29	50	37	12	[illegible]
North Carolina	45	23	6	15	0	39	34	0	[illegible]
North Dakota	6	3	2	2	1	10	9	0	[illegible]
Ohio	139	65	13	112	35	51	41	4	[illegible]
Oklahoma	38	29	3	30	11	9	7	1	[illegible]
Oregon	30	19	4	8	6	27	24	1	[illegible]
Panama	1	0	0	0	0	0	0	0	[illegible]
Pennsylvania	133	47	15	153	58	112	97	6	[illegible]
Puerto Rico	9	3	3	2	0	2	2	0	[illegible]
Rhode Island	7	1	3	11	2	5	4	0	[illegible]
South Carolina	15	8	2	6	3	11	8	0	[illegible]
South Dakota	16	9	3	2	0	11	11	0	[illegible]
Tennessee	38	17	5	26	4	11	8	0	[illegible]
Texas	161	105	16	115	40	25	19	4	[illegible]
Utah	9	1	4	11	2	14	10	0	[illegible]
Vermont	11	8	1	2	0	1	1	0	[illegible]
Virginia	32	12	7	32	6	19	11	0	[illegible]
Washington	40	23	8	19	8	29	24	1	[illegible]
West Virginia	23	12	1	16	2	35	34	0	[illegible]
Wisconsin	61	22	4	36	16	20	18	3	[illegible]
Wyoming	5	1	2	4	0	15	13	0	[illegible]
Total	2,550	1,248	292	1,800	467	1,159	936	55	[illegible]

*P.P.—Private practice.
†I.R.—Industrial radiography.
‡C.D.—Civil defense.

...SHIPMENTS OF RADIOACTIVE ISOTOPES TO FOREIGN COUNTRIES

Country	Dec. 1, 1959–Nov. 30, 1960	Total Jan. 1, 1947 to Nov. 30, 1960	Country	Dec. 1, 1959–Nov. 30, 1960	Total Jan. 1, 1947 to Nov. 30, 1960
[illegible]	24	195	Lebanon	1	32
...ina	179	419	Mexico	84	651
...lia	7	21	Monaco	0	51
[illegible]	7	18	Netherlands	109	352
... Congo	70	405	Netherlands, West Indies	1	7
[illegible]	3	23	New Zealand	25	50
...da	297	1,322	Nicaragua	22	50
[illegible]	0	6	Norway	50	197
[illegible]	1,461	5,016	Pakistan	1	24
[illegible]	23	251	Panama, Republic of	22	52
... Republic of	49	132	Paraguay	8	15
[illegible]	113	222	Peru	89	308
[illegible]	11	26	Philippines	92	338
... Rica	128	993	Poland	11	13
[illegible]	129	540	Portugal	77	119
...ark	12	47	Russia	0	1
...an Republic	20	73	Saudi Arabia	1	3
[illegible]	4	28	Scotland	11	18
[illegible]	24	30	South-West Africa	5	16
...vador	20	73	Spain	5	43
[illegible]	146	491	Sweden	394	1,178
..., Federal Republic	260	611	Switzerland	86	235
[illegible]	0	1	Syria	0	2
[illegible]	48	87	Thailand	16	57
[illegible]	1	3	Trieste	0	4
...and	42	112	Turkey	3	12
...ala	1	5	Tunisia	3	3
[illegible]	0	5	Union of South Africa	69	133
[illegible]	18	123	United Kingdom	205	632
[illegible]	1	7	Uruguay	12	25
[illegible]	1	9	Venezuela	193	863
[illegible]	3	3	West Indies Federation—British	13	33
[illegible]	1	1	Yugoslavia	3	24
[illegible]	47	148	Others [1]	0	489
[illegible]	81	239	Total	5,256	19,258
[illegible]	347	1,467			
[illegible]	67	76			

[1] ...viously reported, i.e., Hawaii, Puerto Rico, etc.

...PMENTS OF RADIOACTIVE ISOTOPES TO FOREIGN COUNTRIES

Kind of Isotope	Dec. 1, 1959–Nov. 30, 1960	Total Jan. 1, 1947 to Nov. 30, 1960	Kind of Isotope	Dec. 1, 1959–Nov. 30, 1960	Total Jan. 1, 1947 to Nov. 30, 1960
...e T	2,562	7,974	Calcium 45	52	292
...rus 32	178	1,608	Sulphur 35	15	206
[illegible]	299	1,312	Others	1,560	5,531
[illegible]	197	911	Total	5,256	19,258
[illegible]	311	1,055			
... 89, 90	82	369			

Research and Development Contracts

RADIOISOTOPES AND PROCESS RADIATION DEVELOPMENT

...-*General Nucleonics.* Radioactive, Independent Transducer-Receiver ...ems.

Air Reduction Co., Inc. Promotion of Chemical Reactions Using Mag... Fields in Conjunction with Beta Radiation.

Armour Research Foundation. Research Study on Neutron Interactions in Ma... ter as Related to Image Formation.

Armour Research Foundation. Radiation Synthesis Involving Halogen... Compounds.

Armour Research Foundation. Feasibility Study of a New Mass Flow Sys...

Armour Research Foundation. Studies of Nuclear Resonant Absorption of Gam... ma Rays.

Army Pictorial Center. Production of a Training Film on Industrial Applica... tions of Radioisotopes.

Battelle Memorial Institute. Development of Process Control by Use of Intrin... Radioactive Tracers.

Battelle Memorial Institute. Effect of Phase on the Radiation Induced Nitra... of Hydrocarbons.

Battelle Memorial Institute. Radiation Induced Graft Polymerization Stud...

Catholic University of America. Limiting Factors in Rapid Identification of Selected Materials by Nuclear Techniques.

University of Chicago (Chicago Midway Lab.). Radioisotope Research, Develop... ment and Related Activities.

Consolidation Coal Co. Development of Techniques for Tritium Labeling of Coal-product Hydrocarbon Mixtures of High Molecular Weight to be Utilized in Development of Methods for Applying Tritium Tracer Techniques to In... dustrial Problems in the Processing of Coal.

Curtiss-Wright Corp. Food Process Development Irradiator.

Evans Research and Development Corp. Development of a Beta Particle Back... Scattering Technique for Small Particle Analysis.

Florida State University. Development of Neutron Activation and Radio... chemical Analytical Methods for Antimony and Bismuth.

Georgia Institute of Technology. Radioisotope Research, Development and Re... lated Activities.

Goodyear Tire and Rubber Co. Isotopic Method for Age Determinations of In... dustrial Products.

Interior, Department of—Bureau of Commercial Fisheries. Analysis of Mar... Factors, Affecting Radiation Processing of Fish.

Interior, Department of—Bureau of Commercial Fisheries. Effect of Low Le... of Radiation on the Essential Amino Acids and B-Vitamins of Haddock Fil... lets and Soft Shell Clam Meats.

Interior, Department of—Bureau of Mines. Joint Research Project Inv... Coal, Metallurgical and Petroleum Investigations Using a High Inte... Source of Gamma Radiation.

Interior, Department of—Geological Survey. Research and Development Pro... Involving Use of Radioisotopes in Various Hydrologic Investigations.

Internal Revenue Service. Joint Research Project for the Determination of ... of Distilled Spirits by Means of Radioactive Hydrogen.

Isotopes, Inc. Study of Potential Applications of Radioisotope Technolo... Water Resource Investigations and Utilization.

Johnston, William H. Laboratories, Inc. Basic Studies in Radiation Techno... Fast Primary Ion Reactions from Electron Impact.

Johnston, William H. Laboratories, Inc. Basic Studies and Development ... Application of Isotope Techniques, Especially *In Situ* Tracers.

…ary of Congress. Monitoring-type Survey of World Literature on Industrial Radioisotopes Applications.

… Little, Inc. Study of Effect of Electrophilic Additives on Radiolytic …ducts of Organic Chain Reactions.

…ed Aircraft Corp. Investigation to Establish the Parameters of Utiliza… of the Compton Backscattering Principle for Non-destructive Testing.

… Co. Design, Fabricate and Test A Nominal 5-Watt Strontium-90 Fueled …wer Generator and Design, Fabricate and Test a Data Processing Telemetry …ckage.

…achusetts Institute of Technology. Radioisotope Research, Development and Related Activities.

…achusetts Institute of Technology. Summer Institute in Isotope Technology … College Teachers.

…al Bureau of Standards. Cooperative Radioisotope R&D Program.

…nal Canners Association. Investigation of Radioisotope Tracer Techniques … Detect and Measure Detergent Residues on Washed Food Products and to …aluate Commercial Food Washing Practices.

…r-Chicago Corp. Exploration of Radiometric Methods for Control of …mical Parameters in Industrial Processes.

…r-Chicago Corp. Preparation of Undergradute College Course in Industrial …er Techniques.

…r Research Corp. Development of Enhanced Light Emitting Phosphors …he Thin Single Crystal Type for Use in Fluoroscopy.

…oma, University of. Study of Sequestration of Metal Ions in Brine Using …isotopes.

… X-Ray Corp. Development of Beta Particle Focusing for X-Ray Genera… and Other Applications.

… Research Foundation. The Development of New Principles and Tech…s for Moisture Determination.

…ion Applications, Inc. The Application of Foam Separation to Fission …duct Separation and Purification.

…ion Applications, Inc. Comparison of Radiation Induced Graft Copoly… Produced Using Electron Accelerators and Isotope Sources.

…on Applications, Inc. A Study of the Mechanism of Radiation Induced …ors of Organic Polymers with Inorganic Salts and Organometallic …ounds.

…on Applications, Inc. Mechanism of Radiation Induced Gelation in …er-monomer Mixtures.

…n Applications, Inc. Study of the Technology and Application of Large … Products Beta Sources.

… Triangle Institute of North Carolina, Inc. Radioisotope Research, …pment and Related Activities.

… Research Institute. Radiation Processing Preservation of Selected … and Vegetables—An Analysis of R&D Programming and Market …

… Research Group (TRG, Inc). Synthesis of Semi-Conductor Mate… Radiation Induced Reactions.

…M Research Foundation. Radioisotope Research, Development, and … Activities.

…earch Center. Applications of Nuclear Radiation and Radioisotopes …le Materials and Processes.

Tracerlab, Inc. Continued Development of Radiochemical Exchange Systems and Study of Clathrate Compounds.

Tracerlab, Inc. Development of a Prototype SO_2 Monitor.

Tracerlab, Inc. Development of an Ion-Exchange Resin with Scintillating Properties.

Tracerlab, Inc. Use of Radioisotopes as a source of X-Rays to Develop Rayleigh Scattering Method for Analysis of Heavy Atoms in Low "Z" Media.

Treasury Department—Bureau of Narcotics. Research for Determining Origin of Opium for Activation Analysis Techniques.

Universal Match Corp. An Investigation of the Effects of Ionizing Radiation on the Sedimentation of Sewage.

APPENDIX 5

Commission-Owned Patents

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING [1]

The following 259 U.S. Letters Patents owned by the United States Government as represented by the Atomic Energy Commission are in addition to the 488 patents listed in the 1959 Annual Report. The patents listed are available for licensing. The total number of patents available for licensing is 2484. Licenses are granted on a nonexclusive, royalty-free basis.

Patent No.	Title	Patentee
[illegible]	Thermocouple Vacuum Gauge	G. W. Price, Cedar Rapids, Iowa.
[illegible]	Method of Isotope Concentration	J. S. Spevack, New York, N.Y.
[illegible]	Linear Accelerator	N. C. Christofilos, Berkeley, Calif.; I. J. Polk, Patchogue, N.Y.
[illegible]	Vacuum Trap	H. S. Gordon, Lafayette, Calif.
[illegible]	Solid State Bonding of Thorium with Aluminum.	S. Storchheim, Kingston, Pa.
[illegible]	Volume Compensating Means for Pulsating Pumps.	D. L. W. Weaver, Idaho Falls, Idaho; R. S. MacCormack, Jr., Westfield, N.J.
[illegible]	Plutonium-Hydrogen Reaction Product, Method of Preparing Same and Plutonium Powder Therefrom.	S. Fried, Chicago, Ill.; H. L. Baumbach, Pacific Palisades, Calif.
[illegible]	Plutonium Cleaning Process	M. Kolodney, New York, N.Y.
[illegible]	Formation of Intermetallic Compound Dispersions.	J. S. Bryner, Eastport, N.Y.
[illegible]	Method of Making Fuel Elements	C. H. Bean, Naperville, Ill.; R. E. Macherey, Villa Park, Ill.
[illegible]	Continuous Chelation-Extraction Process for the Separation and Purification of Metals.	H. W. Crandall, Berkeley, and T. E. Hicks, Los Angeles, Calif.; B. Rubin, Livermore, and J. H. Thomas, Albany, Calif.
[illegible]	Loaded Wave-Guides for Linear Accelerator	W. Walkinshaw, Abingdon, England; L. B. Mullett, Malvern Wells, England
[illegible]	Tungsten Base Alloys	D. H. Schell, and H. Sheinberg, Los Alamos, N. Mex.
[illegible]	Uranous Iodate as a Carrier for Plutonium	D. R. Miller, Richmond, G. T. Seaborg, Lafayette, and S. G. Thompson, Richmond, Calif.
[illegible]	Separation of Fission Product Values from Hexavalent Plutonium by Carrier Precipitation	T. H. Davis, Chicago, Ill.
[illegible]	Method of Producing Tetrafluoride	W. B. Tolley, Tucson, Ariz.; R. C. Smith, Richland, Wash.
[illegible]	Method of Recovering Transuranic Elements of an Atomic Number Below 95	G. T. Seaborg, Lafayette, Calif.; R. A. James, Chicago, Ill.
[illegible]	Method of Oxidizing Plutonium Ion with Bismuthate Ion	C. S. Garner, Los Angeles, Calif.
[illegible]	Separation of Plutonium	H. M. Feder, Park Forest, and R. L. Nuttall, Downers Grove, Ill.
[illegible]	Fabrication of Uranium-Aluminum Alloys	H. A. Saller (deceased)
[illegible]	Method of Increasing the Dispersibility of Slurry Particles	J. P. McBride, Oak Ridge, Tenn.
[illegible]	Nuclear Reactor	J. J. Grebe, Midland, Mich.
[illegible]	Neutronic Reactor Control	R. S. Dreffin, Glen Ellyn, Ill.
[illegible]	Neutronic Reactor Control Rod Drive Apparatus	L. C. Oakes, Knoxville, and C. S. Walker, Oak Ridge, Tenn.
[illegible]	Pressure Sensing Device	K. E. Pope, Albuquerque, N. Mex.
[illegible]	Radiation Detection and Telemetering System	H. K. Richards, Oak Lawn, Ill.
[illegible]	Geiger-Muller Type Counter Tube	I. L. Fowler and L. A. K. Watt, Deep River, Ontario, Canada
[illegible]	Extraction of Plutonium Values from Organic Solutions	G. T. Seaborg, Lafayette, Calif.
[illegible]	Uranium Decontamination	J. S. Buckingham and J. L. Carroll, Richland, Wash.

[1] Issued as of November 29, 1960. 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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Patent No.	Title	Patentee
2,918,366	Decontamination of Neutron-Irradiated Reactor Fuel.	A. G. Buyers, Woodland Hills, E. E. [illegible], Canoga Park, and F. D. Rosen, [illegible], Calif.
2,918,700	Radioactive Concentrator and Radiation Source.	L. P. Hatch, Brookhaven, N.Y.
2,918,717	Self-Sintering of Radioactive Wastes	E. G. Struxness and K. Z. Morgan, [illegible] Ridge, Tenn.; J. R. Johnson, Whit[illegible] [illegible] Minn.; T. N. McVay, Tuscaloosa, Ala.
2,919,175	Process of Recovering Uranium	S. B. Kilner, Knoxville, Tenn.
2,919,186	Uranium Alloys	E. W. Colbeck, Northwich, England.
2,919,236	Nuclear Reactor Including a Package Safety Device.	W. H. Zinn, Dunedin, Fla.
2,919,710	Two-Way Freeze Valve	E. D. Lantz, Saratoga Springs, and [illegible] Clark, Scotia, N.Y.
2,919,972	Removal of Chloride from Aqueous Solutions	M. L. Hyman and J. E. Savolain[illegible], [illegible] Ridge, Tenn.
2,920,024	Molten Fluoride Nuclear Reactor Fuel	C. J. Barton and W. R. Grimes, Oak [illegible] Tenn.
2,920,025	Neutronic Reactor	J. B. Anderson, W. Hartford, Conn.
2,920,200	Ion Source	W. T. Leland, Los Alamos, N. Mex.
2,920,234	Device and Method for Producing a High Density Arc Discharge.	J. S. Luce, Oak Ridge, Tenn.
2,920,235	Method and Apparatus for Producing Intense Energetic Gas Discharge.	P. R. Bell and J. S. Luce, Oak Ridge, Tenn.
2,920,236	Apparatus for Heating Ions	E. S. Chambers, Walnut Creek, and [illegible] Kippenhan, Castro Valley, Calif.; [illegible] Carren, W. A. S. Lamb, and R. J. [illegible] Jr., Berkeley, Calif.
2,921,007	Thermal Neutronic Reactor	B. I. Spinrad, Park Forest, Ill.
2,921,199	Method of Operating a Calutron	P. H. Davidson, Visalia, Calif.
2,921,850	Nickel-Base Alloy	H. Inouye, W. D. Manly and T. K. [illegible] Oak Ridge, Tenn.
2,922,036	Paralyzer for Pulse Height Distribution Analyzer.	E. Fairstein, Oak Ridge, Tenn.
2,922,044	Calutron	E. J. Lofgren, Albany, Calif.
2,922,048	High Coaxial Photomultiplier Tube	N. W. Glass, Los Alamos, N. Mex.
2,922,061	Particle Accelerator	L. C. Teng, Chicago, Ill.
2,922,711	Production of Purified Uranium	L. Burris, Jr., J. B. Knighton and [illegible] Feder, Orland Park, Ill.
2,922,882	Control System for Isotope Separating Apparatus.	S. W. Barnes, Rochester, N.Y.
2,922,886	Method and Apparatus for Testing the Presence of Specific Atomic Elements in a Substance.	J. L. Putman, Abingdon, England
2,922,890	Magnetic Method for Producing High Velocity Shock Waves in Gases.	V. Josephson, Palos Verdes Estates, Calif.
2,923,588	Random Pulse Generator	W. C. Nielson, Albuquerque, N. Mex.
2,923,601	Method of Isotope Concentration	T. I. Taylor, Leonia, N.J.; W. Spindel, [illegible] York, N.Y.
2,923,607	Process of Separating Zirconium Values from Hafnium Values by Solvent Extraction with an Alkyl Phosphate.	D. F. Peppard, Chicago, Ill.
2,923,670	Method and Means for Electrolytic Purification of Plutonium.	C. W. Bjorklund, R. Benz, W. J. [illegible] and J. A. Leary, Los Alamos, N. Mex.; K. A. Walsh, Lakeland, Fla.
2,923,822	Electromagnetic Separation of Isotopes	S. W. Barnes, Rochester, N.Y.; C. M. [illegible] Bainbridge, Ga.
2,923,852	Apparatus for Producing High Velocity Shock Waves and Gases.	F. R. Scott, San Diego, Calif.; V. Josephson, Palos Verdes Estates, Calif.
2,924,294	Apparatus for Cleaning Gases with Electrostatically Charged Particles.	H. F. Johnstone, Urbana, Ill.
2,924,483	Fuel Handling Mechanism	L. J. Koch, Clarendon Hills, Ill., E. [illegible] Chicago, Ill.
2,924,506	Solvent Extraction Process for Plutonium	H. H. Anderson, Newton, Mass.; L. B. [illegible] Richmond, Calif.
2,924,877	Method of Jacketing a Fissionable Body	E. C. Creutz, Santa Fe, N. Mex.
2,925,322	Method of Separating Plutonium	H. G. Heal, Montreal, Canada
2,925,323	Method for the Recovery of Cesium Values	S. J. Rimshaw, Loudon, Tenn.
2,925,327	Continuous Gas Analyzer	S. Katz and C. W. Weber, Oak Ridge, Tenn.
2,925,431	Cationic Exchange Process for the Separation of Rare Earths.	G. R. Choppin, Berkeley; S. G. [illegible] Pleasant Hill, and B. G. Harvey, [illegible] Calif.
2,925,509	Low Energy Counting Chambers	P. M. Hayes, Lafayette, Calif.
2,925,512	High Energy Gaseous Discharge Device	V. Josephson, Palos Verdes Estates, Calif.
2,926,067	Concentration of Pu Using an Iodate Precipitate.	B. A. Fries, Richland, Wash.
2,926,068	Method for the Preparation of Plutonium Halides and Oxyhalides.	N. R. Davidson, Sierre Madre, Calif. [illegible] Katz, Chicago, Ill.
2,926,083	Ternary Alloy-Containing Plutonium	J. T. Waber, Los Alamos, N. Mex

TITLE	PATENTEE
Method of Forming a Protective Coating on Ferrous Metal Surfaces.	D. G. Schweitzer, East Islip, and J. R. Weeks, Port Jefferson, N.Y.; O. F. Kammerer, St. James, and D. H. Gurinsky, Center Moriches, N.Y.
Heat Treated U-Mo Alloy	R. K. McGeary, Pittsburgh, Pa.; W. M. Justusson, Dearborn, Mich.
Neutronic Reactor with Accessible Thimble and Emergency Cooling Features.	W. H. McCorkle, Hinsdale, Ill.
Ion Acceleration System	J. S. Luce and J. A. Martin, Oak Ridge, Tenn.
Ultrasonic Neutron Dosimeter	R. Truell and J. De Klerk, Providence, R.I.; P. W. Levy, Sayville, N.Y.
Control Limiter Device	J. A. DeShong, Jr., Elmhurst, Ill.
Jacketed Uranium Nuclear Reactor Fuel Element.	W. E. Huey, Swarthmore, Pa.
Non-Blocking Stabilized Feed Back Amplifier.	E. Fairstein, Oak Ridge, Tenn.
Intense Energetic Gas Discharge	J. S. Luce, Oak Ridge, Tenn.
Iron Coated Uranium and Its Production	A. G. Gray, Rocky River, Ohio.
Method for Producing Thorium Tetrachloride.	E. A. Mason, Lexington, and C. M. Cobb, Lynn, Mass.
Neutronic Reactor Construction and Operation.	J. T. Weills, and J. M. West, Downers Grove, Ill.
Source of Products of Nuclear Fission	P. Harteck and S. Dondes, Troy, N.Y.
Cooled Neutronic Reactor	E. P. Wigner, Princeton, N.J., E. C. Creutz, Pittsburgh, Pa.
Rotary Switch	J. P. E. Watterberg, Albuquerque, N. Mex.
Arc Discharge and Method of Producing the Same.	R. V. Neidigh, Knoxville, Tenn.
Delta Phase Plutonium Alloys	E. M. Cramer, Espanola, N. Mex.; F. H. Ellinger and C. C. Land, Los Alamos, N. Mex.
Method of Fabricating a Uranium Zirconium Hydride Reactor Core.	I. F. Weeks, Long Beach, and R. V. Goeddel, Riviera, Calif.
Method for Coating Graphite with Metallic Carbides.	M. A. Steinberg, University Heights, Ohio.
Convection Reactor	R. P. Hammond and L. D. P. King, Los Alamos, N. Mex.
Nuclear Reactor Core Design	J. E. Mahlmeister, Van Nuys, Calif., W. S. Peck, Pacoima, Calif., W. V. Haberer, Burbank, Calif., and A.C. Williams, Canoga Park, Calif.
Radiation Measuring Devices	G. M. B. Bouricius, Green-Hills, and G. K. Rusch, Dillonvale, Ohio.
Ion-Stabilized Electron	D. Finkelstein, Hoboken, N.J.
Regeneration of Reactor Fuel Elements	W. E. Roake and W. L. Lyon, Benton County Wash.
N¹ Scaler	C. W. Johnstone, Houston, Tex.
Process for Separating Plutonium by Repeated Precipitation with Amphoteric Hydroxide Carriers	B. F. Faris, Oak Ridge, Tenn.
Metathesis of Plutonium Carrier Lanthanum Fluoride Precipitate with an Alkali	R. B. Duffield, Champaign, Ill.
Preparation of Dibasic Aluminum Nitrate	A. T. Gresky, E. O. Nurmi, R. P. Wischow, and J. E. Savolainen, Oak Ridge, Tenn.; D. L. Foster, Knoxville, Tenn.
Regeneration of Reactor Fuel Elements	W. L. Lyon, Richland, Wash.
Neutronic Reactor Control	H. Hurwitz, Jr., Schenectady, N.Y.
Neutronic Reactor	E. Fermi (deceased).
Apparatus for Arc Welding	J. W. Lingafelter, Richland, Wash.
Electron gun	N. C. Christofilos, Berkeley, and K. W. Ehlers, Lafayette, Calif.
Method and Alloy for Bonding to Zirconium	F. D. McCuaig, LaGrange, Ill., R. D. Misch, Whiting, Ind.
Concentration of Pu Using Oxalate Type Carrier	D. M. Ritter and R. P. S. Black, Oak Ridge, Tenn.
Dissolution Method of Removing Bonding Agents	H. H. Hyman, Chicago, Ill.
Electronuclear Reactor	E. O. Lawrence (deceased), E. M. McMillan and L. W. Alvarez, Berkeley, Calif.
Neutron Source	J. S. Foster, Jr., Livermore, Calif.
High Voltage Ion Source	J. S. Luce, Oak Ridge, Tenn.
Precipitation Method for the Separation of Plutonium and Rare Earths	S. G. Thompson, Richmond, Calif.
Recovery of Americium	M. Ader and H. H. Hyman, Chicago, Ill.
Scavenger and Process of Scavenging	C. M. Olson, Newark, N.J.
Method for Purifying Uranium	J. B. Knighton, Brookfield, and H. M. Feder Park Forest, Ill.
Process of Electroplating Metals with Aluminum.	W. C. Schickner, Columbus, Ohio
Nuclear Reactor Fuel Element and Method of Manufacture.	H. Brooks, Cambridge, Mass.

Patent No.	Title	Patentee
2,934,483	Process of Making Fuel Elements for Neutronic Reactors and Articles Produced Thereby.	W. A. Bostrom, Bridgeville, Pa.; R. B. ... Jr., Los Alamos, N. Mex.
2,935,401	Control Rod Alloy Containing Noble Metal Additions.	W. K. Anderson and W. E. Ray, Schenect... N.Y.
2,935,456	Variable Area Control Rod for Nuclear Reactor.	N. E. Huston, Woodland Hills, Calif.
2,935,686	Frequency Stabilizing System	Q. A. Kerns, Orinda, and O. A. Ander... Oakland, Calif.
2,936,110	Method of Centrifuge Operation	K. Cohen, New York, N.Y.
2,936,119	Simultaneous Differential Equation Computer.	D. M. Collier and L. A. Meeks, Oak Ri... Tenn.; J. P. Palmer, Stonybrook, N.Y.
2,936,213	Process of Reducing Plutonium to Tetravalent State.	D. F. Mastick, Napa, Calif.
2,936,231	Separation of Rare Earth Metal Fission Products from Liquid U-Bi.	R. H. Wiswall, Brookhaven, N.Y.
2,936,273	Steam Forming Neutronic Reactor and Method of Operating It.	S. Untermyer, Scotia, N.Y.
2,936,274	Determination of Specific Neutronic Reactivity.	C. G. Dessauer, Aiken, S.C.
2,936,277	Reactor Control System	J. H. MacNeill, Melbourne, Fla.; J. Y. E... brook, Oak Ridge, Tenn.
2,936,318	Fission Product Removal from Organic Solutions.	R. H. Moore, Richland, Wash.
2,936,363	Apparatus and Method for Arc Welding	R. A. Noland, Chicago, and C. C. Stone, ... dale, Ill.
2,936,372	Radiation Dosimeter	W. R. Balkwell, Jr., San Francisco, and G. ... Adams, Jr., Larkspur, Calif.
2,936,401	Radiation Detector	H. N. Wilson, Oak Ridge, and F. M. G... Morris, Tenn.
2,937,438	Method for Joining Aluminum to Stainless Steel.	L. C. Lemon, Richland, Wash.
2,937,654	Tube Shearing Valve	L. B. Wilner, Los Alamos, N. Mex.
2,937,924	Separation of Plutonium from Fission Products by a Colloid Removal Process.	J. Schubert, Chicago, Ill.
2,937,925	Solvent Extraction Process for Uranium from Chloride Solutions.	C. A. Blake, Jr. and K. B. Brown, Oak Ri... Tenn.; D. E. Horner, Clinton, Tenn.
2,937,939	Method of Producing Niobium Metal	H. A. Wilhelm and E. R. Stevens, Ames, Io...
2,937,981	Suppression of Water Decomposition	A. O. Allen, Shoreham, N.Y.; C. J. H... anadel, Oak Ridge, Tenn.
2,937,982	Method of Making UO_2-Bi Slurries	H. T. Hahn, Richland, Wash.
2,937,984	Control Rod Drive	R. A. Chapellier, Whitestone, N.Y.
2,938,121	Personnel Neutron Dosimeter	J. J. Fitzgerald, Latham, and C. G. Det... Jr., Scotia, N.Y.
2,938,768	Method of Separating Pu from Metathesizing $BiPO_4$ Carrier.	W. J. Know, New Haven, Conn.; S. ... Thompson, Richmond, Calif.
2,938,769	Separation of Hafnium from Zirconium	L. G. Overholser, C. J. Barton, Sr. and J. ... Ramsey, Oak Ridge, Tenn.
2,938,784	Nuclear Fuel Composition	F. H. Spedding and H. A. Wilhelm, Am... Iowa
2,938,791	Method of Producing Shaped Bodies from Powdered Metals.	A. Blainey, London, England.
2,938,807	Method of Making Refractory Bodies	J. C. Anderson, Niagara Falls, N.Y.
2,938,844	Neutronic Reactor Counter Method and System.	C. B. Graham and I. Spiewak, Oak Ri... Tenn.
2,938,845	Superheating in a Boiling Water Reactor	M. Treshow, Hinsdale, Ill.
2,938,846	Fuel Element Fabrication Method	J. N. Hix, Kingston, and J. E. Cunningham, Oak Ridge, Tenn.; G. E. Cooley, McM... ville, Tenn.
2,938,998	High Pressure Dies	W. B. Wilson, Columbus, Ohio.
2,939,633	Automatic Counter	H. P. Robinson, Lafayette, Calif.
2,939,803	Method of Impregnating a Porous Material	G. N. Steele, El Segundo, Calif.
2,940,819	Concentration Process for Plutonium Ions, in an Oxidation State not Greater than +4, in Aqueous Acid Solution.	G. T. Seaborg, Lafayette, and S. G. Thom... Richmond, Calif.
2,940,915	High Temperature, High Power Heterogeneous Nuclear Reactor.	R. P. Hammond, H. M. Busey and W. ... Wykoff, Los Alamos, N. Mex.
2,941,933	Fuel Element for Nuclear Reactor	W. E. Roake, E. A. Evans and D. W. R... Richland, Wash.
2,942,109	Scintillation Spectrometer	P. R. Bell and J. E. Francis, Oak Ridge, Ten...
2,942,116	Neutron Absorption and Shielding Device	I. R. Axelrad, Pittsburgh, Pa.
2,942,736	Crane Positioning Apparatus	W. Landsiedel, Glen Head, H. Wolff, Merr... N.Y.
2,942,937	Adsorption-Bismuth Phosphate Method for Separating Phosphate.	E. R. Russell, Columbia, S.C.; A. W. A... son, Inglewood, Calif., G. E. Boyd, Oa... Ridge, Tenn.
2,942,938	Method of Dissolving Massive Plutonium	J. F. Facer and W. L. Lyon, Richland, W...
2,942,939	Separation of Plutonium Values from Other Metal Values in Aqueous Solutions by Selective Complexing and Adsorption.	R. H. Beaton, Richland, Wash.

5006922

Patent No.	Title	Patentee
…943	Process for Separating Iodine 132 from Fission Products.	M.W. Green, Bellport, N.Y., G. Samos, Lutherville, Md.; W. D. Tucker Sayville, N.Y.
…944	Process of Preparing Zirconium Oxychloride	H. A. Wilhelm and M. L. Andrews, Ames, Iowa.
…965	Method of Separating Uranium from Alloys	P. Chiotti and H. E. Shoemaker, Ames, Iowa.
…195	Heating and Cooling System for Calutron	A. M. Starr, Piedmont, Calif.
…275	Transformer for Joining Unbalanced to Balanced Transmission Means.	B. J. Bittner and R. H. Opperman, Albuquerque, N. Mex.
…921	Catalytic Recombiner for a Nuclear Reactor	L. D. P. King, Los Alamos, N. Mex.
…258	Dual-Ridge Antenna	D. K. Yearout, Sandia Park, and H. L. Jergins, Albuquerque, N. Mex.
…573	Single-Step Conversion UO_3 to UF_4	J. E. Moore, Pittsburgh, Pa.
…293	Process for Jacketing a Core	G. A. Last, Bountiful, Utah.
…740	Ruthenium Decontamination Method	A. T. Gresky, Oak Ridge, Tenn.
…793	Process for Coloring Diamonds	R. A. Dugdale, Harwell, England.
…794	Neutronic Reactor Operational Method and Core System.	C. E. Winters, C. B. Graham, J. S. Culver and R. H. Wilson, Oak Ridge, Tenn.
…972	Ion Source	C. W. Blue, Knoxville, and J. S. Luce, Oak Ridge, Tenn.
…699	Process of Impregnating Graphite with a Uranium Compound.	M. C. Sanz, Los Angeles, R. R. Randolph, Bellflower, and C. Starr, Pacific Palisades, Calif.
…914	Apparatus for Producing and Manipulating Plasmas.	S. A. Colgate, Livermore, J. P. Ferguson, Los Altos, H. P. Furth, Berkeley, and R. E. Wright, Hayward, Calif.
…080	Method of Making Fuel Elements	L. W. Kates, Hempstead, and R. W. Campbell, Malverne, N.Y.; R. H. W. Heartel, Cranford, N.J.
…465	Means and Method for Producing a Vacuum	M. A. Otavka, Chicago, Ill.
…471	Centrifuge End Cap	J. W. Beams, Charlottesville, Va.; L. B. Snoddy (deceased).
…472	Centrifuge Apparatus	C. Skarstrom, Pearl River, and K. Cohen, New York, N.Y.; and H. C. Urey, Leonia, N.J.
…601	Complex Fluorides of Plutonium and an Alkali Metal.	G. T. Seaborg, Lafayette, Calif.
…621	Ternary Alloys of Uranium, Columbium, and Zirconium.	F. G. Foote, Chicago, Ill.
…676	Method of Making Wire Fuel Elements	J. L. Zambrow, Bayside, N.Y.
…774	Preparation of Alkyl Pyrophosphate Extractants.	C. A. Levine, Concord, Calif., W. E. Skiens, Seattle, Wash. and G. R. Moore, Oakland, Calif.
[illegible]	Control for Isotope Separating Apparatus	H. W. Brackney, Bronxville, N.Y.
…902	Magnetic Grid	R. F. Post, Walnut Creek, Calif.
…572	Centrifuges	J. W. Beams, Charlottesville, Va. and L. B. Snoddy (deceased).
…586	Fused Salt Process for Recovery of Values from Used Nuclear Reactor Fuels.	R. H. Moore, Richland, Wash.
…045	Housings and Mountings for Centrifuges	F. C. Rushing, Pittsburgh, Pa.
[illegible]	Loading and Unloading Device	M. Treshow, Hinsdale, Ill.
[illegible]	Method of Protecting Tantalum Crucibles against Reaction with Molten Uranium.	H. M. Feder, Park Forest, and N. R. Chellew, Joliet, Ill.
…414	Self-Regulating Boiling-Water Nuclear Reactors.	J. A. Ransohoff, Wash., D.C.; J. D. Plawchan, San Rafael, Calif.
…416	Concentric Tubular Fuel Element	C. W. Wheelock, Canoga Park, Calif.
…166	Method for Separation of Plutonium from Uranium and Fission Products by Solvent Extraction.	G. T. Seaborg, Lafayette, Calif.; W. J. Blaedel, Madison, Wis.; M. T. Walling, Jr., Richland, Wash.
…167	Method of Inhibiting Corrosion in Uranyl Sulfate Solutions.	E. G. Bohlmann, Concord, and J. C. Griess, Jr., Oak Ridge, Tenn.
…168	Concentration and Decontamination of Solutions Containing Plutonium Values by Bismuth Phosphate Carrier Precipitation Methods.	G. T. Seaborg, Lafayette, and S. G. Thompson, Richmond, Calif.
[illegible]	Method of Suppressing UAl_4 Formation in U-Al Alloys.	M. L. Picklesimer, Knoxville, and W. C. Thurber, Oak Ridge, Tenn.
[illegible]	Mass Spectrometer	F. A. White, Madison, Wis.
[illegible]	Heat Transfer Method	W. R. Gambill, Oak Ridge, and N. D. Greene, La Jolla, Calif.
[illegible]	Reduction of Fluoride to Metal	O. N. Carlson, F. A. Schmidt and F. H. Spedding, Ames, Iowa.
[illegible]	Plutonium-Zirconium Alloys	F. W. Schonfeld and J. T. Waber, Los Almos, N. Mex.
[illegible]	Electrodeposition of Neptunium	G. T. Seaborg, Lafayette, Calif.; A. C. Wahl, Sante Fe, N. Mex.
[illegible]	Method for Electrodepositing Polonium	R. F. Wehrmann, Waukegan, Ill.
[illegible]	Method of Producing U^{233}	G. T. Seaborg, Lafayette, Calif.; R. W. Stoughton, Oak Ridge, Tenn.
[illegible]	Radiation Wave Detection	L. F. Wouters, Hayward, Calif.
[illegible]	Sampling Oscilloscope	R. M. Sugarman, E. Patchogue, N.Y.
[illegible]	Zero-Time Indicator	H. H. Sander, Albuquerque, N. Mex.

Patent No.	Title	Patentee
2,951,448	Centrifugal Pump and Shaft Sealing Means	F. C. Rushing, Pittsburgh, Pa.
2,951,729	Gas Bearing	C. W. Skarstrom, Pearl River, N.Y.
2,951,730	Cushioned Bearing	F. C. Rushing, Pittsburgh, Pa.
2,951,731	Centrifuges	F. C. Rushing, Pittsburgh, Pa.
2,951,740	Processing of Neutron-Irradiated Uranium	H. H. Hopkins, Jr., Richland, Wash.
2,951,793	Electrolysis of Thorium and Uranium	W. N. Hansen, Reseda, Calif.
2,952,012	Analog-to-Digital Data Converter	G. W. Rodgers, D. P. Anderson, G. R. B... and L. H. Minnear, Albuquerque, N. Mex. J. E. Althouse, San Diego, Calif.
2,952,056	Apparatus and Method for Injection Casting	A. B. Shuck, Wheaton, Ill.
2,952,139	Refrigeration System Especially for Very Low Temperature.	P. B. Kennedy, Berkeley, and H. R. S... Oakland, Calif.
2,952,511	Separation of Plutonium Values from Uranium and Fission Product Values.	A. G. Maddock, Montreal, Canada; A. ... Booth, Chalk River, Canada.
2,952,535	Sintering Metal Oxides	W. E. Roake, Richland, Wash.
2,952,600	Neutronic Reactor Control Element	H. W. Newson, Durham, N.C.
2,952,601	Nuclear Conversion Apparatus	G. T. Seaborg, Lafayette, Calif.
2,952,603	Jacketed Fissionable Member	E. R. Boller, Marion, Ind.; J. W. Rob... Pasadena, Tex.
2,952,640	Cesium Recovery from Aqueous Solutions	C. A. Goodall, Torrance, Calif.
2,952,641	Strontium Precipitation	T. R. McKenzie, Richland, Wash.
2,952,802	Electromagnetic Release Mechanism	C. Michelson, Oak Ridge, Tenn.
2,953,510	Neutronic Reactor	H. L. Anderson, Chicago, Ill.
2,953,918	Range Increaser for Pneumatic Gauges	A. H. Fowler and G. B. Seaborn, Jr., Oak Ridge, Tenn.
2,953,993	Pump Construction	G. Strickland, Blue Point, N.Y.; F. L. H... Sayville, N.Y. and H. T. White, M... Park, Pa.
2,954,273	Process of Eliminating Hydrogen Peroxide in Solutions Containing Plutonium Values.	J. G. Barrick, Oak Ridge, Tenn.; B. A. F... El Cerrito, Calif.
2,954,335	Neutronic Reactor	E. P. Wigner, Princeton, N.J.
2,954,421	Low-Loss Cable and Method of Fabrication	R. L. McCarthy, Westtown, Pa.; J. M. ... Newark, Del.
2,955,913	Separation of Rare Earths by Solvent Extraction.	D. F. Peppard, Oak Park, and G. W. M... Chicago, Ill.
2,955,937	Oxidation Resistant Chromium Alloy	J. A. McGurty, Cincinnati; J. F. C... Hamilton, and V. P. Calkins, W... Ohio.
2,955,997	Irradiation Method of Converting Organic Compounds.	A. O. Allen, Shoreham, and J. M. C... Beacon, N.Y.
2,956,169	Ion Pulse Generation	R. F. King, Knoxville, and C. D. M... Ridge, Tenn.; V. E. Parker, Baton R... La.
2,956,195	Hollow Carbon Arc Discharge	J. S. Luce, Oak Ridge, Tenn.
2,956,201	Particle Accelerator and Method of Controlling the Temperature Thereof.	R. B. Neal and W. J. Gallagher, Menlo Park, Calif.
2,956,771	Mass Spectrometer Leak	W. R. Shields, Washington, D.C.
2,956,858	Method of Separting Rare Earths by Ion Exchange.	F. H. Spedding and J. E. Powell, Ames, Iowa
2,957,080	Method and Means for Radiation Dosimetry	J. W. Schulte and J. F. Suttle, Los Alamos, N. Mex.
2,957,096	Neutron Source	N. K. Bernander and R. J. Jones, Oak Ridge, Tenn.
2,957,210	Cave Window	M. Levenson, Downers Grove, Ill.
2,957,709	Sealing Means for Relatively Rotatable Members.	C. W. Skarstrom, Pearl River, N.Y.
2,958,779	Scintillation Exposure Rate Detector	Ward G. Spears, Richland, Wash.
2,959,326	Fluid Controlling Means	H. N. Pouliot, Rochester, Minn.
2,960,398	Direct Ingot Process for Producing Uranium	W. M. Leaders, Webster Groves, and ... Knecht, Kirkwood, Mo.
2,960,653	Pulsed Indicator Circuit	W. I. Linlor, Livermore, and Q. A. ... Berkeley, Calif.
2,960,687	Coincidence Occurrence Indicator	G. H. Robison, N. Merrick, N.Y.; J. F. ...son, Neptune, N.J.
2,961,159	Multi-Channel Electric Pulse Height Analyser with Binary Coded Decimal Display.	J. D. Gallagher and J. L. McKibben, Los Alamos, N. Mex.
2,961,390	Method of Preparing Uranium, Thorium, or Plutonium Oxides in Liquid Bismuth.	J. K. Davidson and W. L. Robb, Schenectady, N.Y.; O. N. Salmon, Oneida, N.Y.
2,961,391	Water Boiler Reactor	L. D. P. King, Los Alamos, N. Mex.
2,961,392	Neutronic Reactors	E. P. Wigner, Chicago, Ill.
2,961,393	Power Breeder Reactor	H. O. Monson, Elmhurst, Ill.
2,961,415	Settable Neutron Radiation Shielding Material.	I. R. Axelrad, Pittsburgh, Pa.
2,961,558	Co-axial Discharges	J. S. Luce, Oak Ridge, Tenn.; L. F. ... N. Andover, Mass.
2,961,559	Methods and Means for Obtaining Hydromagnetically accelerated Plasma Jet.	J. Marshall, Jr., Los Alamos, N. Mex.
2,961,652	Radio Altimeters	R. W. Bogle, Silver Spring, Md.
2,961,653	Radio Ranging Devices	R. W. Bogle, Silver Spring, Md.
2,962,351	Treatment for Improving the Operation of Strong Base Anion Exchange Resins.	P. C. Stevenson, Livermore, Calif.

PUBLICATION

The Atomic Energy
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APPENDIX 6

Publications of the U.S. Atomic Energy Commission

The Atomic Energy Commission sponsors the publication of books, abstract journals, reviews, and research and development reports. In addition, the Commission encourages the publication of research results in the established scientific and technical journals. AEC research and development reports, not published elsewhere, are sold by the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Price lists of these reports are available from the Office of Technical Services. Collections of unclassified AEC publications are deposited in 85 libraries in the United States and 83 countries abroad. *Nuclear Science Abstracts*, the Commission's abstract journal, announces and indexes newly released AEC reports, in the course of covering the world-wide atomic energy literature.

SELECTED RECENT PUBLICATIONS

Advanced Pressurized Water Reactor Study (TID-8502, Parts 1, 2 & 3). U.S. Atomic Energy Commission, 1959. Total pages 1075. Total price $10.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Another of the four advanced design studies initiated in 1958 to assess the feasibility of power generation through the use of certain types of nuclear reactors. This study deals with the advanced pressurized water reactor. Part 1 "Phase I Report"; Part 2 "Appendixes to Phase I Report"; and Part 3 "235 mw Coal-fired Generating Plant".

AEC and Contractor SS Materials Management Meeting, May 25–28, 1959 (TID-7581) U.S. Atomic Energy Commission, 1959. 228 pages. $2.25. (Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.) This meeting covered a broad range of problems encountered in the AEC and SS Materials Management work. The papers prepared and presented by the Atomic Energy Commission and contractor personnel covered such topics as recovery of source and special nuclear materials; determination of a factor assay for uranium reguli; limits of error in weighing; and isotopic analyses by use of transistorized scintillation spectrometer.

A Summary and Evaluation Report of Four Power Reactor Design Studies (TID-8504). U.S. Atomic Energy Commission, 1959. 60 pages. 60 cents. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report summarizes and evaluates the four power reactor design and engineering studies completed for the AEC under Public Law 85-590. The report gives economic and technical conclusions, comparative cost analysis, technical analysis of reference designs, assumptions and data.

Boiling Water Reactors.[1] Andrew W. Kramer, Editor. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 563 pages. $8.50. This reference

[1] U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

work on the history and technology of boiling water reactors was prepared under the auspices of the Argonne National Laboratory, with the coopera-tion of the many scientists and engineers there who conceived and developed this type of reactor. It presents a brief history of the boiling water concept and of the early experiments of the Argonne Laboratory, including the devel-opment and operation of the Experimental Boiling Water Reactor. The var-ious BORAX experiments are described in detail. A thorough explanation is given of the physics underlying the design of the reactor, and a lengthy description of the General Electric Co.'s Vallecitos plant is included. The book concludes with a discussion of present and future research and develop-ment programs for boiling reactors.

Boiling Water Reactor Study (TID–8500, Parts 1, 2 & 3). U.S. Atomic Energy Commission, 1959. Total pages 522. Total price $5.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This is one of four advanced design studies initiated in 1958 to assess the feasibility of power generation through the use of certain type of nuclear reactors. This study deals with the boiling water reactor. Part 1 (Vols. 1 and 2) is entitled "306 mw Power Reactor Conceptual Design"; Part 2 is entitled "Separate Studies"; and Part 3 is entitled "326 mw Case-fired Installation".

Civilian Power Reactor Program. U.S. Atomic Energy Commission. Wash-ington, U.S. Government Printing Office, 1960. (Parts separately numbered and priced).

Part I. Summary of Technical and Economic Status as of 1959. (TID-8516). $1.00.

Part II. Economic Potential and Development Program as of 1959. (TID-8517). 70 cents.

Part III, Book 1. Status Report on Fast Reactors as of 1959. (TID-8518(1)). $1.00.

Part III, Book 2. Status Report on Pressurized Water Reactors as of 1959 (TID–8518(2)). $1.25.

Part III, Book 3. Status Report on Aqueous Homogeneous Reactors as of 1959. (TID–8518(3)). $1.25.

Part III, Book 4. Status Report on Heavy Water Moderated Reactors as of 1959. (TID–8518(4)). $2.25.

Part III, Book 5. Status Report on Boiling Water Reactor Technology as of 1959. (TID–8518(5)). 60 cents.

Part III, Book 6. Status Report on Sodium Graphite Reactors as of 1959 (TID–8518(6)). $1.00.

Part III, Book 7. Status Report on Organic-Cooled Power Reactors as of 1959. (TID–8518(7)). $2.25.

Part III. Book 8. Status Report on Gas-Cooled Reactors as of 1959. TID-8518(8)). 55 cents.

Part IV. Plans for Development as of February 1960. (TID-8519). [illegible] cents.

These reports survey the current status of the AEC's program for the use of reactors to produce power for civilian purposes. All major reactor concepts that are currently being developed under this program are included.

Community Impact of Peaceful Applications of Atomic Energy. (TID–[illegible]) Harold Sandbank. U.S. Atomic Energy Commission, 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 Atomic Energy Commission, and it is concerned with such areas as: the extent of peaceful uses of nuclear materials; effects on localities and local government functions; programs of federal and state agencies and other groups active in this field; standards and requirements controlling the use of nuclear materials; and sources of information and assistance available to communities and local officials.

Compendium of Information for Use in Controlling Radiation Emergencies. TID–8206 (Rev.) Compiled and Edited by Allen Brodsky and G. Victor Beard. U.S. Atomic Energy Commission, 1960. 100 pages. $1.00. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.). This compilation summarizes information which may be needed by trained personnel in exercising rapid and professional judgment during the period immediately following an unexpected radiological incident. Such topics as past experiences in radiation accidents, the shipment of of radioactive materials, the control of fires during radiation emergencies, the results of fuel element burn tests, and monitoring activities are reviewed and discussed.

Conference on the Status of Radiation Effects Research on Structural Materials and the Implications to Reactor Design. (TID–7588) U.S. Atomic Energy Commission, 1959. 306 pages. $4.00. (Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.) This is the published proceedings of the October 1959 meeting of the AEC Welding [illegible] held at Chicago, Ill. The discussion was confined almost exclusively to two aspects of the problem: (1) the significance and value of accumulated data and (2) the development of a research program which would be productive of information useful for design purposes. Some of the topics covered are: techniques for measuring reactor neutron spectra; radiation effects in ferritic steels; practical aspects of reactor pressure vessel design; and the code aspects.

Controlled Thermonuclear Reactions. Edited by Samuel Glasstone and Ralph H. Lovberg. New York, D. Van Nostrand Co., Inc., 1960. 523 pages. $5.60. The principles of controlled thermonuclear reactions are presented. Thermonuclear processes are introduced so as to be understandable by physicists and engineers who have no background in this field. Fundamentals and techniques of thermonuclear research are explained completely enough to supply the foundation needed by one setting out in a research program. The book describes the conditions that are required for controlled thermonuclear reactions and possible routes by which these conditions may be achieved. Plasma theory is discussed employing mathematics of adequate level. Equipment such as pinch and mirror devices is described, together with stellarator and other methods of creating and heating plasma. Experimental techniques employed in controlled thermonuclear research also receive attention.

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Costs of Nuclear Power (TID–8506). U.S. Atomic Energy Commission, 1[illegible]. 29 pages. 50 cents. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report is concerned only with stationary nuclear plants that are designed primarily for the generation of electricity. It considers data on the cost of electricity from those plants that are presently in operation, being built, or planned for early construction. Major topics covered are capital costs, annual fixed charges, fuel-cycle costs, inventory charges, cost of operation and maintenance and total cost of nuclear power.

Cryogenic Engineering. Russell B. Scott. Princeton, N.J., D. Van Nostrand Co., 1959. 368 pages. $5.60. The book covers the entire range of cryogenic engineering and is intended primarily for students, engineers, and scientists who are unfamiliar with low-temperature techniques. It outlines the practical aspects of cryogenic processes and equipment, at the same time providing a careful discussion of the underlying theory. The book describes, in easily understood form, the development and improvement of low-temperature processes and equipment; the determination of the physical properties of materials used to produce, maintain, and utilize low temperatures; and the practical application of low-temperature techniques and processes.

3 *Design Studies for Selecting a Prototype Reactor for a Nuclear Tanker* (TID–8528). U.S. Atomic Energy Commission, 1960. 67 pages. $1.25 (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This study reports on the findings of an evaluation group convened to consider three nuclear-powered tanker design and engineering studies carried out in accordance with Public Law 86–50. This study was conducted to review water-reactor technology in order to determine the relative merit of the various water-reactor propulsion concepts which could be applied to a tanker and their potential to achieve economic operation in the relatively near future. A summary and a comparative tabulation of the cost estimates for the different systems are presented.

The Effects of Nuclear Weapons. Edited by Samuel Glasstone. Washington, U.S. Government Printing Office, 1957. 579 pages. $2.00. A publication prepared by the Armed Forces Special Weapons Project of the Department of Defense at the request of the Atomic Energy Commission. It updates information appearing in *The Effects of Atomic Weapons*, 1950, and provides the latest knowledge of weapons effects obtained by observation and experiment in laboratory work and nuclear test detonations since 1950. It also includes data on radiological, blast and heat effects of nuclear detonations. Requirements of the Federal Civil Defense Administration for information necessary for civil defense planning are taken into account.

Fluid Fuel Reactor.[1] Edited by J. A. Lane, H. G. MacPherson, and Frank Maslan. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. [illegible] pages. $11.50. Comprehensive discussion of three basic types of fluid fuel reactors which summarizes results of research carried on in the United States for almost 10 years. A unique feature of this work is its approach to

[1] A U.S. Government presentation volume for the International Conference on Peaceful Uses of Atomic Energy, Geneva, 1958.

subject from the chemical standpoint rather than from the point of view of mechanical engineering.

Fossil Fuels in the Future (TID-8209). Milton F. Sear. U.S. Atomic Energy Commission, 1960. 63 pages. 75 cents. (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 they 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.

Heavy Water Moderated Power Reactor Plant (TID-8503, Parts 1 and 2). U.S. Atomic Energy Commission, 1959. Total pages 1136. Total price $11.25. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) Another of the four advanced design studies initiated in 1958 to assess the feasibility of power generation through the use of certain types of nuclear reactors. This study deals with the heavy water moderated power reactor. Part 1 "Design Study"; Part 2 "Preliminary Design of the Prototype Plant".

International Conference on the Preservation of Foods by Ionizing Radiations (TID-7585). U.S. Atomic Energy Commission. 1959. 294 pages. $4.00. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This is the published proceedings of a conference sponsored by Massachusetts Institute of Technology, the U.S. Atomic Energy Commission, and the International Atomic Energy Agency held at Cambridge, Massachusetts, July 1959. Some of the topics covered are: reactors as radiation sources; problems of underdeveloped countries; direct and indirect effects of radiations; radiological safety; and electron beam sterilization.

Living With Radiation; the Problems of the Nuclear Age for the Layman. Part I. Fundamentals. Part II. Fire Service Problems. Prepared by Francis L. Brannigan. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1960. Part I, 65 pages. 45 cents. Part II, 199 pages. [illegible]

These publications present what has been found by field experience to be a practical approach to the understanding of the industrial radiation hazard. They are intended for the layman who requires a basic understanding of the radiation problem to his field. Part II is of interest not only to professional firemen but also to those charged with the control of radiation hazards.

Los Alamos Handbook of Radiation Monitoring. (LA-1835, 3d Ed.). Compiled and edited by Jerome E. Dummer, Jr., U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1959. 180 pages. 60 cents. An entirely rewritten and updated version of the "General Handbook for Radiation Monitoring" which was prepared by Los Alamos Scientific Laboratory to provide the Monitoring Group at Los Alamos with the basic data which would be available to them at all times. The book is pocket size and is designed to serve the purposes of the Los Alamos Scientific Laboratory. Some of the topics covered are monitor's check list, emergency monitoring, LASL radiation safety policies, decontamination, table of isotopes, monitoring instru-ments, alpha, beta-gamma neutron and tritium monitoring and air sampling.

Management of Nuclear Materials. Edited by Ralph F. Lumb. New York, D. Van Nostrand Co., Inc., 1960. 516 pages. $16.50. This book presents techniques used in the management and control of special nuclear materials, i.e., (1) obtaining data by sampling, weighing, and analyzing analytically; (2) taking, verifying, and maintaining inventory; (3) recording data on individual forms and periodic reports; and (4) controlling data flow and data utilization. A brief description of the processes from ore buying through scrap recovery from reactor operations is given as background. The book will be of interest to companies presently processing nuclear materials and companies interested in entering the field and wanting to determine what is involved in accounting for nuclear materials. The book includes a discussion of the philosophy of nuclear materials and management, a general description of records and statistical techniques, and detailed nuclear manage-ment considerations of each process.

Metallurgy and Fabrication of Fuel Elements. A. R. Kaufman and others of Nuclear Metals, Inc. New York, Interscience Publishers, Inc. (In Press.) Metallurgists and fabrication specialists interested in the production of nuclear reactor fuel elements will find this volume indispensable. Reactor engineers will obtain from it much useful information for conceptual design purposes. The book describes all aspects of fuel element fabrication: mate-rials, production, assembly, and inspection. The nature of nuclear reactors, the conditions which fuel elements will encounter in reactors, the important physics and engineering design factors, the metallurgy of uranium, thorium, plutonium, and their alloys plus ceramics and cermets, the choice of cladding material, the manufacturing procedures for producing fuel elements from the various components and for assembling them into clusters, and useful in-spection methods are discussed. A brief discussion of fuel element economics and reprocessing problems is included. A short chapter on fluid fuels pro-vides perspective on homogeneous reactors. Also included are a glossary of terms and phase diagrams of uranium, thorium, plutonium, and their alloys.

The Metallurgy of Hafnium. Edited by D. E. Thomas and E. T. Hayes. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1960. 384 pages. $1.50. A reference work dealing with the science and technology of the extraction, fabrication, properties, and uses of the metal hafnium. Individual chapters present information generally unavailable previously. The book, illustrated by 85 line drawings and photographs, follows the natural sequence of functions involved in processing the ore through to a finished product.

Midwestern Conference on the Industrial Uses of Isotopes (TID-7571). U.S. Atomic Energy Commission, 1959. 270 pages. $2.75. (Available from Office of Technical Services, Department of Commerce, Washington 25, D.C.) A conference on industrial uses of isotopes was held at Manhattan, Kansas, February 25 and 26, 1959. Some representative papers covered industrial application of Cobalt 60; radioisotopes as sources of electrical power; radio-isotopes in the petroleum industry; radioisotopes for radiography of ...

ments; and castings ... applications.

Neutron Cross Sections ... and Robert B. Schwa... Government Printing ... vised and updated edi... sections. It is intend... book contains tables ... plots of curves of tota... data has been careful... oratories throughout t...

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Nuclear Reactor Experi... Nostrand Co., Inc., 1... 40 experiments inv... measurements.

Nuclear Reactor Metall... Murphy, Princeton, N... A volume of course n... International School ... Laboratory.

Oklahoma Conference— ... Energy Commission, ... tendent of Documents ... Comprises a collectio... Radioisotopes in Agri... such major topics as ... study of genetic mat...

Organic Cooled Power ... Atomic Energy Com... (Available from Offic... Washington 25, D.C.) ... initiated in 1958 to as... of certain types of ... Cooled Power Reacto... "Reactor Concept E... Design"; Part 5 "300 ments; and castings and radioactivity oil well logging and oil field tracer applications.

Neutron Cross Sections (BNL–325, Second Edition). Edited by Donald J. Hughes and Robert B. Schwartz, Brookhaven National Laboratory. Washington, U.S. Government Printing Office, 1958. 373 pages. $4.50. This is a completely revised and updated edition of experimentally determined values of neutron cross sections. It is intended for physicists, chemists, and reactor engineers. The book contains tables of thermal cross sections and resonance parameters and plots of curves of total and partial cross sections as functions of energy. The data has been carefully evaluated and the most recent results from many laboratories throughout the world are included.

1959 Nuclear Data Tables. Edited by K. Way. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1959. 151 pages. $1.00. The 1959 Nuclear Data Tables is the successor to the New Nuclear Data Cumulations which were published from 1952 through 1957. A change in the method of presenting and cumulating experimental results for individual nuclei has made it possible to omit from an annual volume data organized according to nucleus and to devote the yearbook instead to information which has been systematized according to some nuclear property or some specific topic. The book presents 10 compilations containing new data in fields of low-energy nuclear physics appearing in the literature during the periods indicated.

Nuclear Reactor Experiments. Edited by J. B. Hoag. Princeton, N.J., D. Van Nostrand Co., Inc., 1958. 480 pages. $6.75. A laboratory manual detailing the experiments involving the theory and practice of fission reactor measurements.

Nuclear Reactor Metallurgy. Edited by Walter D. Wilkinson and William F. Murphy, Princeton, N.J., D. Van Nostrand Co., Inc., 1958. 382 pages. $5.60. A volume of course material in applied reactor metallurgy developed at the International School of Nuclear Science and Engineering of Argonne National Laboratory.

Oklahoma Conference—Radioisotopes In Agriculture (TID–7578). U.S. Atomic Energy Commission, 1959. 292 pages. $2.00. (Available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.) Comprises a collection of papers presented at the April 1959 Conference on Radioisotopes in Agriculture held at Oklahoma State University and treats such major topics as radioiodine and thyroid functions; radioisotpes in the study of genetic materials; ruminology and medical applications.

Organic Cooled Power Reactor Study (TID–8501, Parts 1, 2, 3, 4 & 5). U.S. Atomic Energy Commission, 1959. Total pages 1500. Total price $15.00. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This is another of the four advanced design studies initiated in 1958 to assess the feasibility of power generation through the use of certain types of nuclear reactors. This study deals with the Organic-Cooled Power Reactor. Part 1 is entitled "Summary of Study"; Part 3 "Reactor Concept Evaluation"; Part 4 "75 mw Power Plant Conceptual Design"; Part 5 "300 mw Coal-fired Power Plant Comparison Study".

Physical Metallurgy of Uranium.[1] A. N. Holden. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 272 pages. $5.75. A comprehensive and unified treatment of the physical metallurgy of uranium, which summarizes, correlates, and critically evaluates the wealth of information that has become available in the field during the past several years. Although important experimental techniques and results are thoroughly described, emphasis has been placed upon interpretation in terms of fundamental properties and mechanisms.

The Physics of Intermediate Spectrum Reactors. Edited by J. R. Stehn. U.S. Atomic Energy Commission, Washington, 1959. 487 pages. $3.00 (paper bound). U.S. Government Printing Office. This handbook is the third volume of the Naval Reactors Physics Handbook, written for persons having knowledge of the physics of nuclear reactors. It is an accumulation of physics information obtained from the work on intermediate-spectrum reactors at Knolls Atomic Power Laboratory. Material covers the importance of the properties of critical assemblies and of techniques for obtaining related experimental information; the uses of critical assemblies and reactor theory in making and testing predictions of reactivity variation during operation; the spread of heat generation in space and time; nuclear effects resulting from presence of beryllium or sodium in the reactor; the transient or near transient behavior of intermediate reactors.

Potential Nonnuclear Uses for Depleted Uranium (TID–8203). Harlan W. Nelson and Roland L. Carmichael. U.S. Atomic Energy Commission, [illegible]. 58 pages. 75 cents. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report presents potential uses of depleted uranium in the fields of semiconductors, cathodic protection, ion exchange, heavy-density media for mineral concentration, and metallurgy. The sections involving metallurgical applications, radiation shielding, and ceramic uses are presented in detail. Also included are sections devoted to the past industrial uses for uranium and to the health and safety aspects of handling depleted uranium in the industrial shop.

Principles of Nuclear Reactor Engineering. Samuel Glasstone. New York, D. Van Nostrand Co., 1955. 861 pages. $7.95. A text written for the student and the practicing engineer. An overall review of the fundamental scientific principles upon which reactor engineering is based.

Proceedings of the AEC Symposium for Chemical Processing of Irradiated Fuels From Power, Test, and Research Reactors (TID–7583). U.S. Atomic Energy Commission, 1959. 458 pages. $4.50. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A review is presented in this symposium of the technology currently available from processing spent fuels from research, test, and power reactors. The twenty-one papers included reports from the General Electric Co., Hanford Atomic Products Operation, the Phillips Petroleum Co. Atomic Energy Division, the E. I. du Pont de Nemours and Co., and the Oak Ridge National Laboratory.

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[1] A U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

Proceedings of a Confe
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Proceedings of a Conference on the Theoretical Aspects of Controlled Fusion Research (TID-7582). U.S. Atomic Energy Commission, 1959. 232 pages. $2.00. (Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.) Comprises a compilation of papers given at the Gatlinburg Conference on theoretical aspects of controlled fusion research. Unlike the previous meeting at Gatlinburg, which covered all aspects of Sherwood, this meeting was limited to theoretical papers, and covered such topics as transport phenomena; waves in plasmas; stability; adiabatic invariants; and shock waves.

Proceedings of the 1959 Symposium on Low-Temperature Nuclear Process Heat (TID-7580). U.S. Atomic Energy Commission, 1959. 76 pages. $0.75. (Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.) These are papers given at a symposium conducted by the Atomic Energy Commission on the development and potential industrial uses of reactors for the production of low-temperature process heat. During the symposium attendees were asked to complete a questionnaire designed to elicit industry's interest in process heat reactors and the extent to which industry would participate in their development. A tabulation of the answers is included.

Project Sherwood—The U.S. Program in Controlled Fusion.[1] Amasa Bishop. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 228 pages. $5.75. Account of the extensive research and development undertaken by the U.S. Atomic Energy Commission for harnessing the energy of thermonuclear reactions. It presents a factual and readable account of Project Sherwood, including its origin, its development, its problems, and the outlook for its eventual success. The book describes the basic principles involved in a fusion reaction, and the various methods now being studied to control thermonuclear energy, with the hope of eventually producing net power.

Prospecting for Uranium. U.S. Atomic Energy Commission and U.S. Geological Survey. Revised January 1957. Washington, U.S. Government Printing Office, 1957. 217 pages. 75 cents. A nontechnical booklet describing the uranium-bearing minerals, where to look for them, and instruments to use in prospecting and in laboratory testing and analysis of ores. It contains six color plates of principal minerals. Laws, regulations, and price schedules for uranium-bearing ores are included.

Radiation: A Tool for Industry (ALI-52). U.S. Atomic Energy Commission, 1959. Washington, U.S. Government Printing Office. 414 pages. $2.50. (Available from the Office of Technical Services.) This one year survey of industrial applications of ionizing radiation, undertaken in 1958 by Arthur D. Little, Inc., is based on interviews with workers in the field and on analysis of selected literature. The survey revealed that ionizing radiation is not yet a processing tool of major importance to industry generally, however, because it has not yet demonstrated sufficient advantages over established methods of achieving a similar result. Skillfully oriented research and development will improve the likelihood of radiation becoming a tool of major importance for industry.

[1] U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

Radiation Biology and Medicine: Selected Reviews in the Life Sciences.[1] Edited by W. D. Claus. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 968 pages. $11.50. A review of advances in thought and research in the uses and effects of nuclear radiation in the life sciences in the United States. Chapters are included on basic mechanisms of biological reaction to radiation, mutational effects of radiation, mathematical biology, mammalian response to radiation, radiation safety, medical uses of atomic radiation, agricultural uses of radiation, tracer applications, instrumentation and dosimetry.

Radiations From Radioactive Atoms in Frequent Use. L. Slack and Katharine Way. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1959. 75 pages. 55 cents. This book is designed especially for scientists and technicians in the biological and medical sciences who are concerned with estimations and calculations of dose. Tables and graphs for each radioactive atom show explicitly the energies and intensities of the particle and electromagnetic radiations emitted both by the decay in nucleus and also by the orbital electrons in the rearrangements which follow the nuclear transformation. Auxiliary graphs are given on gamma ray dose rates, half-thickness values for gamma rays, electron ranges, average beta ray energies, fluorescence yields, L-shell vacancies per K-shell vacancy, etc.

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.)

Each monograph in the series is an up-to-date compilation of the latest available radiochemical information and procedures written by an expert on radiochemistry and is intended as a primary source of radiochemical information. 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.

The monographs are of interest not only to the radiochemist but also to geochemists, nuclear physicists, biochemists, nuclear engineers and workers in medicine, environmental health, fall-out analysis, activation analysis, and others having occasion to use radiochemical techniques.

Monographs on the following elements have been issued: Chromium; Rhodium; Molybdenum; Barium, Calcium, and Strontium; Zirconium and Hafnium; Astatine; Indium; Cadmium; Arsenic; Francium; Thorium; Fluorine, Chlorine, Bromine, and Iodine; Americium and Curium.

Radioisotopes at Work for Agriculture (SRIA–9). A. Gerlof Homan and Richard R. Tarrice. U.S. Atomic Energy Commission, 1959. 200 pages. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report has as its objectives to estimate the probable economic benefits from the use of radioisotopes in agriculture at present and in the future, and to present a detailed analysis of the current and probable future use for radioisotopes in agriculture. The investigation

[1] A U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

covered the use of radioisotopes in research in the fields of farm animal sciences and veterinary medicine, agricultural entomology, plant genetics, plant physiology, and soil sciences and water.

Radioisotopes in Industry (NYO–2977). John J. McMahon and Arnold Berman. U.S. Atomic Energy Commission, 1959. 136 pages. $2.75. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report, prepared by the National Industrial Conference Board for the Commission, is based on the experiences of 523 companies that have realized savings through the use of radioisotopes. Twenty types of industries.

Radioisotopes in Medicine (SRIA–13). Richard R. Tarrice and Mark S. Blumberg. U.S. Atomic Energy Commission, 1959. 180 pages. $3.00. (Available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This study, conducted by the Stanford Research Institute for the Atomic Energy Commission Office of Isotopes Development, had as its purpose a better understanding of the current position of radioisotope use in the field of medicine. Specific data is given on the medical research, diagnostic, and therapeutic uses of radioisotopes.

Radioisotopes in Science and Industry. U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office, 1960. 176 pages. $1.25. A detailed account of isotope utilization since the inception of the Commission's distribution program. Agriculture, medicine, and industry have benefited from the use of radioisotopes, and new applications are being developed.

Reactor Handbook (Second Edition). Prepared under contract with the United States Atomic Energy Commission. New York, Interscience Publishers, Inc. (Each volume priced separately.)

Volume I. *Materials.* Edited by C. R. Tipton, Jr., 1960. $36.50.
Volume II. *Fuel Reprocessing.* Edited by S. M. Stoller and R. B. Richards. (In press.)
Volume III. *Physics and Shielding.* Edited by H. Soodak and E. P. Blizard. (In press.)
Volume IV. *Engineering.* Edited by Stuart McLain. (In press.)

Published in four volumes, the Reactor Handbook will provide authoritative accounts of nuclear theory, data, hardware, and processes developed in atomic energy programs. Representing the efforts of several hundred authors and contributors the Handbook is intended as a desk reference for technical people engaged in research, development, and design. The process of gathering, evaluating, digesting, and organizing the information included in the four volumes was under the guidance of an Editorial Review Board composed of H. Brooks, P. F. Gast, J. P. Howe, S. Lawroski, M. C. Leverett, and W. H. Zinn, Chairman.

Report on Civilian Reactor Fuel Elements (TID–8505). U.S. Atomic Energy Commission, 1959. 191 pages. $1.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) A report prepared by the Civilian Reactor Fuel Element Review Group which was established by the division of Reactor Development to assist the AEC in the formulation of long range plans for the development of fuel element technology. The report contains the following sections: Major conclusions;

fuel problems of major reactor types; materials problems; supporting technology; and summary of conclusions.

Report of the Fluid Fuel Reactor Task Force (TID–8507). U.S. Atomic Energy Commission, 1959. 188 pages. $1.75. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This report was prepared by a task force composed of fifteen highly qualified engineers and scientists from the Atomic Energy Commission, its national laboratories and contractor organizations, and representatives of the architect-engineering and utility industry. The task force was organized and commenced to perform a critical evaluation of the three fluid fuel reactor concepts (Aqueous homogeneous—AHR, molton salt—MSR, and liquid metal fuel—LMFR) under development by the Commission. The report represents the group evaluation and judgment of the three fluid fuel reactor concepts.

The Shippingport Pressurized Water Reactor.[1] By personnel of the Naval Reactors Branch, Division of Reactor Development, U.S. Atomic Energy Commission; Bettis Plant Westinghouse Electric Corp.; and Duquesne Light Co. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 600 pages. $9.50. An account of the research and development for and construction of the first large-scale central station nuclear powerplant to be built and operated in the U.S. This is the basic sourcebook for this plant and its technology. For those who want more detailed information, selected references are given at the end of each chapter.

Sodium Graphite Reactors.[1] Chauncey Starr and R. W. Dickinson. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 304 pages. $6.50. A unified and coherent presentation of sodium graphite reactor technology. Emphasis has been placed on the design and development of the Sodium Reactor Experiment (SRE); however, information applicable to sodium graphite systems and in many cases, to reactor design in general is included. The Hallam Nuclear Power Facility, a full-scale sodium graphite plant on which construction has started, is described.

Solid Fuel Reactors.[1] By J. R. Dietrich and W. H. Zinn. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 864 pages. $10.75. Reviews our basic concepts, present status of development in the United States, and technical and economic outlooks in this country for five projected solid fuel nuclear power reactor types. Chapters are included on the fast-neutron power reactor; the experimental breeder reactor; the Enrico Fermi Atomic Power Plant; heavy-water power reactors; gas-cooled reactors, organic-cooled and moderated reactors; and plutonium recycling in thermal reactors.

Sourcebook on Atomic Energy, Second Edition (revised and updated). Samuel Glasstone. New York, D. Van Nostrand Co., 1958. 641 pages. $4.40. This is considered the standard sourcebook on atomic and nuclear science today. It presents a comprehensive technical description of the theory, history, development, and uses of atomic and nuclear energy. Chapters are included on the structure of the atom, radioactivity, isotopes, nuclear reactors, neutron research, acceleration of charged particles, new elements, radiation protection and health physics, and other phases of nuclear science.

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[1] A U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958.

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...posium on High Flux Materials Testing Reactors (TID–7584). U.S. Atomic Energy Commission, 1959. 447 pages. $4.50. (Available from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.) This is the published proceedings of the September 1959 meeting held in Brussels, Belgium. The papers cover the AEC test reactor program; the design and uses of high flux research and test reactors; design of loops for high flux reactors; safety principles in the instrumentation of reactors; and fast neutron dosimetry in research reactors.

...ching With Radioisotopes. U.S. Atomic Energy Commission, Washington, U.S. Government Printing Office, 1959. 60 pages. 40 cents. Based on materials submitted by teachers in many schools and colleges, this manual of experiments with radioisotopes was prepared to supplement and extend the initial publication, *Laboratory Experiments With Radioisotopes—For High School Demonstrations.* As an aid to teachers using the publication, Part I is an extensive introductory section that contains definitions and notes on equipment and techniques and gives special attention to proper procedures and safety. Part II gives 16 suggested experiments. Each experiment begins with pertinent questions and answers and each is written in an "open-ended" manner with the hope that variations will occur to teachers and students. Five appendixes are: Some References on Radioactivity; Licensing of Byproduct Material; Radioactive Isotopes for Sale Under a General AEC License; Some Suppliers of Radioisotopes; Radioactive Decontamination Procedures.

...rium Production Technology.[1] F. L. Cuthbert. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 320 pages. $6.50. This book contains practically all the information currently available on thorium production technology. Chapters are included on thorium history, sources, and uses; properties of thorium; thorium-bearing ores; their deposits and methods of concentration; extraction of thorium from ores; purification of thorium concentrates; preparation of thorium metal by reduction; melting of thorium; fabrication of thorium; health and safety aspects of thorium production; ...ing procedures.

... Transuranium Elements.[1] Glenn T. Seaborg. Reading, Mass., Addison-Wesley Publishing Co., 1958. 354 pages. $7.00. This book provides a complete summary of the chemical and nuclear properties of the known synthetic transuranium elements, as well as the prospects for future transuranium elements. It is divided into four parts, the first of which begins with the discovery of plutonium in 1940 as the result of the bombardment of natural uranium with deuterons in the University of California's 60-inch cyclotron. The next discusses the chemical properties of the actinide elements, ranging from one of the heaviest elements, thorium, to Mendelevium. The third part is devoted to the nuclear properties of the transuranium elements, and the fourth to the as yet undiscovered elements.

...um Ore Processing.[1] Edited by J. W. Clegg and D. D. Foley. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 448 pages. $7.50. Here, for the first time in book form, is a condensed but essentially complete description of practices and in winning uranium from its ores. While the emphasis

[1] U.S. Government presentation volume for the International Conference on the ...ful Uses of Atomic Energy, Geneva, 1958.

is on a well-rounded presentation of current practices in the United States; techniques in other countries are also described. Because of its comprehensive and authoritative nature, the volume should be a valuable reference for all workers in the field. Various processes are described in full, and there are many helpful comments and observations. Each chapter is accompanied by an extensive reference list.

Uranium Production Technology. Edited by Charles D. Harrington and Archie E. Ruehle. Princeton, N.J., D. Van Nostrand Co., Inc., 1959. 579 pages. $17.50. Presents the entire field of technology in the United States of uranium metal production from uranium concentrates or high-grade uranium ore. It includes a description of the diethyl ether and tributyl phosphate solvent extraction, deoxidation, hydrofluorination, reduction and casting processes. Rolling, forging, extrusion, and machining fabrication techniques are also discussed along with the chemistry and physical metallurgy of uranium. Chapters on uranium alloys, producing uranium hexafluoride, producing enriched uranium, new technology, and health hazard control complete the book. Limited amounts of history, pertinent production details, and development work are included. This comprehensive book, the first in its field, includes work done at many AEC installations throughout this country. It is written for the student of metallurgy both in an academic institution and in industry.

U.S. Research Reactor Operation and Use.[1] Edited by J. W. Chastain, Jr. Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958. 384 pages. $[illegible] This book is intended primarily for scientists, engineers, and administrators owning or using a reactor. It also may serve as a text or reference for introductory courses in reactor engineering. It sets forth information not only about technical aspects, characteristics, and operating problems but also on administrative, legal and cost problems.

PERIODICAL PUBLICATIONS

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, $18.00, domestic; $22.50, foreign; price per single copy, $[illegible] domestic; 25 percent extra for foreign mailing. Cumulated—index issues: Annual subscription rate, $15.00, domestic; $17.50, foreign; price per single copy varies according to the number of pages. Published bimonthly. The bimonthly publication contains abstracts of all current Commission declassified and unclassified reports, of non-Commission reports related to atomic energy, and of articles appearing in both foreign and domestic periodical literature.

Nuclear Safety (Technical Progress Reviews). Prepared by Oak Ridge National Laboratory for the U.S. Atomic Energy Commission, W. B. Cottrell, editor, R. A. Charpie, advisory editor. Washington, U.S. Government Printing Office. Available on subscription for $2.00 a year, 55 cents per issue. Published quarterly. This quarterly review on nuclear safety is intended for reactor designers, reactor builders, reactor fuel specialists, regulatory and

[1] A U.S. Government presentation volume for the International Conference on the Peaceful Uses of Atomic Energy. Geneva, 1958.

public safety officials, and others concerned with nuclear safety—this new journal in the Commission's Technical Progress Review series summarizes current developments in this important field. Activities of AEC's Advisory Committee on Reactor Safeguards and Hazards Evaluation Branch are also summarized, and recent safeguards reports are reviewed.

Power Reactor Technology (Technical Progress Review). Prepared by the General Nuclear Engineering Corp. for U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office. Available on subscription for $2.00 per year domestic; $2.50 foreign; 55 cents per copy. Published quarterly. This quarterly review of reactor development is intended to assist interested organizations in the task of keeping abreast of new results in reactor technology for civilian application. Each issue of the journal reviews reactor development progress on a current basis.

Reactor Core Materials (Technical Progress Review). Prepared by Battelle Memorial Institute for U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office. Available on subscription for $2.00 per year domestic; $2.50 foreign; 55 cents per copy. Published quarterly. This quarterly review covers significant developments in the field of solid reactor core materials. It provides a convenient condensed source of information to two types of readers: (1) those who wish to keep abreast of developments in a general way and (2) those interested in learning where to find detailed accounts of work in particular areas. Complete bibliographies are provided at the end of each section.

Reactor Fuel Processing (Technical Progress Review). Prepared by Argonne National Laboratory of the U.S. Atomic Energy Commission. Washington, U.S. Government Printing Office. Available on subscription for $2.00 per year domestic; $2.50 foreign; 55 cents per copy. Published quarterly. This quarterly review of reactor fuel processing is intended to assist interested organizations in keeping abreast of progress in this field. Each review covers those particular subjects in which significant advances have been made.

Depository Libraries

In order to make the nonclassified results of Commission research and development available to the public, the following libraries serve as depositories for essentially all the Commission's nonclassified reports. The Commission also makes available through these libraries atomic energy reports of countries other than the U.S. that are abstracted in NSA. A number of other university and public libraries also receive copies of the reports that are sold by the Office of Technical Services.

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Warsaw, Biura Pelnomocnika Rzadu do Spraw Wykorzystania Energ Jadrowej.

Portugal
Lisbon, Junta de Energía Nuclear.

Republic of the Congo
Leopoldville, Université Lovanium.

Scotland
Glasgow, Mitchell Library.

Spain
Madrid, Junta de Energía Nuclear.

Sweden
Stockholm, Atomenergi AB.

Switzerland
Geneva, United Nations Library.
Zurich, Institut fur Physik, Eidg. Technische Hochschule.

Thailand
Bangkok, Office of the Thai Atomic Energy Commission, Departmen Science.

Turkey
Ankara, Turkish Atomic Energy Commission, Atomic Energy Library.

Union of South Africa
Pretoria, Atomic Energy Board Library, Council for Scientific and Indus Research.

United Nations
New York, N.Y., U.N. Headquarters.

Uruguay
Montevideo, Universidad de Montevideo.

Venezuela
Caracas, Instituto Venezolano de Investigaciones Cientificas.

Viet-Nam
Saigon, Office of Atomic Energy.

Yugoslavia
Belgrade, Federal Nuclear Energy Commission.

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.
New York, N.Y.	New York, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Pennsylvania and New Jersey.
Aiken, S.C.	Alabama, Florida, North Carolina, South Carolina and Georgia.
Idaho Falls, Idaho	Montana, Utah and Idaho.
Oakland, Calif.	California and Hawaii.
Grand Junction, Colo.	Colorado, Wyoming, Kansas and Nebraska.
Lemont, 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.

APPENDIX 8

Regulations of the U.S. Atomic Energy Commission[1]

Part 4—Criteria and Procedures for Determining Eligibility for Security Clearance

APPLICATION TO GOVERNMENT EMPLOYMENT

The current title of 10 CFR Part 4 is changed from "Criteria and Procedures for Determining Eligibility for Security Clearance" to "Criteria and Procedures for Determining Eligibility for Security Clearance for AEC employment."

The three amendments to the present 10 CFR Part 4, "Criteria and Procedures for Determining Eligibility for Security Clearance" are as follows:

Section 4.2 is amended to read as follows:

§ 4.2 Scope.

The criteria and procedures outlined in this part shall be used in those cases in which there are questions of eligibility for AEC security clearance for employment, involving:

(a) Employees (including consultants) of, and applicants for employment with, the Atomic Energy Commission;

(b) Those other persons designated by the General Manager of the Atomic Energy Commission.

B. Paragraph (c) of § 4.25(c) is amended to read:

§ 4.25 Appointment of Personnel Security Boards.

* * * * *

(c) The personnel of the Board shall be selected from a panel of individuals possessing the highest degree of integrity, ability and good judgment. Such panels may not include an employee of the AEC as a voting member of a Personnel Security Board;

C. Paragraph (b) of § 4.32 is amended to read:

§ 4.32 Action by the General Manager.

* * * * *

(b) In making his determination, the mature viewpoint and responsible judgment of Commission staff members available for consideration by the General Manager;

(Sec. 161, 68 Stat. 948, as amended; 42 U.S.C. 2201)

Dated at Washington, D.C., this [illegible] day of July 1960.

A. R. Luedecke,
General Manager.

Part 8—Interpretations

PRICE-ANDERSON ACT

An interpretation of section 170 is hereby added to the regulations in Title 10, Chapter 1, CFR Part 8, which contains interpretations of the Atomic Energy Act of 1954 (68 Stat. 919) and of regulations of the Atomic Energy Commission issued thereunder.

§ 8.2 Interpretation of Price-Anderson Act, section 170 of the Atomic Energy Act of 1954.

(a) It is my opinion that an indemnity agreement entered into by the Atomic Energy Commission under the authority of the Atomic Energy Act of 1954 (42 U.S.C. § 2011, et seq.), hereafter cited as "the Act," as amended by Public Law 85–256 (the "Price-Anderson Act") (42 U.S.C. § 2210) indemnifies persons indemnified against public liability for bodily injury, sickness, disease or death

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[1] Policies and regulations of the U.S. Atomic Energy Commission announced prior to this Annual Report can be found in the *Federal Register* and in the following semiannual reports to Congress: Fifth, Sixth, Ninth through the Seventeenth and Nineteenth through the Twenty-fifth; also in the Annual Report for 1959.

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elements are present.
(c) In the case of dan
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S. Rep. 296, 85th Cong.,
1957) (hereafter cited a
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[1] Sec. 11u. "The term
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and in connection with the
the nuclear incident occurs,
claims arising out of an act
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of persons indemnified: Pro
property is covered under t
financial protection required,
which is located at the site
connection with the activity
the incident occurs."
Sec. 11o. "The term 'n
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A. R. LUEDECKE,
General Manager.

INTERPRETATIONS

ANDERSON ACT

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… loss of or damage to property, or for … of use of property caused outside … United States by a nuclear incident … within the United States.

… Section 170 authorizes the Com… to indemnify against "public liability" as defined in section 11(u) of … Act.[1] Coverage under the Act there… is predicated upon "public liabil…" and requires (1) "legal liability" … (2) a "nuclear incident." Determi… of the Act's coverage, therefore, necessitates a finding that these two … are present.

… In the case of damage outside of … United States caused by a nuclear … based in the United States there … be a "nuclear incident" as defined … section 11(o) since there would be an occurrence within the United States … * * * damage."[2] The "occur…" would be "within the United States" since "occurrence" is intended … the Act to be "that event at the site of … licensed activity * * * which may … damage rather than the site where … damage may perhaps be caused." … Rep. 296, 85th Cong., 1st Sess., p. 16 (…) (hereafter cited as Report). In section 11(o) an "occurrence" is that … causes damage. It would be, therefore, an event taking place at the site. This definition of "occurrence" is referred to in the Report at page 22 and is crucial to the Act's placing of venue under section 170(e).[3] In its definition of "nuclear incident," the Act makes no limitation upon the place where the damage is received but states only that the "occurrence" must be within the United States.

(d) Similarly, the requirement of "legal liability" would be met. The words of the Act impose no limitation that the liability be one for damage caused in the United States but, on the contrary, are exceedingly broad permitting indemnification for "any legal liability." In the most exhaustive study of the subject, it is stated that the phrase "any legal liability" indicates that liability for damage outside the United States is covered by the Act. Atomic Industrial Forum, Financial Protection Against Atomic Hazards 61 n. 355 (1957).

(e) Thus the precise language of the Act provides coverage for damage ensuing both within and without the United States arising out of an occurrence within the United States. There would be no occasion for doubt were it not for a single statement contained in the Report of the Joint Committee on Atomic Energy on the Price-Anderson Act. The Report states, at p. 16 that "if there is anything from a nuclear incident at the licensed activity which causes injury abroad, or if there is any activity abroad which causes further injury in the United States the situation will require further investigation at that time." This sentence follows an explicit and

[1] Sec. 11u. "The term 'public liability' … any legal liability arising out of or … from a nuclear incident, except … under State or Federal Workmen's Compensation Acts of employees of persons indemnified who are employed at the site of … in connection with the activity where … nuclear incident occurs, and except for … arising out of an act of war. 'Public liability' also includes damage to property … persons indemnified: *Provided,* That such property is covered under the terms of the financial protection required, except property … is located at the site of and used in connection with the activity where the nuclear incident occurs."

[2] Sec. 11o. "The term 'nuclear incident' … any occurrence within the United … causing bodily injury, sickness, disease, death, or loss of or damage to property, or for loss of use of property, arising … resulting from the radioactive, toxic, … or other hazardous properties of … special nuclear, or byproduct ma… * * *."

[3] In order to provide a framework for establishing the limitation of liability, the Commission or any person indemnified is permitted to apply to the appropriate district court of the United States which has venue in bankruptcy matters over the site of the nuclear incident. Again it should be pointed out that the site is where the occurrence takes place which gives rise to the liability, not the place where the damage may be caused * * *." Report, p. 22.

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lengthy statement that the "occurrence" is an event at the site of the activity:

> * * * The occurrence which is the subject of this definition is that event at the site of the licensed activity, or activity for which the Commission has entered into a contract, which may cause damage, rather than the site where the damage may perhaps be caused. This site must be within the United States. The suggested exclusion of facilities under license for export was not accepted. This is because the definition of "nuclear incident" limits the occurrence causing damage to one within the United States. It does not matter what license may be applicable if the occurrence is within the United States. If there is anything from a nuclear incident at the licensed activity which causes injury abroad or if there is any activity abroad which causes further injury in the United States the situation will require further investigation by the Congress at that time * * *

Read literally, the last sentence would seem inconsistent with the preceding statement. It is, however, possible to read the sentence as consistent with the preceding statement if it is taken as indicating a recognition by Congress of the fact that the statutory limitation of liability to $500,000,000 would probably not limit claims by foreign residents to that amount in foreign courts and that therefore the persons indemnified were not fully protected against bankrupting claims, one of the primary purposes of the bill.[4]

(f) The point in question received scant consideration during the hearings preceding adoption of the bill held by the Joint Committee on Atomic Energy. A summary of the study of the Atomic Industrial Forum, cited above, was introduced into the record of the hearing and included a conclusion that the provisions of the bill seemed to cover the situation.[5] That conclusion would seem entitled to more than ordinary weight since the Forum study received the careful consideration of the Joint Committee,[6] and the study referenced a statement from the 1956 Report very similar to the confusing statement in the 1957 Report noted above.[7]

(g) There was also a rather ambiguous colloquy in the hearings between Representative Cole and Mr. Charles Haugh in which Representative Cole indicated that the Joint Committee "* * * will do pretty well if we successfully protect the American people and property owners in this country without worrying about those that live abroad."[8]

(h) Congress, in enacting the Price-Anderson Indemnity Act added to section 2 of the Atomic Energy Act of 1954 a new subsection which stated, inter alia:

> In order * * * to encourage the development of the atomic energy industry, * * * the United States may make funds available for a portion of the damages suffered by the public from nuclear incidents, and may limit the liability of those persons liable for such losses.

This statutory purpose is frustrated if the atomic energy industry is not protected from bankrupting liabilities for damages caused abroad by an accident occurring in the United States.[9] In the

[4] Atomic Industrial Forum, Financial Protection Against Atomic Hazards, The International Aspects, p. 52 (1959).

[5] Hearings before the Joint Committee on Atomic Energy, Governmental Indemnity and Reactor Safety, 85th Cong., 1st Sess., p. 181 (1957) (hereinafter referred to as "Hearings.")

[6] Hearings, p. 168.

[7] Hearings, p. 182.

[8] Hearings, p. 97. It is significant to enhance that Mr. Haugh stated at that point the problem of the reactor operator who is concerned with any type of liability. He noted that the insurance contracts would cover "* * * the instance where * * * something happen[ed] out of the country and a suit is brought in the United States on that."

[9] The Atomic Industrial Forum study stated that "[T]o be adequate, the government indemnity must cover industry's liability to residents of the countries who suffer as a result of an accident at an installation located in the United States," p. 61. This is certainly the case and one of the major Congressional purposes is frustrated should the Act be said to be unclear on this point. The principal reason for the conclusion that there is coverage reached in the Forum study is the fact that Price-Anderson provides indemnity for "any legal liability." Arthur Murphy, Director of the study, in a

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Report, p. 11.

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Report, the Joint Committee on Atomic Energy made explicit mention of the fact that the private insurance to be provided for reactor operators included coverage for damage in Canada and Mexico and, at another point, noted the Committee's hope that the insurance contract in its final form would cover the same scope as the bill.[10]

(i) It is my opinion that since the language of the Act draws no distinction between damage received in the United States and that received abroad, none can properly be drawn. To read the Act as imposing such a limitation in the absence of statutory direction and in the light of an avowed Congressional intention to encourage the development of the atomic energy industry would be unwarranted. The confusing sentence cited in the Report must, therefore, be read consistently with the language of the Act in the manner suggested above, i.e., as recognizing Congressional inability to limit foreign liability, or must be ignored as inconsistent with the broad coverage of the statutory language.

L. K. Olson,
General Counsel.

April 26, 1960.

...has stated that the confusing sentence in the Report is "* * * inconsistent with the flat coverage of any legal liability by the indemnity." Murphy, Liability for Atomic Accidents and Insurance, in Law and Administration in Nuclear Energy 75 (1959). In testimony before the Joint Committee this year, Professor Samuel D. Estep, one of the authors of the comprehensive study of Atoms and the Law apparently relying upon legislative history, stated that the problem of a reactor accident in the United States causing damage in a foreign country ... nuclear, presumably since he considered the phrase "and legal liability" directed at a different problem. Hearings before the Joint Committee on Atomic Energy, Indemnity and Reactor Safety, 86th Cong., 1st Sess., p. 77 (1959); Stason Estep, and Pierce, Atoms and the Law, 577 (1959). Professor Estep stated that there "surely ought to be" change and suggested a clarifying amendment. His statement that the phrase "any legal liability" covers only the question of restrictions for claims seems to me erroneous since the language used, "any legal liability," seems intentionally broad. Additionally, should this very narrow reading be given to admittedly broad statutory language, the Congressional purpose would be defeated.

[10] Report, p. 11.

Part 10—Criteria and Procedures for Determining Eligibility for Access to Restricted Data or Defense Information Within Industry

The following regulations of the Commission establishing the criteria and procedures for resolving questions concerning the eligibility of an individual who is not an AEC employee or applicant for AEC employment for access to Restricted Data pursuant to the Atomic Energy Act of 1954, as amended, or for access to defense information, are published to implement Executive Order 10865, 25 F.R. 1583 (February 24, 1960). It should be noted that these rules relate to personnel employed by or applicants for employment with AEC contractors, agents, access permittees, and licensees of the AEC, while the rules contained in Part 4 of the Atomic Energy Commission's rules and regulations relate to criteria and procedures for resolving questions concerning the eligibility of an individual for security clearance for AEC employment under the Atomic Energy Act of 1954, as amended.

Because these regulations relate to the performance of AEC functions as described in section 4(2) of the Administrative Procedure Act of 1946, 5 U.S.C. section 1003(2), the Commission has found that general notice of proposed rulemaking and public procedure thereon are not required and that good cause exists why these rules should be made effective immediately without the customary period of prior notice.

Because of the important nature of the regulations contained herein, the Commission invites written comments from interested members of the public. These comments should be mailed to the General Counsel, U.S. Atomic Energy Commission, Washington 25, D.C.

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Pursuant to the Administrative Procedure Act, the following rules are published as a document subject to codification, to be effective immediately upon publication in the FEDERAL REGISTER.

AUTHORITY: §§10.1 to 10.38 issued under sec. 161, 68 Stat. 948, as amended; 42 U.S.C. 2201.

GENERAL PROVISIONS

§ 10.1 Purpose.

This part establishes the criteria, procedures, and methods for resolving questions concerning the eligibility of an individual for access to Restricted Data pursuant to the Atomic Energy Act of 1954, as amended. The appropriate provisions of this part are also to be used to the extent the Commission has responsibilities under Executive Order 10865, 25 F.R. 1583 (February 24, 1960).

§ 10.2 Scope.

The criteria and procedures outlined in this part shall be used in those cases in which there are questions of eligibility for AEC access authorization involving:

(a) Those employees (including consultants) of, and those applicants for employment with, contractors and agents of the Atomic Energy Commission;

(b) Access permittees and licensees of the AEC and their employees (including consultants) and applicants for employment; and

(c) Those other persons designated by the General Manager of the Atomic Energy Commission.

§ 10.3 Reference.

The pertinent sections of the Atomic Energy Act of 1954 are as follows:

SEC. 141. *Policy.* It shall be the policy of the Commission to control the dissemination and disclosure of Restricted Data in such a manner as to assure the common defense and security * * *

SEC. 145. *Restriction.* (a) No arrangement shall be made under section 31, no contract shall be made or continued in effect under section 41, and no license shall be issued under section 103 or 104, unless the person with whom such arrangement is made, the contractor or prospective contractor, or the prospective licensee agrees in writing not to permit any individual to have access to Restricted Data until the Civil Service Commission shall have made an investigation and report to the Commission on the character, associations, and loyalty of such individual, and the Commission shall have determined that permitting such person to have access to Restricted Data will not endanger the common defense and security.

(b) Except as authorized by the Commission or the General Manager upon a determination by the Commission or General Manager that such action is clearly consistent with the national interest, no individual shall be employed by the Commission nor shall the Commission permit any individual to have access to Restricted Data until the Civil Service Commission shall have made an investigation and report to the Commission on the character, associations, and loyalty of such individual and the Commission shall have determined that permitting such person to have access will not endanger the common defense and security.

(c) In the event an i[...] pursuant to subsections (a [...] section develops any data [...] individual who is the subj[...] gation is of questionable [...] Service Commission shall r[...] the Federal Bureau of Inv[...] conduct of a full field inv[...] sults of which shall be furn[...] Service Commission for its [...] appropriate action.

(d) If the President dee[...] national interest, he may f[...] cause investigations of an[...] which are required by sub[...] (b) of this section to be ma[...] Bureau of Investigation i[...] Civil Service Commission.

(e) Notwithstanding th[...] subsections (a) and (b) o[...] majority of the members of [...] shall certify those specific [...] are of a high degree of imp[...] tivity and upon such cert[...] vestigation and reports r[...] provisions shall be made [...] Bureau of Investigation in[...] Civil Service Commission.

(f) The Commission shall [...] ards and specifications in w[...] scope and extent of investiga[...] by the Civil Service Comm[...] subsections (a) and (b) [...] such standards and specific[...] based on the location and [...] work to be done, and shall, a[...] siderations, take into accou[...] importance to the commo[...] security of the Restricted [...] access will be permitted.

(g) Whenever the Congres[...] a state of war exists, or in th[...] national disaster due to ene[...] Commission is authorized dur[...] war or period of national [...] enemy attack to employ ind[...] permit individuals access to [...] pending the investigation re[...] mination required by sectio[...] extent that and so long as t[...] finds that such action is requ[...] impairment of its activities [...] the common defense and se[...]

SEC. 161. *General provision[...]* formance of its functions the [...] authorized to:

(a) Establish advisory bo[...] with and make recommend[...] Commission on the legislatio[...] administration, research and o[...]

loyalty of such individual, and the Commission shall have determined that permitting such person to have access to Restricted Data will not endanger the common defense and security.

(c) In the event an investigation made pursuant to subsections (a) and (b) of this section develops any data reflecting that the individual who is the subject of the investigation is of questionable loyalty, the Civil Service Commission shall refer the matter to the Federal Bureau of Investigation for the conduct of a full field investigation, the results of which shall be furnished to the Civil Service Commission for its information and appropriate action.

(d) If the President deems it to be in the national interest, he may from time to time cause investigations of any group or class which are required by subsections (a) and (b) of this section to be made by the Federal Bureau of Investigation instead of by the Civil Service Commission.

(e) Notwithstanding the provisions of subsections (a) and (b) of this section, a majority of the members of the Commission shall certify those specific positions which are of a high degree of importance or sensitivity and upon such certification the investigation and reports required by such provisions shall be made by the Federal Bureau of Investigation instead of by the Civil Service Commission.

(f) The Commission shall establish standards and specifications in writing as to the scope and extent of investigations to be made by the Civil Service Commission pursuant to subsections (a) and (b) of this section. Such standards and specifications shall be based on the location and class or kind of work to be done, and shall, among other considerations, take into account the degree of importance to the common defense and security of the Restricted Data to which access will be permitted.

(g) Whenever the Congress declares that a state of war exists, or in the event of a national disaster due to enemy attack, the Commission is authorized during the state of war or period of national disaster due to enemy attack to employ individuals and to permit individuals access to Restricted Data pending the investigation report, and determination required by section 145b, to the extent that and so long as the Commission finds that such action is required to prevent impairment of its activities in furtherance of the common defense and security.

Sec. 161. *General provisions.* In the performance of its functions the Commission is authorized to:

a. Establish advisory boards to advise with and make recommendations to the Commission on the legislation, policies, administration, research and other matters: Provided, That the Commission issues regulations setting forth the scope, procedure, and limitations of the authority of each such board.

* * * * *

(c) Make such studies and investigations, obtain such information, and hold such meetings or hearings as the Commission may deem necessary or proper to assist it in the administration or enforcement of this act, or any regulations or orders issued thereunder. For such purposes the Commission is authorized to administer oaths and affirmations, and by subpoena to require any person to appear and testify, or to appear and produce documents, or both, at any designated place. No person shall be excused from complying with any requirements under this paragraph because of his privilege against self-incrimination, but the immunity provisions of the Compulsory Testimony Act of February 11, 1893, shall apply with respect to any individual who specifically claims such privilege. Witnesses subpoenaed under this subsection, shall be paid the same fees and mileage as are paid witnesses in the district courts of the United States.

* * * * *

(n) Delegate to the General Manager or other officers of the Commission any of those functions assigned to it under this Act except those specified in sections 51, 57a(3), 61, 102 (with respect to the finding of a practical value), 108, 123, 145b (with respect to the determination of those persons to whom the Commission may reveal Restricted Data in the national interest), 145e, and 161a.

§ 10.4 Policy.

It is the policy of the Atomic Energy Commission to carry out its responsibility for the security of the atomic energy program in a manner consistent with traditional American concepts of justice. To this end, the Commission has established criteria for determining eligibility for access authorization and will afford those individuals described in § 10.2 the opportunity for administrative review of questions concerning their elibilibity for access authorization.

§ 10.5 Definitions.

As used in this part:

(a) "Access authorization" means an administrative determination that an individual is eligible for access to Restricted Data or defense information;

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(b) "Personnel Security Board" means an advisory board appointed by the Manager of Operations and consisting of three members, one of whom shall be designated as Chairman;

(c) "Hearing Counsel" means an AEC attorney assigned to prepare and conduct Personnel Security Board hearings;

(d) "AEC Personnel Security Review Board" means an advisory appeal board located in Washington, D.C., consisting of three members, one of whom shall be designated as Chairman;

(e) "Commission" means the commission of five members or a quorum thereof sitting as a body, as provided by section 21 of the Atomic Energy Act of 1954, as amended.

CRITERIA FOR DETERMINING ELIGIBILITY FOR ACCESS TO RESTRICTED DATA OR DEFENSE INFORMATION

§ 10.10 Application of the criteria.

(a) The decision as to access authorization is a comprehensive, common-sense judgment, made after consideration of all the relevant information, favorable or unfavorable, as to whether the granting of access authorization would endanger the common defense and security and would be clearly consistent with the national interest.

(b) To assist in making these determinations, on the basis of all the information in a particular case, there are set forth in this part a number of specific types of derogatory information. These criteria are not exhaustive but contain the principal types of derogatory information which create a question as to the individual's eligibility for access authorization. While there must necessarily be adherence to such criteria, the Commission is not limited thereto, nor precluded from exercising its judgment that information or facts in a case under its cognizance are derogatory although at variance with, or outside the scope of, the stated categories. These criteria are subject to continuing review and may be revised from time to time as experience and circumstances may make desirable.

(c) When the reports of investigation of an individual contain information reasonably tending to establish the truth of one or more of the items in the criteria, such information shall be regarded as substantially derogatory and shall create a question as to his eligibility for access authorization. Managers of Operations shall refer cases involving substantially derogatory information to the Director, Division of Security, AEC. The Director, Division of Security, AEC, may authorize the granting of access authorization on the basis of the information in the case or may authorize the conduct of an interview with the individual and, on the basis of such interview and such other investigation as he deems appropriate, may authorize the granting of access authorization. Otherwise, a question concerning the eligibility of an individual for access authorization shall be resolved in accordance with the procedures set forth in § 10.20 et seq.

(d) In resolving a question concerning the eligibility or continued eligibility of an individual for access authorization, the following principles shall be applied by the Board:

(1) Where there are grounds sufficient to establish a reasonable belief as to the truth of one or more of the items in Category "A", this shall be the basis for a recommendation for denying or revoking access authorization if not satisfactorily rebutted by the individual.

(2) Where there are grounds sufficient to establish a reasonable belief as to the truth of one or more of the items in Category "B", the extent of activities, the period in which such activities occurred, the length of time which has since elapsed, and the attitudes and convictions of the individual shall be considered in determining whether the recommendation will be adverse or favorable.

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§ 10.11 Derogatory information.

(a) *Category "A" derogatory information.* Category "A" includes those cases in which the individual or his spouse has:

(1) Committed or attempted to commit, or aided, or abetted another who committed or attempted to commit, any act of sabotage, espionage, treason or sedition;

(2) Knowingly established an association with espionage or sabotage agents of a foreign nation; with individuals reliably reported as suspected of espionage or sabotage; with representatives of foreign nations whose interests may be inimical to the interests of the United States, with traitors, seditionists, anarchists, or revolutionists;

(3) Held membership in any organization or group designated by the Attorney General pursuant to Executive Order 10450, as amended, provided the individual did not withdraw from such membership when the organization was so identified, or did not otherwise establish his rejection of its subversive aims; or prior to the declaration by the Attorney General, participated in the activities of such an organization in a capacity where he should reasonably have had knowledge as to the subversive aims of the organization and did not establish his rejection of its subversive aims. (If an organization has been removed from the Attorney General's list, membership in the organization after such removal shall not be considered as Category "A" derogatory information but may be considered as Category "B" derogatory information.)

(4) Publicly or privately advocated revolution by force or violence to overthrow the Government of the United States or the alteration of the form of government of the United States by unconstitutional means;

Category "A" also includes those cases in which the individual has:

(5) Deliberately omitted significant information from or falsified his Personnel Security Questionnaire or Personal History Statement concerning a significant matter;

(6) Wilfully violated or disregarded security regulations to a degree which would endanger the common defense and security; or intentionally disclosed classified information to any person not authorized to receive it;

(7) Any mental illness of a nature which in the opinion of competent medical authority may cause significant defect in the judgment or reliability of the individual;

(8) Been convicted of crimes indicating habitual criminal tendencies;

(9) Been, or is, a user of drugs habitually, without adequate evidence of rehabilitation.

(b) *Category "B" derogatory information.* In evaluating items under this category, the extent of the activities, the period in which such activities occurred, the length of time which has since elapsed, and the attitudes and convictions of the individual shall be considered. Category "B" includes those cases in which the individual or his spouse has:

(1) Advocated totalitarian, fascist, communist or other subversive political ideologies and has not subsequently established his rejection of them.

(2) Associated with persons falling within the provisions of Category "B", subparagraph (1) of this paragraph, when the individual himself did not establish his rejection of such ideologies. (Ordinarily this will not include chance or casual meetings nor contacts limited to normal business or official relations.)

(3) Affiliated with any organization or group designated in Category "A", paragraph (a)(3), of this section, provided the individual did not discontinue such affiliation when the organization was so identified or did not otherwise establish his rejection of its subversive aims;

(4) Associated with any person falling within the provisions of Category "A", paragraph (a)(3), of this section, provided the individual did not discon-

tinue such association when the organization was so identified or did not otherwise establish his rejection of its subversive aims. (Ordinarily this will not include chance or casual meetings nor contacts limited to normal business or official relations.)

(5) Parent(s), brother(s), sister(s), spouse, or offspring residing in a nation whose interests may be inimical to the interests of the United States, or in satellites or occupied areas thereof (to be evaluated in the light of the risk that pressure applied through such close relatives could force the individual to reveal sensitive information or perform an act of sabotage); Category "B" also includes those cases in which the individual:

(6) Refuses to serve in the Armed Forces when such refusal cannot be clearly shown to be due to religious convictions;

(7) Has been grossly careless in failing to protect or safeguard any Restricted Data or defense information;

(8) Has abused trust, has been dishonest, or has engaged in infamous, immoral or notoriously disgraceful conduct without adequate evidence of reformation;

(9) Is a sexual pervert or homosexual;

(10) Is a user of alcohol habitually and to excess, or has been such without adequate evidence of rehabilitation;

(11) Refuses, upon the ground of constitutional privilege against self-incrimination, to testify before a Congressional Committee regarding charges of his alleged disloyalty or other misconduct.

PROCEDURES

§ 10.20 Purpose of the procedures.

These procedures establish methods for the conduct of personnel security board hearings and administrative review of questions concerning an individual's eligibility for access authorization pursuant to the Atomic Energy Act of 1954, as amended, and Executive Order 10865, when it has been determined that such questions cannot be favorably resolved by interview or other investigation.

§ 10.21 Suspension of access authorization.

In those cases where information is received which raises a question concerning the continued eligibility of an individual for AEC access authorization, the Manager of the office concerned shall forward to the General Manager, via the Director, Division of Security, AEC, his recommendation as to whether the individual's access authorization should be suspended pending the final determination resulting from the operation of the procedures provided in this part. In making this recommendation the Manager shall consider such factors as the seriousness of the derogatory information developed, the possible access of the individual to classified information, and the individual's opportunity by reason of his position to commit acts adversely affecting the national security. The access authorization of an individual shall not be suspended except by direction of the General Manager.

§ 10.22 Notice to individual.

A notification letter, prepared by the Division of Security, AEC, approved by the Office of the General Counsel, and signed by the Manager of Operations, shall be presented to each individual whose eligibility for access authorization is in question. Where practicable, such letter shall be presented to the individual in person. The letter shall state:

(a) That reliable information in the possession of the Commission has created a substantial doubt concerning the individual's eligibility for access authorization;

(b) The information which creates a substantial doubt regarding the individual's eligibility for access authorization shall be as comprehensive and detailed as the national security permits;

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(c) In the event the individual desires a Board hearing he must within twenty days of the date of receipt of the notification letter indicate in writing to the Manager from whom he receives such letter that he wishes a hearing before a Personnel Security Board;

(d) That within twenty days of the date of receipt of the notification letter, the individual shall file with the Manager from whom he received such letter a written answer under oath or affirmation, to each item of reported information which raises the question of his eligibility for access authorization;

(e) That, if the individual so requests, a hearing will be scheduled before a Personnel Security Board with due regard for the convenience and necessity of the parties or their representatives for the purpose of affording the individual an opportunity of supporting his eligibility for access authorization;

(f) That, if the individual requests a hearing, he will be notified in writing of the membership of a Personnel Security Board when it is appointed by the Manager;

(g) That the individual will have the right to appear personally before a Personnel Security Board, and present evidence in his own behalf, through witnesses, or by documents, or both, and subject to the limitations set forth in § 10.27(f), be present during the entire hearing and be accompanied, represented and advised by counsel of his own choosing;

(h) That the individual's failure to file a written request for a hearing before a Personnel Security Board, in accordance with paragraphs (c) and (d) of this section, will be considered as a relinquishment by him of the opportunity of availing himself of the hearing and review procedure provided in this part, and that in such event a recommendation as to the final action to be taken will be made by the Manager of Operations and submitted to the General Manager for his decision on the basis of the information in the case without reference to a Personnel Security Board;

(i) His access authorization status until further notice;

(j) The name of the designated AEC official to contact for any further information desired.

§ 10.23 Additional information.

A copy of this part shall be given to the individual with the notification letter.

§ 10.24 Failure of individual to request a hearing.

(a) In the event the individual fails, within the prescribed time, to file a written request for a hearing before a Personnel Security Board, pursuant to § 10.22, a recommendation as to the final action to be taken shall be made by the Manager of Operations to the General Manager on the basis of the information in the case;

(b) The Manager of Operations may for good cause shown, at the request of the individual, extend the time for filing a written request for a hearing or for filing a written answer to the matters contained in the notification letter.

§ 10.25 Selection of AEC Hearing Counsel.

(a) Upon receipt from the individual of his written answer to the notification letter, signifying his desire to appear before a Personnel Security Board and answering under oath or affirmation the allegations contained in the notification letter, an AEC attorney shall forthwith be assigned to act as Hearing Counsel;

(b) Hearing Counsel shall, prior to the scheduling of the Board hearing, review the information in the case and shall request the presence of witnesses and the production of physical evidence in accordance with the provisions of paragraphs (m), (n), (o), and (p) of § 10.27. When the presence of a witness is deemed by the Hearing Counsel to be necessary or desirable to a proper determination of the issues before the

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Board, the Manager shall make arrangement by subpoena or otherwise for such witnesses to appear, be confronted by the individual, and be subject to examination and cross-examination;

(c) Hearing Counsel is authorized to consult directly with the individual if he is not represented by counsel, or if so represented with his counsel or representative, for purposes of reaching mutual agreement upon arrangements for an expeditious hearing of the case. Such arrangements may include clarification of issues, and stipulations with respect to testimony and the contents of documents and other physical evidence. Such stipulations when entered into shall be binding upon the individual and the Atomic Energy Commission for the purposes of this part. Prior to such consultation the Hearing Counsel shall advise the individual of his right to Counsel or other representation and of the possibility that any statements made by the individual to the Hearing Counsel may be used in subsequent proceedings;

(d) The individual is responsible for producing witnesses in his own behalf or presenting other proof before the board to support his answer and defense to the allegations contained in the notification letter. When requested, however, Hearing Counsel shall assist him to the extent practicable and necessary. In the Hearing Counsel's sound discretion he may request the Manager of Operations to arrange for the issuance of subpoenas for witnesses to attend the hearing in the individual's behalf, or for the production of specific documents or other physical evidence, provided a showing of the necessity for such assistance has been made.

§ 10.26 Appointment of Personnel Security Boards.

(a) Upon receipt of advice from the Hearing Counsel that all arrangements for an expeditious hearing have been completed, the Manager shall forthwith appoint a Personnel Security Board consisting of three members, one of whom shall be designated as the Chairman of the Personnel Security Board;

(b) The personnel of the Board, where practicable as determined by the Manager, shall consist of at least one member who is an attorney and one member who is familiar with the general field of work of the individual;

(c) The personnel of the Board shall be selected from a panel of individuals possessing the highest degree of integrity, ability, and good judgment. Such panels may include employees of the AEC or its contractors but no employee of an AEC contractor shall serve as a member of a Personnel Security Board hearing the case of an employee of, or an applicant for employment with, the contractor;

(d) All persons serving as members of Personnel Security Boards shall have an AEC "Q" clearance;

(e) No person shall serve as a member of a Personnel Security Board who has prejudged the case to be heard, who possesses information that would make it embarrassing to render impartial recommendations or advice; or who for bias or prejudice generated for any reason would be unable to render fair and impartial recommendations or advice;

(f) Immediately upon the appointment of a Personnel Security Board, the Manager will notify the individual of the identity of the members of the Personnel Security Board and of his right to challenge any member for cause, such challenge or challenges, accompanied by the reasons therefor, to be submitted to the Manager within seventy-two hours of the receipt of the notice;

(g) In the event that the individual challenges a member or members of the Personnel Security Board, the justification of the action of the individual shall be determined by the Manager. Where the challenge of the individual is sustained, the Manager shall forthwith appoint such new members as required to

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stitute a full Personnel Security Board and notify the individual. The individual shall have the right to challenge such new members for cause and such challenge shall be dealt with in the same manner as an original challenge. The Manager shall also notify the individual of his rejection of any challenge. The Personnel Security Board shall convene as soon as is reasonably practicable;

(b) The Manager of Operations shall notify the individual in writing, at least one week in advance, of the date, hour, and place the Personnel Security Board will convene. In the event the individual fails to appear at the time and place specified, a recommendation as to the final action to be taken shall be made by the Manager of Operations to the General Manager on the basis of the information in the case. However, the Manager of Operations may for good cause shown, at the request of the individual, permit the individual to appear before a Personnel Security Board at a later scheduled date, hour, and place.

Conduct of proceedings.

(a) The proceedings shall be conducted by the Chairman of the Personnel Security Board in an orderly, impartial, and decorous manner with every effort made to protect the interests of the Government and of the individual and to arrive at the truth. In no case shall undue delay be tolerated nor will the individual be hampered by unduly restricting the time necessary for proper preparation and presentation. In performing their duties, the members of the Board shall always bear in mind and make clear to all concerned that the proceeding is an administrative hearing and not a trial;

(b) The proceedings shall be open only to duly authorized representatives of the staff of the Atomic Energy Commission, the individual, his counsel, and such persons as may be officially authorized by the Board. Witnesses shall not testify in the presence of other witnesses;

(c) 1. Hearing Counsel shall examine and cross-examine witnesses and otherwise assist the Board in such a manner as to bring out a full and true disclosure of all facts, both favorable and unfavorable, having a bearing on the issues before the Board. In performing his duties, he shall avoid the attitude of a prosecutor and shall always bear in mind that the proceeding is an administrative hearing and not a trial;

2. Hearing Counsel shall not participate in the deliberations of the Board, and shall express no opinion to the Board concerning the merits of the case. He shall also advise the individual of his rights under these procedures when the individual is not represented by counsel of his own choosing;

(d) The Board may ask the individual AEC representatives, and other witnesses any supplemental questions which the Board deems appropriate to assure the fullest possible disclosure of relevant and material facts. The proponent of a witness shall conduct the direct examination of that witness;

(e) During the course of the proceedings the Chairman shall rule in open session on all questions presented to the Board for its determination, subject to the objection of any member of the Board. In the event of an objection by any member of the Board, a majority vote of the Board shall be determinative and constitute the ruling of the Chairman. Voting may be either in open or closed session on all questions except recommendations to grant or deny access authorization, which shall be in closed session;

(f) In the event it appears in the course of the hearing that Restricted Data or defense information may be disclosed, it shall be the duty of the Chairman to assure that disclosure is not made to persons who are not authorized to receive it;

(g) The Board shall admit in evidence any matters either oral or written which are material, relevant and competent in determining the issues involved, including the testimony of responsible persons concerning the integrity of the individual. The utmost latitude shall be permitted with respect to relevancy, materiality, and competency. Every reasonable effort shall be made to obtain the best evidence available. Hearsay evidence may for good cause shown be admitted without regard to technical rules of admissibility and accorded such weight as the circumstances warrant;

(h) Testimony of the individual and witnesses shall be given under oath or affirmation, and the individual and witnesses shall be subject to cross-examination. Attention of the individual and the witness shall be invited to 18 U.S.C. 1001 and 18 U.S.C. 1621;

(i) The individual shall be afforded the opportunity of testifying in his own behalf;

(j) The Board shall endeavor to obtain all the facts that are reasonably available in order for it to arrive at its recommendations. If, prior to or during the proceeding, in the opinion of the Board the allegations in the notification letter are not sufficient to cover all matters into which inquiry should be directed, the Board shall recommend to the Manager concerned that, in order to give more adequate notice to the individual, the notification letter should be amended. Any amendment shall be made with the concurrence of the Director, Division of Security, AEC, and the Office of the General Counsel. If, in the opinion of the Board, the circumstances of such an amendment may involve an undue hardship to the individual, because of limited time to answer the new allegations in the notification letter, an appropriate adjournment shall be granted upon the request of the individual;

(k) Unless permitted by paragraphs (*l*), (m), (n), (*o*), and (p) of this section, the record may contain no information adverse to the individual on any controverted issue unless (1) the information or its substance has been made available to the individual and he offers no objection to its presentation; or (2) the information or its substance is made available to him and the individual is afforded an opportunity to cross-examine the person providing the information. Information whose admission is not prohibited by this paragraph, or by any other provision of this part, may be received and made a part of the record and may be considered by the Board or officials charged with making determinations under this part;

(*l*) A written or oral statement of a person relating to the characterization in the notification letter of any organization or person other than the individual may be received and considered by the Board without affording the individual an opportunity to cross-examine the person making the statement on matters relating to the characterization of such organization or person, provided the individual is given notice that it has been received and may be considered by the Board, and is informed of its contents provided such is not prohibited by § 10.27 (f);

(m) The individual shall be afforded an opportunity to cross-examine persons who have made oral or written statements adverse to the individual relating to a controverted issue except that any such statement may be received and considered by the Board without affording such opportunity in either of the following circumstances:

(1) The head of the department supplying the statement certifies that the person who furnished the information is a confidential informant who has been engaged in obtaining intelligence information for the Government and that disclosure of his identity would be substantially harmful to the national interest;

(2) The Commission or its special designee for that particular purpose has preliminarily determined, after considering information furnished by the investigative agency as to the reliability

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the person and the accuracy of the statement concerned, that the statement concerned appears to be reliable and material, and the Commission or such special designee has determined that failure of the Board to receive and consider such statement would, in view of the access to Restricted Data or defense information sought, be substantially harmful to the national security and that the person who furnished the information cannot appear to testify (i) due to death, severe illness, or similar cause, in which case the identity of the person and the information to be considered shall be made available to the individual, or (ii) due to some other cause determined by the Commission to be good and sufficient.

(4) Whenever procedures under paragraph (m) (1) or (2) of this section are used (1) the individual shall be given a summary of the information which shall be as comprehensive and detailed as the national security permits, and (2) appropriate consideration shall be accorded to the fact that the individual did not have an opportunity to cross-examine such person or persons;

(n) Records compiled in the regular course of business, or other physical evidence other than investigative reports, may be received and considered subject to rebuttal without authenticating witnesses, provided that such information has been furnished to the AEC by an investigative agency pursuant to its responsibilities in connection with assisting the Commission to safeguard Restricted Data or defense information;

(o) Records compiled in the regular course of business, or other physical evidence other than investigative reports, relating to a controverted issue which, because they are classified, may not be inspected by the individual, may be received and considered provided that;

(1) The Commission or its special designee for that purpose has made a preliminary determination that such physical evidence appears to be mate-

(2) The Commission or such designee has made a determination that failure to receive and consider such physical evidence would, in view of the access to Restricted Data or defense information sought, be substantially harmful to the national security; and

(3) To the extent that national security permits, a summary or description of such physical evidence shall be made available to the individual. In every such case, information as to the authenticity and accuracy of such physical evidence furnished by the investigative agency shall be considered.

(q) The Board may request the Manager to arrange for additional investigation on any points which are material to the deliberations of the Board and which the Board believes need extension or clarification. In this event, the Board shall set forth in writing those issues upon which more evidence is requested, identifying where possible persons or sources from which evidence should be sought. The Manager shall make every effort through appropriate sources to obtain additional information upon the matters indicated by the Board;

(r) A written transcript of the entire proceedings shall be made by a person possessing appropriate AEC clearance and, except for portions containing Restricted Data or defense information, a copy of such transcript shall be furnished the individual without cost.

§ 10.28 Recommendation of the Board.

(a) The Board shall carefully consider the record and the standards set forth herein. In reaching its determination the Board shall consider the demeanor of the witnesses who have testified before the Board, the probability or likelihood of the truth of their testimony, their credibility, the authenticity and accuracy of documentary evidence, or the lack of evidence upon some material points in issue. If the individual is, or may be, handicapped by the non-disclosure to him of confiden-

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tial information or by lack of opportunity to cross-examine confidential informants, the Board shall take that fact into consideration. The Board may also consider as part of the record the individual's past employment in the atomic energy program, and the nature and sensitivity of the job he is or may be expected to perform. Possible impact of the loss of the individual's services upon the AEC program shall not be considered by the Board;

(b) The Board shall make specific findings based upon the record as to whether each of the allegations contained in the notification letter is true or false and the significance which the Board attaches to such allegations. These findings shall be supported fully by a statement of reasons which constitute the basis for such findings;

(c) The recommendation of the Board shall be predicated upon its findings. If, after considering all the factors in the light of the criteria set forth in this part, the Board is of the opinion that it will not endanger the common defense and security and will be clearly consistent with the national interest to grant access authorization to the individual, it shall make a favorable recommendation; otherwise, it shall make an adverse recommendation;

(d) The recommendation of the Board shall be determined by a majority vote. In the event of a dissent from the majority, the recommendation of the minority member shall be made a matter of record together with a statement of the reasons leading to his conclusions. The recommendation of the Board shall be submitted to the Manager accompanied by a statement of the reasons leading to the Board's conclusions.

§ 10.29 New evidence.

(a) In the event of the discovery of new evidence by the individual prior to final determination of the individual's eligibility for access authorization, such evidence shall be submitted by the individual or his representative to the Manager of Operations from whom he received his notification letter;

(b) The Manager of Operations with the advice of Hearing Counsel shall review the application for the presentation of new evidence to ascertain its materiality and relevancy and further whether the individual or his representative was without fault in failing to present such evidence before. In the event it is determined that the new evidence should be received, the Manager of Operations shall:

(1) Refer the matter to the Personnel Security Board which had been appointed in the individual's case where the Manager of Operations has not yet transmitted the record to the General Manager. The Board receiving the application for the presentation of new evidence shall determine the form in which it shall be received, whether by testimony before the Board, by deposition, or by affidavit.

(2) In those cases where the Manager of Operations has forwarded the record to the General Manager, the application for presentation of new evidence shall be referred to the General Manager with appropriate comments and recommendations. In the event the General Manager determines that the new evidence should be received, he shall determine the form in which it shall be received, whether by testimony before a Personnel Security Board, by deposition, or by affidavit.

§ 10.30 Actions on the recommendations.

(a) The recommendations of the Board and any dissent therefrom shall be signed by the members of the Board, as appropriate, and together with the record of the case, shall be transmitted with the least practicable delay to the Manager of Operations concerned.

(b) Upon receipt of the findings and recommendation of the Board, and the record, the Manager shall forthwith transmit it to the General Manager

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...30 Actions on the recommenda...tions.

...) The recommendations of the...
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...the Director, Division of Security... In those cases where denial... authorization is recommended... Board, the Manager of Operations... shall forward a statement con... the effect which denial of access... would have upon the ...ation ...energy program;

...The General Manager may return ...ord to the Manager for further ...edings by the Personnel Security ...with respect to specific matters ...ated by the General Manager;

...(1) In the event of a recommen... by the Board for a denial of ... authorization, the individual ... immediately notified in writing ... fact by the General Manager, or ...signee, and shall be informed of ...Board's findings with respect to ...allegation contained in the notifi... letter. The individual shall also ...ised of his right to request a re... of his case by the AEC Personnel ...ity Review Board and of his right ...mit a brief to support his conten... The request for a review shall be ...ted to the General Manager with... days after the receipt of the no... The brief shall be forwarded to ...General Manager through the Di... Division of Security, AEC, not ...than 10 days after receipt of such ... unless such time is extended by ...General Manager for good cause ...n;

...Where the individual requests a ... of the adverse recommendation, ...General Manager shall forthwith ...the record, with all findings and ...mendations, to the Personnel Se...Review Board;

...In the event the individual fails ...uest a review by the AEC Person...urity Review Board of an adverse ...mendation within the prescribed ...the final determination shall be ... the basis of the record with all ... and recommendations;

...) Where the Board has made a ...endation favorable to the indi... and the General Manager proposes to transmit the record to the Personnel Security Review Board for its recommendation, the General Manager shall immediately cause the individual to be notified of that fact and of those matters contained in the notification letter concerning which he desires the advice of the Personnel Security Review Board. He shall further inform the individual that he may submit a brief concerning such matters for the consideration of the Personnel Security Review Board. Such brief shall be filed not later than 10 days from the receipt of the notice by the individual, unless extended for good cause shown. The brief shall be forwarded to the General Manager for transmission to the Personnel Security Review Board.

§ 10.31 Recommendations of the AEC Personnel Security Review Board.

(a) The AEC Personnel Security Review Board shall make its deliberations based upon the record, supplemented by such brief as the individual submits. The Personnel Security Review Board may request such additional briefs as it deems appropriate. In any case where the AEC Personnel Security Review Board determines that additional evidence or further proceedings are necessary, it may return the record to the General Manager with a recommendation that the case be remanded to the Manager of Operations for appropriate action;

(b) In its deliberations, the AEC Personnel Security Review Board shall make its findings and recommendations as to the eligibility of an individual for access authorization on the record supplemented by additional testimony or briefs, as determined by the Board. When additional testimony is taken by the Personnel Security Review Board a verbatim transcript of such testimony shall be made part of the record;

(c) The Personnel Security Review Board shall not concern itself with the possible impact of the loss of the individual's services upon the AEC program;

(d) After its deliberations, the AEC Personnel Security Review Board shall make its findings and recommendations on the record in writing to the General Manager.

§ 10.32 Action by the General Manager.

(a) The General Manager, on the basis of the record accompanied by all recommendations, shall then make a final determination whether access authorization shall be granted or denied, unless the provisions of § 10.27 (m), (n), (o), or (p) have been used, in which case the decision to deny or revoke access authorization may be made only by the Commission;

(b) In making the determination as to whether access authorization shall be granted or denied, the General Manager or Commission shall give due recognition to the favorable as well as the unfavorable information concerning the individual and shall take into account the value of the individual's services to the atomic energy program and the operational consequences of denial of access authorization;

(c) In the event of an adverse determination the General Manager shall notify the individual through the Manager of Operations of his decision that access authorization is being denied or revoked and of his findings with respect to each allegation contained in the notification letter for transmittal to the individual.

§ 10.33 Action by the Commission.

(a) Whenever an individual has not been afforded an opportunity to confront and cross-examine witnesses who have furnished information adverse to the individual under the provisions of § 10.27 (m), (n), (o), or (p) and an adverse recommendation has been made by the General Manager, the Commissioners shall personally review the record and determine whether access authorization shall be granted, denied or revoked, based upon the record;

(b) When the Commission determines to deny or revoke access authorization the individual will be notified through the Manager of Operations of its decision that access authorization is being denied or revoked and of its findings with respect to each allegation contained in the notification letter for transmittal to the individual;

(c) Nothing contained in these procedures shall be deemed to limit or affect the responsibility and powers of the Commission to deny or revoke access to Restricted Data or defense information if the security of the nation so requires. Such authority may not be delegated and may be exercised only when the Commission determines that the procedures prescribed in § 10.27 (m), (n), (o), or (p) cannot be invoked consistently with the national security and such determination shall be conclusive.

§ 10.34 Reconsideration of cases.

(a) Where, pursuant to the procedures set forth in §§ 10.20 to 10.33, the General Manager or the Commission has made a determination granting access authorization to an individual, the individual's eligibility for access authorization shall be reconsidered only when subsequent to the time of the prior hearing, there is new substantially derogatory information or a significant increase in the scope or sensitivity of the Restricted Data or defense information to which the individual has or will have access;

(b) Where, pursuant to these procedures, the Commission or General Manager has made a determination denying access authorization to an individual, the individual's eligibility for access authorization may be reconsidered when there is a bona fide offer of employment requiring access to Restricted Data or defense information and either material and relevant new evidence, which the individual and his representative

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... fault in failing to present before ... convincing evidence of reformation ... rehabilitation. Requests for reconsideration shall be submitted in ... to the General Manager through ... Manager of Operations having jurisdiction over the position for which access authorization is required. Such ... shall be accompanied by an affidavit setting forth in detail the information referred to above. The General Manager shall cause the individual to ... notified as to whether his eligibility ... access authorization will be reconsidered and, if so, the method by which reconsideration will be accomplished;

... Where access authorization has ... granted to an individual by a Manager of Operations without recourse to ... procedures set forth in §§ 10.20 to ... the individual's eligibility for access authorization shall be reconsidered ... a case where subsequent to the ... of the access authorization, ... substantially derogatory information has been received or there is a ... significant increase in the scope or sensitivity of the Restricted Data or defense information to which the individual has or will have access, and in any ... case only with specific prior approval of the Director, Division of ... AEC.

MISCELLANEOUS

§ ... Terminations.

... the event the individual is no ... an applicant for access authorization or no longer requires access authorization the procedures of this part ... be terminated without a final determination as to his eligibility for ... authorization.

§ ... Attorney Representation.

... the event the individual is represented by an attorney or other such representative, the individual shall file ... the AEC a document designating ... attorney or representative and authorizing such attorney or representative to receive all correspondance, transcripts and other documents pertaining to the proceeding under this part.

§ 10.37 Certifications.

Whenever information is made a part of the record under the exceptions authorized by § 10.27 (m), (n), (o), and (p), the record shall contain certificates evidencing that the determinations required therein have been made.

§ 10.38 Washington Area cases.

In those cases which may arise involving individuals within the Washington Area of AEC operations, an Assistant General Manager designated by the General Manager shall discharge the functions and responsibilities assigned to Managers of Operations in these procedures.

Dated at Washington, D.C., this 1st day of July 1960.

A. R. LUEDECKE,
General Manager.

PART 25—PERMITS FOR ACCESS TO RESTRICTED DATA

Part 25 is amended in its entirety to revise the procedures and categories of information under the Access Permit Program. Because interested persons will not be adversely affected and because the action liberalizes the conditions under which information may be obtained, the Commission has found that good cause exists why the regulations in this part should be made effective immediately.

Pursuant to the Administrative Procedure Act, Public Law 404, 79th Cong., 2d sess., the following rules are published as a document subject to codification, to be effective upon publication in the FEDERAL REGISTER.

GENERAL PROVISIONS

GENERAL PROVISIONS

§ 25.1 Purpose.

This part establishes procedures and standards for the issuance of an Access Permit to any person subject to this part who requires access to Restricted Data relating to the civil uses of atomic energy for use in his business, trade or profession; provides for the amendment, renewal, suspension, termination and revocation of an Access Permit; and specifies the terms and conditions under which the Commission will issue the Permit.

§ 25.2 Applicability.

The regulations in this part apply to any person within or under the jurisdiction of the United States who desires access to Restricted Data for use in his business, profession or trade.

§ 25.3 Definitions.

As used in this part:

(a) "Access Permit" means a permit, issued by the Atomic Energy Commission, authorizing access by the named permittee to Restricted Data relating to the civil uses of atomic energy in accordance with the terms and conditions stated on the permit.

(b) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919), including any amendments thereto.

(c) "Category" means a category of Restricted Data designated in Appendix "A" to the regulations in this part.

(d) "Commission" means the Atomic Energy Commission or its duly authorized representatives.

(e) "Permittee" means the holder of a permit issued pursuant to the regulations in this part.

(f) "Person" means (1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission, any state or any political subdivision of, or any political entity within a state, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing.

(g) "Restricted Data" means all data concerning (1) design, manufacture or utilization of atomic weapons; (2) the production of special nuclear material; or (3) the use of special nuclear material in the production of energy, but shall not include data declassified or removed from the Restricted Data category pursuant to section 142 of the Act.

§ 25.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 25.5 Communications.

All communications concerning the regulations in this part, and applications filed under them, should be addressed to the Commission Operations Office listed in Appendix "B" of this part responsible for the geographical area in which (a) the applicant's principal place of business is located, or (b) the principal place where the applicant

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§ 25.6 Categories of av... ...tion.

For administrative pu... ...mission has categorized ... which will be made avai... ...es into two categories ... Appendix "A" to this pa... ...formation and informa... ...the design, manufact... ...of atomic weapons a... these categories an... made available under thi...

§ 25.7 Specific waivers.

The Commission may... ...of any interested pa... waivers from the requir... part as it determines are... ...and will not consti... ...to the common ... security.

APPLICATIONS

§ 25.11 Applications.

(a) Any person desiri... ...stricted Data pursuant ... should submit an appl... (p. 378), in triplicate, ... permit to the Commissio... ...fice, listed in Appendi... ...part, responsible for the ... the applicant's prin... business is located, or ... place where the app... the Restricted Data is loc...

(b) Where an individ... ...to Restricted Data ... performance of his duti... ...ployee, the application ... permit must be filed in t... employer.

(c) Self-employed pr... ...desiring access to R... file the application ... for an individual ...

(d) Each application ... following information

(1) Name of applica... subsidiaries or d...

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ry" means a category of
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ration, partnership, firm,
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ion, group, Government
than the Commission, any
political subdivision of, or
entity within a state, or
and (2) any legal succes-
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... Categories of available informa-
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... has categorized Restricted Data
... will be made available to permit-
... into two categories as set forth in
... Appendix "A" to this part. Top Secret
... information and information pertaining
... design, manufacture or utiliza-
... of atomic weapons are not included
... these categories and will not be
... available under this part.

... Specific waivers.

The Commission may, upon applica-
... of any interested party, grant such
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... and will not constitute an undue
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APPLICATIONS

... Applications.

... Any person desiring access to Re-
...ed Data pursuant to this part
... submit an application (Form
... 378), in triplicate, for an access
... to the Commission's Operations
... listed in Appendix "B" to this
... responsible for the area in which
... the applicant's principal place of
... is located, or (2) the princi-
...ce where the applicant will use
... Restricted Data is located.

Where an individual desires ac-
... Restricted Data for use in the
...mance of his duties as an em-
... the application for an access
... must be filed in the name of his
...er.

Self-employed private consult-
... desiring access to Restricted Data,
file the application in their own
... for an individual access permit.
Each application should contain
... following information:

Name of applicant (unincorpo-
... subsidiaries or divisions of a
corporation must apply in the name of
the corporation);

(2) Address of applicant;

(3) Description of business or occu-
pation of applicant;

(4) (i) If applicant is an individual,
state citizenship.

(ii) If applicant is a partnership,
state name, citizenship and address of
each partner and the principal location
where the partnership does business.

(iii) If applicant is a corporation or
an unincorporated association, state:

(*a*) The state where it is incorpo-
rated or organized and the principal
location where it does business;

(*b*) The names, addresses and citi-
zenship of its directors and of its
principal officers;

(*c*) Whether it is owned, controlled
or dominated by an alien, a foreign
corporation, or foreign government, and
if so, give details.

(iv) If the applicant is acting as
agent or representative of another per-
son in filing the application, identify
the principal and furnish information
required under this subparagraph with
respect to such principal;

(5) Total number of full-time em-
ployees;

(6) Classification of Restricted Data
(Confidential or Secret) to which access
is requested;

(7) Potential use of the Restricted
Data in the applicant's business, pro-
fession or trade. If access to Secret
Restricted Data is requested, list the
specific categories by number and fur-
nish detailed reasons why such access
within the specified categories is needed
by the applicant. The need for Secret
information should be stated by de-
scribing its proposed use in specific
research, design, planning, construction,
manufacturing, or operating projects;
in activities under licenses issued by the
Commission; in studies or evaluations
planned or underway; or in work or
services to be performed for other
organizations.

In addition, if access to Secret Restricted Data in category C–65 Plutonium Production is requested, the application should also include sufficient information to satisfy the requirements of § 25.15(b)(2).

(8) Principal Location(s) at which Restricted Data will be used.

(e) Applications should be signed by a person authorized to sign for the applicant.

(f) Each application shall contain complete and accurate disclosure with respect to the real party or parties in interest and as to all other matters and things required to be disclosed.

§ 25.12 Non-eligibility.

The following persons are not eligible to apply for an access permit:

(a) Corporations not organized under the laws of the United States or a political subdivision thereof.

(b) Any individual who is not a citizen of the United States.

(c) Any partnership not including among the partners one or more citizens of the United States; or any other unincorporated association not including one or more citizens of the United States among its principal officers.

(d) Any organization which is owned, controlled or dominated by the Government of, a citizen of, or an organization organized under the laws of a country or area listed as a Subgroup A country or destination in § 371.3 (15 CFR 371.3) of the Comprehensive Export Schedule of the United States Department of Commerce.

(e) Persons subject to the jurisdiction of the United States who are not doing business within the United States.

§ 25.13 Additional information.

The Commission may, at any time after the filing of the original application and before the termination of the permit, require additional information in order to enable the Commission to determine whether the permit should be granted or denied or whether [illegible] should be modified or revoked.

§ 25.14 Public inspection of [illegible] tions.

Applications and documents submitted to the Commission in connection with applications may be made available for public inspection in accordance with the regulations contained in Part 9 [illegible] of this chapter.

§ 25.15 Requirements for approval of applications.

(a) An application for an access permit authorizing access to Confidential Restricted Data in the categories [illegible] forth in Appendix "A" will be approved only if the application demonstrates that the applicant has a potential need or application for such data in his business, trade or profession and has filed a complete application form.

(b)(1) An application for an access permit authorizing access to Secret Restricted Data will be approved only if the application demonstrates that the applicant has a need for such data in his business, trade or profession and has filed a complete application form.

(2) An application for an access permit authorizing access to Secret Restricted Data in category C–65 Plutonium Production will be approved only if the application demonstrates that the applicant:

(i) Is directly engaged in a substantial effort to develop, design, build or operate a chemical processing plant or other facility related to his participation in the peaceful uses of atomic energy for which such production and cost data are needed; or

(ii) Is furnishing to a permittee having access to C–65 under subdivision (i) of this subparagraph, substantial scientific, engineering or other professional services to be used by said permittee in carrying out the activities for which said permittee received access to category C–65.

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arrying out the activities for ...
permittee received access to ...
-65.

PERMITS

...5.21 Issuance.

(a) Upon a determination that an ...cation meets the requirements of ... regulation, the Commission will ... to the applicant an access permit ... Form AEC 379.

(b) An Access Permit is not a security clearance. It does not authorize ... individual not having an appropriate AEC security clearance to receive Restricted Data. See § 25.24 and Part ... of this chapter.

...22 Scope of permit.

(a) All access permits will as a minimum authorize access, subject to the ... and conditions of the access permit, to Confidential Restricted Data in ...ories C-44 and C-65.

(b) In addition, access permits may authorize access, subject to the terms and conditions of the access permit, to ... Secret Restricted Data as is in... within the particular category or ...ories specified in the permit.

...23 Terms and conditions of access.

(a) Neither the United States, nor ... Commission, nor any person acting ... behalf of the Commission makes ... warranty or other representation, ... or implied, (1) with respect to ... accuracy, completeness or usefulness of any information made available ...suant to an access permit, or (2) ... the use of any such information ... not infringe privately owned ...

(b) The Commission hereby waives ... rights with respect to any invention or discovery as it may have pursuant ... section 152 of the Act by reason ... invention or discovery having ... made or conceived in the course of, ... connection with, or resulting from ... to Restricted Data received under ... terms of an access permit.

(c) Each permittee shall:

(1) Comply with all applicable provisions of the Atomic Energy Act of 1954 ... with Part 95 of this chapter and with all other applicable rules, regulations and orders of the Commission;

(2) Be deemed to have waived all claims for damages under section 193 of title 35 U.S. Code by reason of the imposition of any secrecy order on any patent application and all claims for just compensation under section 173 of the Atomic Energy Act of 1954, with respect to any invention or discovery made or conceived in the course of, in connection with or as a result of access to Restricted Data received under the terms of the access permit;

(3) Be deemed to have waived any and all claims against the United States, the Commission and all persons acting on behalf of the Commission that might arise in connection with the use, by the applicant, of any and all information supplied by them pursuant to the access permit;

(4) Obtain and preserve in his files written agreements from all individuals who will have access to Restricted Data under his access permit. The agreement shall be as follows:

In consideration for receiving access to Restricted Data under the access permit issued by the AEC, I hereby agree to:

(a) Waive all claims for damages under section 183 of Title 35 U.S. Code by reason of the imposition of any secrecy order on any patent application, and all claims for just compensation under section 173 of the Atomic Energy Act of 1954, with respect to any invention or discovery made or conceived in the course of, in connection with or resulting from access to Restricted Data received under the terms of the access permit issued to (insert the name of the holder of the access permit),

(b) Waive any and all claims against the United States, the Commission and all persons acting on behalf of the Commission that might arise in connection with the use, by me, of any and all information supplied by them pursuant to the access permit issued to (insert the name of the holder of the access permit).

(5) Pay all established charges for personnel security clearances, AEC consulting services, publication and reproduction of documents, and such other services as the Commission may furnish in connection with the access permit.

§ 25.25 Administration.

With respect to each permit issued pursuant to the regulations in this part, the cognizant Operations Office, will:

(a) Process all personnel security clearances requested in connection with the permit;

(b) Review the procedures submitted by the Applicant, in accordance with Part 95 of this chapter, for the safeguarding of Restricted Data; and

(c) Provided information to the permittee with respect to the sources and locations of Restricted Data available under this permit and to assist the permittee in other matters pertaining to the administration of his permit.

§ 25.25 Term and renewal.

(a) Each access permit will be issued for a two year term, unless otherwise stated in the permit.

(b) Applications for renewal shall be filed in accordance with § 25.11. Each renewal application must be complete, without reference to previous applications. In any case in which a permittee has filed a properly completed application for renewal more than thirty (30) days prior to the expiration of his existing permit, such existing permit shall not expire until the application for a renewal has been finally acted upon by the Commission.

§ 25.26 Assignment.

An access permit is nontransferable and nonassignable.

§ 25.27 Admendment.

An access permit may be amended from time to time upon application by the permittee. An application for amendment may be filed, in triplicate, in letter form and shall be signed by an individual authorized to sign on behalf of the applicant. The term of an access permit shall not be altered by an amendment thereto.

§ 25.28 Commission action on application to renew or amend.

In considering an application by a permittee to renew or amend his permit, the Commission will apply the criteria set forth in § 25.15. Failure of an applicant to reply to a Commission request for additional information concerning an application for renewal or amendment within 60 days shall result in rejection of the application without prejudice to resubmit a properly completed application at a later date.

§ 25.29 Suspension, revocation and termination of permits.

The Commission may revoke or suspend any access permit for any material false statement in the application or in any report submitted to the Commission pursuant to the regulations in this part or because of conditions or facts which would have warranted a refusal to grant the permit in the first instance, or for violation of any of the terms and conditions of the Atomic Energy Act of 1954 or Commission rules, regulations or orders issued pursuant thereto. A permittee should request termination of his permit when he no longer requires Restricted Data for use in his business, trade or profession.

§ 25.30 Exceptions and additional requirements.

Notwithstanding any other provision in the regulations in this part, the Commission may deny an application for an access permit or suspend or revoke an access permit, or incorporate additional conditions or requirements in any access permit, upon finding that such denial, revocation or the incorporation of such conditions and limitations is necessary or appropriate in the interest of the common defense and security or is otherwise in the public interest.

§ 25.31 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or any regulation or order issued thereunder. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty

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punished by fine or
both, as provided by l

Dated at Germantow
day of April 1960.

For the Atomic Ene

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APPENDIX

Categories of Restricte
Including Scope Notes f

C-44 *Nuclear Technol*
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cerning nuclear technolog
information on the follow
a. Materials, including
organic and inorganic
cluded are such technical
ology and fabrication of
mission studies, cladding te
ation studies.
b. Chemistry, chemical
radiochemistry of all the
compounds. Included ar
processes of chemical s
active waste handling a
processing.
c. Reactor physics, engi
nology including theory,
studies and operation of
systems and reactor comp
This category does not i
a. Information which
which can be calculated a
as distinguished from d
production rates and unit
tonium production progran
b. Information on an a
reactor system which falls
of the military reactor cate
44, 55 and 86.
c. Top Secret informati
tion concerning weapons o
and of isotope separation.
C-45 *Plutonium Produ*
gory includes information
ment and separations t
als or from which can
and or planned (as distin
) capacities, productio
for the Hanford and
production facilities.
technology which does
calculation of producti
of Hanford or Savann
facilities is categorize
Technology.

ion will apply the criteria
§ 25.15. Failure of an ap
ly to a Commission reques
al information concerning
on for renewal or amend
60 days shall result in a
he application without pre
ubmit a properly completed
at a later date.

spension, revocation and ter
n of permits.

mission may revoke or sus
cess permit for any material
nent in the application or in
submitted to the Commission
o the regulations in this part
of conditions or facts which
e warranted a refusal to grant
t in the first instance, or for
f any of the terms and condi
e Atomic Energy Act of 1954
ission rules, regulations or
ued pursuant thereto. A per
uld request termination of his
hen he no longer requires Re
Data for use in his business
profession.

Exceptions and additional re
ements.

hstanding any other provision
gulations in this part, the Com
may deny an application for an
ermit or suspend or revoke any
ermit, or incorporate additional
is or requirements in any ac
mit, upon finding that such
evocation or the incorporation
conditions and limitations is
y or appropriate in the inter
e common defense and security
erwise in the public interest.

Violations.

junction or other court order
obtained prohibiting any viola
any provision of the Act or any
on or order issued thereunder
son who willfully violates any
n of the Act or any regulation
issued thereunder may be guilty

a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

Dated at Germantown, Md., this 11th day of April 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

APPENDIX A

Categories of Restricted Data Available (Including Scope Notes for Each Category)

C-44 *Nuclear Technology.* This category includes classified technical information concerning nuclear technology. It may contain information on the following:

a. Materials, including metals, ceramics, organic and inorganic compounds. Included are such technical areas as the technology and fabrication of fuel elements, corrosion and fabrication studies, cladding techniques and radiation studies.

b. Chemistry, chemical engineering and radiochemistry of all the elements and their compounds. Included are techniques and processes of chemical separations, radioactive waste handling and feed material processing.

c. Reactor physics, engineering and technology including theory, design, criticality studies and operation of reactors, reactor systems and reactor components.

This category does not include:

a. Information which reveals or from which can be calculated actual or planned (as distinguished from design) capacities, production rates and unit costs for the plutonium production program; or

b. Information on an actual or planned reactor system which falls within the scope of military reactor categories—C-82, 83, 85 and 86.

c. Top Secret information and information concerning weapons or classified methods of isotope separation.

C-45 *Plutonium Production.* This category includes information on reactor, fuel element and separations technology which reveals or from which can be calculated actual or planned (as distinguished from design) capacities, production rates and unit costs for the Hanford and Savannah River production facilities.

Technology which does not reveal or enable calculation of production rates and unit costs of Hanford or Savannah River production facilities is categorized in C-44—Nuclear Technology.

APPENDIX B

Commission's Operations Offices

Albuquerque Operations Office, U.S. Atomic Energy Commission, P.O. Box 5400, Albuquerque, N. Mex.

Chicago Operations Office, U.S. Atomic Energy Commission, 9800 South Cass Avenue, Argonne, Ill.

Hanford Operations Office, U.S. Atomic Energy Commission, P.O. Box 550, Richland, Wash.

Idaho Operations Office, U.S. Atomic Energy Commission, P.O. Box 2108, Idaho Falls, Idaho.

New York Operations Office, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, N.Y.

Oak Ridge Operations Office, U.S. Atomic Energy Commission, P.O. Box E, Oak Ridge, Tenn.

San Francisco Operations Office, U.S. Atomic Energy Commission, 518 17th Street, Oakland 12, Calif.

Savannah River Operations Office, U.S. Atomic Energy Commission, P.O. Box A, Aiken, S.C.

Geographical areas of responsibility

Arizona, Kansas, New Mexico, Oklahoma, and Texas.

Illinois, Indiana, Iowa, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

Alaska, Oregon, and Washington.

Colorado, Idaho, Montana, Utah, and Wyoming.

Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

Arkansas, Kentucky, Louisiana, Mississippi, Missouri, Panama Canal Zone, Puerto Rico, Tennessee, Virginia, Virgin Islands, and West Virginia.

California, Hawaii, Nevada, and U.S. Pacific Territories.

Alabama, Florida, Georgia, North Carolina, and South Carolina.

PART 30—LICENSING OF BY PRODUCT MATERIAL

EXEMPT CONCENTRATIONS

On October 31, 1958, the Commission issued for public comment a proposed amendment to "Licensing of Byproduct Material," 10 CFR Part 30, which would exempt byproduct material from licensing requirements when contained in products in specified low concentrations. The amendment published below retains the substantive provisions set forth in the proposed rule although changes have been made in the text and concentration values to reflect recent information from the National Committee on Radiation Protection and is consonant with the Radiation Protection Guide approved by the President on May 13, 1960.

The exemption is intended to facilitate the distribution of products subjected to control procedures involving the use of byproduct material. With the exception of the person who introduces the byproduct material into a product, a license will not be required in order to receive, use, transfer, or dispose of such products. The licensee who introduces byproduct material into a product may transfer the byproduct material only if the transfer is made in accordance with a license issued pursuant to § 30.24(h) of the amendment. This limitation, however, would not restrict the transfer to a duly licensed person of byproduct material intended for analytical or laboratory purposes or for waste disposal.

The license-exempt concentrations in § 30.73 *Schedule C*, of the following amendment are equal to the lowest value for each byproduct material given in Table I of National Bureau of Standards Handbook 69 for continuous occupational exposure (168-hour week). The values selected are those for soluble forms which in general are lower than for insoluble forms. The products in which license-exempt concentrations would be permitted are items such as oil, gasoline, plastics, and similar commercial or industrial items where inhalation or ingestion is unlikely. In addition, while the concentration values in NBS 69 are based on continuous exposure for a whole lifetime, such exposure from the products involved here is highly unlikely. It is highly improbable, therefore, that any member of the public will receive an organ dose in excess of a small fraction of 0.5 rem, the Radiation Protection Guide for members of the general population recommended by the President in his memorandum dated May 13, 1960. The proposed exempt concentrations are high enough to make quality control applications feasible from the measurement standpoint and low enough to assure safety of the public.

The values set forth in the following amendment are established as concentrations which the Commission considers may be exempted from licensing requirements to the extent provided in this amendment. However, applicants for licenses pursuant to § 30.24(h) of the amendment will be required to show that, for their particular purpose, lower concentrations than those specified in § 30.73 are not feasible. The Commission does not propose to license the distribution of products containing byproduct material under this amendment if it is likely that such products will be ingested or inhaled.

Persons licensed under this amendment to distribute products containing byproduct material would be required to file an annual report describing the products transferred and the total amount of each byproduct material in such products transferred during the year. This will keep the Commission informed of the total amount of activity transferred in such concentrations and provide a basis for a continuing evaluation of the addition of radioactivity to the environment.

The scheduled concentrations pertain to the parent activity in those cases where a radioisotope disintegrates into other radioactive isotopes or daughter products. The proposed exemption does not extend to imports of byproduct material. Requirements for the issuance of a license authorizing the transfer of products or materials containing byproduct material are separately stated in § 30.24(h) of the amendment published below.

The Commission has found that the exemption set forth in this amendment will not constitute an unreasonable risk to the common defense and security and

to the health and s
Section 274 of the
of 1954, as amended
other things, proce
for the discontinuar
Commission's regul
ties with respect to
and special nuclear
assumption thereof
withstanding, any
the Commission an
assumption of regu
ties previously exe
mission, the Commi
under subsection 2
rule or order, "that
processor, or produ
ment, device, commo
uct containing sou
special nuclear mate
for possession or co
uct except pursuant
by the Commission."
Prior to executing
viding for assumptic
sponsibilities by a st
will consider exerci
conferred on it by su
respect to distributio
ered by the followin
Pursuant to the A
cedure Act, Public I
gress, 2d session, T
Part 30, "Licensing
rial." is amended a
thirty days after
FEDERAL REGISTER:
1. Add a new § 30.9
§ 30.9 Exempt conc
(a) Except as pro
any person is exemp
ments for a license
of the Act and fr
in this part to the ex
son receives, possess
uses or acquires pro
containing byproduc
centrations not in ex
in § 30.73.
(b) This section s
to authorize the im

by the President in his m dated May 13, 1960. The exempt concentrations are gh to make quality control s feasible from the measurement point and low enough to assure safety of the public.

ies set forth in the following it are established as concentrations which the Commission considers can be exempted from licensing requirements to the extent provided in the amendment. However, applicants for licenses pursuant to § 30.24(h) of the amendment will be required to show that for their particular purpose, lower concentrations than those specified in § 30.73 are not feasible. The Commission does not propose to license the distribution of products containing byproduct material under this amendment if it is likely that such products will be ingested or inhaled.

ns licensed under this amendment to distribute products containing byproduct material would be required to file an annual report describing the kinds of products transferred and the total quantity of each byproduct material in such products transferred during the year. This will keep the Commission informed of the total amount of activity transferred in such concentrations and provide a basis for a continuing evaluation of the addition of radioactivity to the environment.

scheduled concentrations pertain to the parent activity in those cases where a radioisotope disintegrates into other radioactive isotopes or daughter products. The proposed exemption does not extend to imports of byproduct material. Requirements for the issuance of a license authorizing the transfer of products or materials containing byproduct material are separately stated in § 30.24(h) of the amendment published below.

The Commission has found that the exemption set forth in this amendment will not constitute an unreasonable risk to the common defense and security and to the health and safety of the public.

Section 274 of the Atomic Energy Act of 1954, as amended, establishes, among other things, procedures and criteria for the discontinuance of certain of the Commission's regulatory responsibilities with respect to byproduct, source, and special nuclear materials, and the assumption thereof by the states. Notwithstanding, any agreement between the Commission and any state for the assumption of regulatory responsibilities previously exercised by the Commission, the Commission is authorized under subsection 274c, to require, by rule or order, "that the manufacturer, processor, or producer of any equipment, device, commodity, or other product containing source, byproduct, or special nuclear material shall not transfer possession or control of such product except pursuant to a license issued by the Commission."

Prior to executing any agreement providing for assumption of regulatory responsibilities by a state, the Commission will consider exercising the authority conferred on it by subsection 274c with respect to distribution of products covered by the following amendments.

Pursuant to the Administrative Procedure Act, Public Law 404, 79th Congress, 2d session, Title 10, Chapter I, Part 30, "Licensing of Byproduct Material" is amended as follows, effective [illegible] days after publication in the Federal Register:

1. Add a new § 30.9 to read as follows:

§ 30.9 Exempt concentrations.

(a) Except as provided in § 30.32(f), any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in this part to the extent that such person receives, possesses, uses, transfers, owns or acquires products or materials containing byproduct material in concentrations not in excess of those listed in § 30.73.

(b) This section shall not be deemed to authorize the import of byproduct material or products containing byproduct material.

§ 30.24 [Amendment]

2. Add a new § 30.24(h) to read as follows:

(h) *Licensing the transfer of products containing exempt concentrations of byproduct material.* (1) An application for a specific license to transfer possession or control of products or materials containing exempt concentrations of byproduct material which the transferor has introduced into the product or material will be approved if the applicant:

(i) Satisfies the general requirements specified in § 30.23;

(ii) Submits a description of the product or material into which the byproduct material will be introduced, intended use of the byproduct material and the product into which it is introduced, method of introduction, initial concentration of the byproduct material in the product or material, control methods to assure that no more than the specified concentration is introduced into the product or material, estimated time interval between introduction and transfer of the product or material, and estimated concentration of the radioisotope in the product or material at the time of transfer by the licensee; and

(iii) Provides reasonable assurance that the concentrations of the byproduct material at the time of transfer will not exceed the concentrations in § 30.73, that reconcentration of the byproduct material in concentrations exceeding those in § 30.73 is not likely, that the product or material is not likely to be inhaled or ingested, and that use of lower concentrations is not feasible.

(2) Each person licensed under this paragraph shall file an annual report with the Director, Division of Licensing and Regulation, describing the kinds and quantities of products transferred, the concentration of byproduct material contained and the quantity of byproduct

material transferred during the reporting period. Each report shall be filed as of June 30 and shall be filed within 30 days thereafter.

§ 30.32 [Amendment]

3. Add a new § 30.32(f) to read as follows:

(f) Notwithstanding the provisions of §§ 30.9 and 30.32(c) of this part, no person licensed by the Commission pursuant to the regulations in this part shall transfer possession or control of any product or material containing concentrations of byproduct material not exceeding those specified in § 30.73 which he has introduced into the product or material unless the transferor has received a license from the Commission pursuant to § 30.24(h) authorizing such transfer. The provisions of this paragraph (f) shall not apply to transfers to duly licensed persons of products or materials containing byproduct material for analytical, laboratory, or waste disposal purposes. This paragraph shall not be deemed to modify any authority granted to any person in a specific license issued by the Commission prior to the effective date of this paragraph.

4. Add a new § 30.73 to read as follows:

§ 30.73 Schedule C.

Element (atomic number)	Isotope	Column I Gas concentration uc/ml [1]	Column II Liquid and solid concentration uc/ml [2]
Antimony (51)	Sb 122		3×10^{-4}
	Sb 124		2×10^{-4}
	Sb 125		1×10^{-3}
Argon (18)	A 37	1×10^{-3}	
	A 41	4×10^{-7}	
Arsenic (33)	As 73		5×10^{-3}
	As 74		5×10^{-4}
	As 76		2×10^{-4}
	As 77		8×10^{-4}
Barium (56)	Ba 131		2×10^{-3}
	Ba 140		3×10^{-4}
Beryllium (4)	Be 7		2×10^{-2}
Bismuth (83)	Bi 206		[illegible]
Bromine (35)	Br 82	4×10^{-7}	[illegible]
Cadmium (48)	Cd 109		[illegible]
	Cd 115m		[illegible]
	Cd 115		[illegible]
Calcium (20)	Ca 45		[illegible]
	Ca 47		[illegible]
Carbon (6)	C 14	1×10^{-6}	[illegible]
Cerium (58)	Ce 141		[illegible]
	Ce 143		[illegible]
	Ce 144		[illegible]
Cesium (55)	Cs 131		[illegible]
	Cs 134m		[illegible]
	Cs 134		[illegible]
Chlorine (17)	Cl 38	9×10^{-7}	[illegible]
Chromium (24)	Cr 51		[illegible]
Cobalt (27)	Co 57		[illegible]
	Co 58		[illegible]
	Co 60		[illegible]
Copper (29)	Cu 64		[illegible]
Dysprosium (66)	Dy 165		[illegible]
	Dy 166		[illegible]
Erbium (68)	Er 169		[illegible]
	Er 171		[illegible]
Europium (63)	Eu 152 (T/2N9.2 Hrs)		[illegible]
	Eu 155		[illegible]
Fluorine (9)	F 18	2×10^{-6}	[illegible]
Gadolinium (64)	Gd 153		[illegible]
	Gd 159		[illegible]
Gallium (31)	Ga 72		[illegible]
Germanium (32)	Ge 71		[illegible]
Gold (79)	Au 196		[illegible]
	Au 198		[illegible]
	Au 199		[illegible]
Hafnium (72)	Hf 181		[illegible]
Hydrogen (1)	H 3	5×10^{-6}	[illegible]
Indium (49)	In 113m		[illegible]
	In 114m		[illegible]
Iodine (53)	I 126	3×10^{-9}	[illegible]
	I 131	3×10^{-9}	[illegible]
	I 132	8×10^{-8}	[illegible]
	I 133	1×10^{-8}	[illegible]
	I 134	2×10^{-7}	[illegible]
Iridium (77)	Ir 190		[illegible]
	Ir 192		[illegible]
	Ir 194		[illegible]
Iron (26)	Fe 55		[illegible]
	Fe 59		[illegible]
Krypton (36)	Kr 85m	1×10^{-6}	
	Kr 85	3×10^{-6}	
Lanthanum (57)	La 140		[illegible]
Lead (82)	Pb 203		[illegible]
Lutetium (71)	Lu 177		[illegible]

See footnotes at end of table.

Element (atomic number)	Isotope
Manganese (25)	Mn 52
	Mn 54
	Mn 56
Mercury (80)	Hg 197m
	Hg 197
	Hg 203
Molybdenum (42)	Mo 99
[illegible]dymium (60)	Nd 147
	Nd 149
Nickel (28)	Ni 65
[illegible]bium (Columbium) (41)	Nb 95
	Nb 97
[illegible] (76)	Os 185
	Os 191m
	Os 191
	Os 193
Palladium (46)	Pd 103
	Pd 109
Phosphorus (15)	P 32
Platinum (78)	Pt 191
	Pt 193m
	Pt 197m
	Pt 197
[illegible]ium (19)	K 42
[illegible]odymium [illegible]	Pr 142
	Pr 143
[illegible]ethium [illegible]	Pm 147
	Pm 149
[illegible] (75)	Re 183
	Re 186
	Re 188
[illegible] (45)	Rh 103m
	Rh 105
[illegible] (37)	Rb 86
[illegible] (44)	Ru 97
	Ru 103
	Ru 105
	Ru 106
[illegible] (62)	Sm 153
[illegible] (21)	Sc 46
	Sc 47
	Sc 48
[illegible] (34)	Se 75
[illegible] (14)	Si 31
[illegible] (47)	Ag 105
	Ag 110m
	Ag 111
[illegible] (11)	Na 24
[illegible] (38)	Sr 89
	Sr 91
	Sr 92
[illegible] (16)	S 35
[illegible] (73)	Ta 182
[illegible] (43)	Tc 96m
	Tc 96

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Isotope	Column I Gas concentration uc/ml [1]	Column II Liquid and solid concentration uc/ml [2]
206	----------	[illegible]
82	4×10[illegible]	[illegible]
109	----------	[illegible]
115m	----------	[illegible]
115	----------	[illegible]
a 45	----------	[illegible]
a 47	----------	[illegible]
14	1×10^{-4}	[illegible]
e 141	----------	[illegible]
e 143	----------	[illegible]
e 144	----------	[illegible]
s 131	----------	[illegible]
s 134m	----------	[illegible]
s 134	----------	[illegible]
Cl 38	9×10[illegible]	[illegible]
Cr 51	----------	[illegible]
Co 57	----------	[illegible]
Co 58	----------	[illegible]
Co 60	----------	[illegible]
Cu 64	----------	[illegible]
Dy 165	----------	[illegible]
Dy 166	----------	[illegible]
Er 169	----------	[illegible]
Er 171	----------	[illegible]
Eu 152 (T/2N9.2 Hrs)	----------	[illegible]
Eu 155	----------	[illegible]
F 18	2×10[illegible]	[illegible]
Gd 153	----------	[illegible]
Gd 159	----------	[illegible]
Ga 72	----------	[illegible]
Ge 71	----------	[illegible]
Au 196	----------	[illegible]
Au 198	----------	[illegible]
Au 199	----------	[illegible]
Hf 181	----------	[illegible]
H 3	5×10[illegible]	[illegible]
In 113m	----------	[illegible]
In 114m	----------	[illegible]
I 126	3×10[illegible]	[illegible]
I 131	3×10[illegible]	[illegible]
I 132	8×10[illegible]	[illegible]
I 133	1×10[illegible]	[illegible]
I 134	2×10[illegible]	[illegible]
Ir 190	----------	[illegible]
Ir 192	----------	[illegible]
Ir 194	----------	[illegible]
Fe 55	----------	[illegible]
Fe 59	----------	[illegible]
Kr 85m	1×10[illegible]	
Kr 85	3×10[illegible]	
La 140	----------	[illegible]
Pb 203	----------	[illegible]
Lu 177	----------	[illegible]

es at end of table.

5006973

Element (atomic number)	Isotope	Column I Gas concentration uc/ml [1]	Column II Liquid and solid concentration uc/ml [2]
…anese (25)	Mn 52	----------	3×10^{-4}
	Mn 54	----------	1×10^{-3}
	Mn 56	----------	1×10^{-3}
…ury (80)	Hg 197m	----------	2×10^{-3}
	Hg 197	----------	3×10^{-3}
	Hg 203	----------	2×10^{-4}
…bdenum	Mo 99	----------	2×10^{-3}
…ymium	Nd 147	----------	6×10^{-4}
	Nd 149	----------	3×10^{-3}
… (28)	Ni 65	----------	1×10^{-3}
… (Co-…bium) (41)	Nb 95	----------	1×10^{-3}
	Nb 97	----------	9×10^{-3}
… (76)	Os 185	----------	7×10^{-4}
	Os 191m	----------	3×10^{-2}
	Os 191	----------	2×10^{-3}
	Os 193	----------	6×10^{-4}
…dium (46)	Pd 103	----------	3×10^{-3}
	Pd 109	----------	9×10^{-4}
…orus (15)	P 32	----------	2×10^{-4}
…num (78)	Pt 191	----------	1×10^{-3}
	Pt 193m	----------	1×10^{-2}
	Pt 197m	----------	1×10^{-2}
	Pt 197	----------	1×10^{-3}
…um (19)	K 42	----------	3×10^{-3}
…ymium	Pr 142	----------	3×10^{-4}
	Pr 143	----------	5×10^{-4}
…thium	Pm 147	----------	2×10^{-3}
	Pm 149	----------	4×10^{-4}
… (75)	Re 183	----------	6×10^{-3}
	Re 186	----------	9×10^{-4}
	Re 188	----------	6×10^{-4}
… (45)	Rh 103m	----------	1×10^{-1}
	Rh 105	----------	1×10^{-3}
… (37)	Rb 86	----------	7×10^{-4}
…um (44)	Ru 97	----------	4×10^{-3}
	Ru 103	----------	8×10^{-4}
	Ru 105	----------	1×10^{-3}
	Ru 106	----------	1×10^{-4}
… (62)	Sm 153	----------	8×10^{-4}
… (21)	Sc 46	----------	4×10^{-4}
	Sc 47	----------	9×10^{-4}
	Sc 48	----------	3×10^{-4}
… (34)	Se 75	----------	3×10^{-3}
… (14)	Si 31	----------	9×10^{-3}
…	Ag 105	----------	1×10^{-3}
	Ag 110m	----------	3×10^{-4}
	Ag 111	----------	4×10^{-4}
… (11)	Na 24	----------	2×10^{-3}
… (38)	Sr 89	----------	1×10^{-4}
	Sr 91	----------	7×10^{-4}
	Sr 92	----------	7×10^{-4}
…	S 35	9×10^{-8}	6×10^{-4}
… (73)	Ta 182	----------	4×10^{-4}
… (43)	Tc 96m	----------	1×10^{-1}
	Tc 96	----------	1×10^{-3}

Element (atomic number)	Isotope	Column I Gas concentration uc/ml	Column II Liquid and solid concentration uc/ml [2]
Tellurium (52)	Te 125m	----------	2×10^{-3}
	Te 127m	----------	6×10^{-4}
	Te 127	----------	3×10^{-3}
	Te 129m	----------	3×10^{-4}
	Te 131m	----------	6×10^{-4}
	Te 132	----------	3×10^{-4}
Terbium (65)	Tb 160	----------	4×10^{-4}
Thallium (81)	Tl 200	----------	4×10^{-3}
	Tl 201	----------	3×10^{-3}
	Tl 202	----------	1×10^{-3}
	Tl 204	----------	1×10^{-3}
Thullium (69)	Tm 170	----------	5×10^{-4}
	Tm 171	----------	5×10^{-3}
Tin (50)	Sn 113	----------	9×10^{-4}
	Sn 125	----------	2×10^{-4}
Tungsten (Wolfram) (74).	W 181	----------	4×10^{-3}
	W 187	----------	7×10^{-4}
Vanadium (23)	V 48	----------	3×10^{-4}
Xenon (54)	Xe 131m	4×10^{-6}	----------
	Xe 133	3×10^{-6}	----------
	Xe 135	1×10^{-6}	----------
Ytterbium (70)	Yb 175	----------	1×10^{-3}
Yttrium (39)	Y 90	----------	2×10^{-4}
	Y 91m	----------	3×10^{-2}
	Y 91	----------	3×10^{-4}
	Y 92	----------	6×10^{-4}
	Y 93	----------	3×10^{-4}
Zinc (30)	Zn 65	----------	1×10^{-3}
	Zn 69m	----------	7×10^{-4}
	Zn 69	----------	2×10^{-2}
Zirconium (40)	Zr 95	----------	6×10^{-4}
	Zr 97	----------	2×10^{-4}
Beta and/or gamma emitting byproduct material not listed above with half-life less than 3 years.	----------	1×10^{-10}	1×10^{-6}

NOTE 1: Many radioisotopes disintegrate into isotopes which are also radioactive. In expressing the concentrations in Schedule C, the activity stated is that of the parent isotope and takes into account the daughters.

NOTE 2: For purposes of § 30.9 where there is involved a combination of isotopes, the limit for the combination should be derived as follows:

Determine for each isotope in the product the ratio between the concentration present in the product and the exempt concentration established in Schedule C for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity). (Footnote Continued on following page.)

Dated at Germantown, Md., this 8th day of August 1960.

For the Atomic Energy Commission.

R. E. HOLLINGSWORTH,
Acting General Manager.

PART 30—LICENSING OF BYPRODUCT MATERIAL

LICENSING CRITERIA FOR RADIOGRAPHY

On March 15, 1960, the Commission issued for public comment a proposed amendment to 10 CFR Part 30 which would establish special requirements for the issuance of specific licenses for the use of sealed sources of byproduct material in radiography. Comments filed by interested persons have been given careful consideration.

The following rules are published as a document subject to codification, effective 30 days after publication in the FEDERAL REGISTER. The requirements of this regulation are in addition to, and not in substitution for, other requirements of the Atomic Energy Commission.

1. Add the following definitions to § 30.4:

(r) "Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the regulations of this part and the conditions of the license.

(s) "Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or survey instruments in radiography.

Example:

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} + \frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} \leq 1$$

[1] Values are given only for those materials normally used as gases.

[2] uc/gm for solids.

(t) "Radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of byproduct materials.

2. Revise § 30.4(1) to read as follows:

(1) "Sealed source" means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material.

3. Add the following paragraph to § 30.24:

(g) *Use of sealed sources in radiography.* An application for a specific license for use of sealed sources in radiography will be approved if:

(1) The applicant satisfies the general requirements specified in § 30.23; and

(2) The applicant will have an adequate program for training radiographers and radiographers' assistants and submits to the Commission a schedule or description of such program which specifies the:

(i) Initial training;

(ii) Periodic training;

(iii) On-the-job training;

(iv) Means to be used by the licensee to determine the radiographer's knowledge and understanding of and ability to comply with Commission regulations and licensing requirements, and the operating and emergency procedures of the applicant;

(v) Means to be used by the licensee to determine the radiographer's assistant's knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant; and

(3) The applicant has established and submits to the Commission satisfactory written operating and emergency procedures as described in § 31.202 of this chapter; and

(4) The applicant will have an adequate internal inspection system or other management control, to assure that Commission license provisions, Commission regulations, and the applicant's operating and emergency pro-

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Dated at Germant
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For the Atomic E
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PART 31—RADIATION
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ures are followed by radiographers and radiographer's assistants; and

(5) The applicant submits a description of its overall organizational structure pertaining to the radiography program, including specified delegations of authority and responsibility for operation of the program; and

(6) The applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources, for possible leakage and contamination and submits to the Commission a description of such procedures including:

(i) Instrumentation to be used,

(ii) Method of performing test, e.g., points on equipment to be smeared and method of taking smear, and

(iii) Pertinent experience of the person who will perform the test.

(Sec. 161, 68 Stat. 948; 42 U.S.C. 2201)

Dated at Germantown, Md., this 18th day of November 1960.

For the Atomic Energy Commission.

WOODFORD B. MCCOOL,
Secretary.

PART 31—RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

On March 15, 1960, the Commission published for public comment a new proposed regulation, 10 CFR Part 31, to establish radiation safety requirements for persons utilizing sealed sources of byproduct material for radiography. Comments filed by interested persons have been given careful consideration. The regulation is designed to codify provisions which have been developed through experience and applied in the course of licensing radiography operations. It will minimize the need for the inclusion in licenses of special provisions applicable to radiography and provides guidance as to information required in license applications.

The following rules are published as a document subject to codification, effective 30 days after publication in the FEDERAL REGISTER. The requirements of this regulation are in addition to, and not in substitution for, other requirements of the Atomic Energy Commission.

AUTHORITY: §§ 31.1 to 31.501 issued under sec. 161, 68 Stat. 948; 42 U.S.C. 2201.

GENERAL PROVISIONS

§ 31.1 Purpose.

The regulations in this part establish radiation safety requirements for persons utilizing sealed sources of byproduct material for radiography. The requirements of this part are in addition to, and not in substitution for, other requirements of this chapter.

§ 31.2 Scope.

The regulations in this part apply to all licensees who use byproduct material for radiography under a license issued by the Commission pursuant to the regulations in Part 30 of this chapter: *Provided, however*, That nothing in this part shall apply to uses of byproduct material for medical diagnosis or therapy.

§ 31.3 Definitions.

As used in this part:

(a) "Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of these regulations and the conditions of the license.

(b) "Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or survey instruments in radiography.

(c) "Radiographic Exposure Device" means any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved, or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure.

(d) "Radiography" means the examination of the structure of materials by nondestructive methods utilizing sealed sources of byproduct material.

(e) "Sealed source" means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material.

(f) "Storage Container" means a device in which sealed sources are transported or stored.

(g) Other terms defined in section 11 of the Atomic Energy Act, as amended, shall have the same meaning when used in this part.

§ 31.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

EQUIPMENT CONTROL

§ 31.101 Limits on levels of radiation for radiographic exposure devices and storage containers.

Radiographic exposure devices measuring less than four (4) inches from the sealed source storage position to any exterior surface of the device shall have no radiation level in excess of 50 milliroentgens per hour at six (6) inches from any exterior surface of the device. Radiographic exposure devices measuring a minimum of four (4) inches from the sealed source storage position to any exterior surface of the device, and all storage containers for sealed sources or for radiographic exposure devices, shall have no radiation level in excess of 200 milliroentgens per hour at any exterior surface, and ten (10) milliroentgens per hour at one meter from any exterior surface. The radiation levels specified are with the sealed source in the shielded (i.e., "off") position.

§ 31.102 Locking of radiographic exposure devices and storage containers.

Each radiographic exposure device shall be provided with a lock or outer locked container designed to prevent unauthorized or accidental removal or exposure of a sealed source and shall be kept locked at all times except when under the direct surveillance of a radiographer or radiographer's assistant or as may be otherwise authorized pursuant to § 31.301. Each storage container likewise shall be provided with a lock and kept locked when containing sealed sources except when the con-

tainer is under the
of a radiographer
assistant.

§ 31.103 Storage pr

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§ 31.104 Radiation s

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§ 31.105 Leak testing
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§ 31.103 Storage precautions.

Locked radiographic exposure devices and storage containers shall be physically secured to prevent tampering or removal by unauthorized personnel.

§ 31.104 Radiation survey instruments.

The licensee shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by this part and Part 20 of this chapter. Each radiation survey instrument shall be calibrated at intervals not to exceed three (3) months and after each instrument servicing and a record maintained of the latest date of calibration. Instrumentation required by this section shall have a range such that two milliroentgens per hour through one roentgen per hour can be measured.

§ 31.105 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.

(a) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized by the Commission to do so.

(b) Each sealed source shall be tested for leakage at intervals not to exceed 6 months. In the absence of a certificate from a transferor that a test has been made within the 6 months prior to the transfer, the sealed source shall not be put into use until tested.

(c) The leak test shall be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed source storage position, or other appropriate measuring point, by a procedure to be approved pursuant to § 30.24(g)(6) of this chapter. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission.

(d) Any test conducted pursuant to paragraphs (b) and (c) of this section which reveals the presence of 0.005 microcurie or more of removable radioactive material shall be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or to be disposed of, in accordance with Commission regulations. A report shall be filed, within 5 days of the test, with the Director, Division of Licensing and Regulation, U.S. Atomic Energy Commission, Washington 25, D.C., describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall be sent to the Manager of the nearest Atomic Energy Commission Operations Office listed in Appendix D of Part 20 of this chapter "Standards For Protection Against Radiation."

(e) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least one (1) inch square bearing the prescribed radiation caution symbol in conventional colors, magenta or purple on a yellow background, and at least the instructions: "Danger—Radioactive Material—Do Not Handle—Notify Civil Authorities if Found."

§ 31.106 Quarterly inventory.

Each licensee shall conduct a quarterly physical inventory to account for all sealed sources received and possessed under his license. The records of the inventories shall be maintained for inspection by the Commission, and shall include the quantities and kinds of byproduct material, location of sealed sources, and the date of the inventory.

§ 31.107 Utilization logs.

Each licensee shall maintain current logs, which shall be kept available for inspection by the Commission at the address specified in the license, showing for each sealed source the following information:

(a) A description (or make and model number) of the radiographic exposure device or storage container in which the sealed source is located;

(b) The identity of the radiographer to whom assigned; and

(c) The plant or site where used and dates of use.

PERSONAL RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHERS AND RADIOGRAPHERS' ASSISTANTS

§ 31.201 Limitations.

(a) The licensee shall not permit any person to act as a radiographer as defined in this part until such person:

(1) Has been instructed in the subjects outlined in Appendix A of this part and shall have demonstrated understanding thereof;

(2) Has received copies of and instruction in the regulations contained in this part and the applicable sections of Part 20 of this chapter, AEC license(s), and the licensee's operating emergency procedures, and shall have demonstrated understanding thereof; and

(3) Has demonstrated competence to use the radiographic exposure devices, sealed sources, related handling tools and survey instruments which will be employed in his assignment.

(b) The licensee shall not permit any person to act as a radiographer's assistant as defined in this part until such person:

(1) Has received copies of and instructions in the licensee's operating and emergency procedures, and shall have demonstrated understanding thereof; and

(2) Has demonstrated competence to use under the personal supervision of the radiographer the radiographic exposure devices, sealed sources, related handling tools and radiation survey instruments which will be employed in his assignment.

§ 31.202 Operating and emergency procedures.

The licensee's operating and emergency procedures shall include instructions in at least the following:

(a) The handling and use of licensed sealed sources and radiographic exposure devices to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in Part 20 of this chapter "Standards For Protection Against Radiation";

(b) Methods and occasions for conducting radiation surveys;

(c) Methods for controlling access to radiographic areas;

(d) Methods and occasions for locking and securing radiographic exposure devices, storage containers and sealed sources;

(e) Personnel monitoring and the use of personnel monitoring equipment;

(f) Transporting sealed sources to field locations, including packing of radiographic exposure devices and storage containers in the vehicles, posting of vehicles and control of the sealed sources during transportation;

(g) Minimizing exposure of persons in the event of an accident;

(h) The procedure for notifying proper persons in the event of an accident; and

(i) Maintenance of records.

§ 31.203 Personnel monitoring control.

(a) The licensee shall not permit any person to act as a radiographer or as a radiographer's assistant unless, at all times during radiographic operations each such person shall wear a film badge and either a pocket dosimeter or pocket chamber. Pocket dosimeters and pocket chambers shall be capable of measuring doses from zero to at least 200 milliroentgens. A film

badge shall be assigned
only one person.

(b) Pocket dosimet
chambers shall be rea
corded daily. A film
immediately processed
chamber or pocket do
charged beyond its ra
badge reports received
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shall be maintained fo
the Commission.

PRECAUTIONARY PROCEDU
GRAPHIC OPERA

§ 31.301 Security.

During each radiogra
the radiographer or rad
assistant shall maintain a
lance of the operation to
unauthorized entry into a
area, as defined in Part 2
ter, except (a) where the
area is equipped with a
or an alarm system a
§ 20.203(c)(2), or (b) w
radiation area is lock
against unauthorized
entry.

§ 31.302 Posting.

Notwithstanding any
§ 20.204(c) of this cha
which radiography is be
shall be conspicuously
quired by § 20.203 (b) a
this chapter.

§ 31.303 Radiation surv
records.

(a) No radiographic o
be conducted unless cali
erable radiation survey in
as described in § 31.104 is
used at each site where
exposures are made.

(b) A physical radiatio
be made after each rad
exposure during a radiogra
to determine that the seal
been returned to its shiel

badge shall be assigned to and worn by only one person.

(b) Pocket dosimeters and pocket chambers shall be read and doses recorded daily. A film badge shall be immediately processed if a pocket chamber or pocket dosimeter is discharged beyond its range. The film badge reports received from the film badge processor and records of pocket dosimeter and pocket chamber readings shall be maintained for inspection by the Commission.

PRECAUTIONARY PROCEDURES IN RADIOGRAPHIC OPERATIONS

§ 31.301 Security.

During each radiographic operation the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Part 20 of this chapter, except (a) where the high radiation area is equipped with a control device or an alarm system as described in § 20.203(c)(2), or (b) where the high radiation area is locked to protect against unauthorized or accidental entry.

§ 31.302 Posting.

Notwithstanding any provisions in § 20.204(c) of this chapter, areas in which radiography is being performed shall be conspicuously posted as required by § 20.203 (b) and (c)(1) of this chapter.

§ 31.303 Radiation surveys and survey records.

(a) No radiographic operation shall be conducted unless calibrated and operable radiation survey instrumentation as described in § 31.104 is available and used at each site where radiographic exposures are made.

(b) A physical radiation survey shall be made after each radiographic exposure during a radiographic operation to determine that the sealed source has been returned to its shielded condition.

(c) A physical radiation survey shall be made to determine that each sealed source is in its shielded condition prior to securing the radiographic exposure device and storage container as specified in § 31.102.

(d) Records shall be kept of the surveys required by paragraph (c) of this section and maintained for inspection by the Commission.

EXEMPTIONS AND ADDITIONAL REQUIREMENTS

§ 31.401 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 31.402 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

§ 31.501 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provisions of the Act or any regulation or order issued thereunder. Any person who wilfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment, or both, as provided by law.

APPENDIX A

I. Fundamentals of radiation safety.

A. Characteristics of gamma radiation.

B. Units of radiation dose (mrem) and quantity of radioactivity (curie).

C. Hazards of excessive exposure of radiation.

D. Levels of radiation from licensed material.

E. Methods of controlling radiation dose.
1. Working time.
2. Working distances.
3. Shielding.
II. Radiation detection instrumentation to be used.
A. Use of radiation survey instruments.
1. Operation.
2. Calibration.
3. Limitations.
B. Survey techniques.
C. Use of personnel monitoring equipment.
1. Film badges.
2. Pocket dosimeters.
3. Pocket chambers.
III. Radiographic equipment to be used.
A. Remote handling equipment.
B. Radiographic exposure devices.
C. Storage containers.
IV. The requirements of pertinent Federal Regulations.
V. The licensee's written operating and emergency procedures.

Dated at Germantown, Maryland this 18th day of November 1960.

For the Atomic Energy Commission.

WOODFORD B. MCCOOL,
Secretary.

PART 40—CONTROL OF SOURCE MATERIAL

EXEMPTED PRODUCTS; URANIUM

The following amendment is designed to relieve persons receiving or possessing uranium contained in aircraft counterweights installed in aircraft from the necessity of obtaining a specific license from the Atomic Energy Commission authorizing such receipt or possession. Under the amendment to § 40.60, the uranium in such counterweights is exempted from the specific licensing requirement of § 40.10 relating to transfers, deliveries and receipt of possession or title. The Commission has found that the transfer, delivery and receipt of possession or title to uranium in such products involve unimportant quantities of source material within the meaning of section 62 of the Atomic Energy Act of 1954, as amended, which are not of significance to the common defense and security, and that such activities can be conducted without adversely affecting public health and safety.

Inasmuch as this amendment is intended to relieve from rather than to impose restrictions under regulations currently in effect and will not adversely affect the public health and safety, the Commission has found that general notice of proposed rule making and public procedure thereon are unnecessary and good cause exists why this amendment should be made effective without the customary period of notice and prior publication in the FEDERAL REGISTER.

Effective upon publication in the FEDERAL REGISTER, Part 40, Title 10, Code of Federal Regulations, "Control of Source Material," is hereby amended as follows:

Section 40.60 *Schedule I: Exempted products* is amended to include an additional exempted product by the addition of the following new paragraph (i):

(i) Uranium contained in aircraft counterweights installed in aircraft provided that any such counterweight has been impressed with a statement, clearly legible after plating, which states "Caution—Radioactive Material—Uranium"; and provided further that the exemption contained in this paragraph shall not be deemed to authorize the chemical, physical, metallurgical or other treatment or processing of any such counterweight or the installation in, or removal from, an aircraft of any such counterweight, without a specific license from the Commission.

Dated at Germantown, Md., this [illegible] day of June 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

PART 50—LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

DEFINITION OF "TESTING FACILITY"; HEARING AND REPORTS

The following amendments implement subsection 182b and 189a of the Atomic Energy Act of 1954, as amended, by incorporating in 10 CFR Part 50 a definition of "testing facility" and the statu-

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Advisory Committee on
guards and formal hear
applications for power an

Notice of proposed iss
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ERAL REGISTER on Marcl
F.R. 2449).

Effective 30 days after
the FEDERAL REGISTER, 1(
is hereby amended as fol

1. Paragraph (r) of §
nated paragraph (s).
new paragraph (r) is ad

§ 50.2 Definitions.

* * *

(r) "Testing facility"
clear reactor which is
scribed in § 50.21(c) and
application has been filed
authorizing operation at:

(1) A thermal power le
of 10 megawatts; or

(2) A thermal power le
of 1 megawatt, if the reac
tain:

(i) A circulating loop
core in which the applican
conduct fuel experiments;

(ii) A liquid fuel loadin

(iii) An experimental f
core in excess of 16 squa
cross-section.

2. The following new
added:

§ 50.57 Hearing and repor
visory Committee on R
guards.

(a) Each application for
a production or utilizat
which is of a type describe
(b) or 50.22 and each appl
license for a testing facilit
any application for a pr
utilization facility which i
scribed in § 50.21 (a) or
referred to the Advisory C
Reactor Safeguards for rev
port thereon. Such repo
made part of the record of

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...ary requirement of review by the Advisory Committee on Reactor Safeguards and formal hearings on license applications for power and test reactors.

Notice of proposed issuance of these amendments was published in the FEDERAL REGISTER on March 28, 1959 (24 F.R. 2449).

Effective 30 days after publication in the FEDERAL REGISTER, 10 CFR Part 50 is hereby amended as follows:

1. Paragraph (r) of § 50.2 is redesignated paragraph (s). The following new paragraph (r) is added to § 50.2:

§ 50.2 Definitions.

* * * * *

(r) "Testing facility" means a nuclear reactor which is of a type described in § 50.21(c) and for which an application has been filed for a license authorizing operation at:

(1) A thermal power level in excess of 10 megawatts; or

(2) A thermal power level in excess of 1 megawatt, if the reactor is to contain:

(i) A circulating loop through the core in which the applicant proposes to conduct fuel experiments; or

(ii) A liquid fuel loading; or

(iii) An experimental facility in the core in excess of 16 square inches in cross-section.

2. The following new section is added:

§ 50.57 Hearing and reports of the Advisory Committee on Reactor Safeguards.

(a) Each application for a license for a production or utilization facility which is of a type described in §§ 50.21 (b) or 50.22 and each application for a license for a testing facility shall, and any application for a production or utilization facility which is of a type described in § 50.21 (a) or (c) may, be referred to the Advisory Committee on Reactor Safeguards for review and report thereon. Such report shall be made part of the record of the application and available to the public, except to the extent that security classification prevents disclosure.

(b) The Commission will hold a hearing after 30 days' notice and publication once in the FEDERAL REGISTER on each application for a license for a production or utilization facility which is of a type described in §§ 50.21(b) or 50.22, and on each application for a license for a testing facility.

(Sec. 161, 60 Stat. 948; 42 U.S.C. 2201)

Dated at Germantown, Md., this 29th day of January, 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

PART 70—SPECIAL NUCLEAR MATERIAL

MISCELLANEOUS AMENDMENTS

On August 6, 1959, the Atomic Energy Commission issued for public comment a proposed amendment to Part 70 requiring that persons holding special nuclear material licenses furnish the Commission semi-annual reports as of June 30 and December 31 concerning special nuclear material distributed by the Commission pursuant to section 53 of the Atomic Energy Act of 1954, as amended. These reports, to be submitted on Form AEC–578, would provide the Commission with information concerning special nuclear material received, transferred or possessed by the licensee or for which the licensee is financially responsible to the Commission. In addition to providing information semi-annually as to the location of material, the report would include information needed in computing use, loss of material and related charges for special nuclear material.

Based on comments received from interested persons, certain revisions have been made in the proposed reporting form and in the accompanying instructions. On the form itself Item 1d has been added to identify the ending date of the period for which the report is prepared. In the accompanying instructions;

(1) Licensees are instructed to send the original and one copy to the Commission's Oak Ridge Operations Office and one to the Commission's Washington Headquarters.

(2) Concerning Items 6 and 10, the language is modified to make it clear that the report should list each receipt or shipment, rather than provide only the total quantities received from or shipped to others during the period. The instructions also now require that an asterisk be used to identify material for which the licensee was charged or relieved, during the reporting period, with respect to financial responsibility to the Commission.

(3) Concerning Items 12, 13 and 17, the instructions are modified to require identification of the licensee having financial responsibility with respect to losses and burn-up.

Copies of Form AEC–578 may be obtained from the Director, Division of Licensing and Regulation, U.S. Atomic Energy Commission, Washington 25, D.C.

The proposed amendment as published on August 6, 1959, would have required that all special nuclear material licensees furnish a report semi-annually to the Commission. The amendment has been changed so that the June 30 report will not be required from licensees who during the six months preceding June 30 had losses or burn-up of less than ten grams of special nuclear material, and who did not receive or transfer any special nuclear material, or financial responsibility therefor.

Effective upon publication in the FEDERAL REGISTER, 10 CFR Part 70, "Special Nuclear Material", is amended in the following respects:

(1) Redesignate §§ 70.53 and 70.54 as 70.54 and 70.55, respectively.

(2) Add the following new § 70.53:

§ 70.53 Material Status Reports.

Each licensee shall submit to the Commission on Form AEC–578 reports concerning special nuclear material [illegible] uted by the Commission pursuant [illegible] section 53 of the Act and received, [illegible] ferred or possessed by the licensee [illegible] which the licensee is financially [illegible] sible. Such reports shall be made [illegible] December 31 and June 30 of each [illegible] and shall be filed with the Commission within 30 days after the end of [illegible] period covered by the report, except [illegible] any licensee who during the six months preceding June 30 had losses or burn-up of less than ten grams of special nuclear material and did not receive or transfer any special nuclear material or financial responsibility therefor [illegible] required to file only an annual report [illegible] of December 31. The Commission [illegible] permit a licensee to submit Material Status Reports at other times [illegible] good cause is shown.

Dated at Germantown, Md., this [illegible] day of February 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

PART 80—GENERAL RULES OF PROCEDURE ON APPLICATIONS FOR THE DETERMINATION OF REASONABLE ROYALTY [illegible] JUST COMPENSATION OR GRANT [illegible] AWARD FOR PATENTS, INVENTIONS [illegible] DISCOVERIES

MISCELLANEOUS AMENDMENTS

In order to permit the Patent Compensation Board to conduct its [illegible] ings by panel pursuant to section [illegible] of the Atomic Energy Act of 1954 [illegible] amended, two changes to the rules [illegible] respect thereto, 10 CFR Part 80, [illegible] promulgated by this notice. New [illegible] is added to permit the Commission [illegible] designate a chairman of the Board [illegible] to provide for the designation by [illegible] chairman of panels to hear cases [illegible] sisting of three members of the Board. The definition of "Board" contained [illegible] § 80.2(b) of the regulations has been [illegible] vised to include a panel of three [illegible] bers of the Board.

Because these amendments deal [illegible] matters relating to agency organization

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Pursuant to the Admi
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lations, Part 80, is amend
effective 30 days after pub
FEDERAL REGISTER:

1. Section 80.2(b) is am
as follows:

§ 80.2 Definitions.

* * *

(b) "Board" means the
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atomic Energy Act of 1954,
or any three or more mem
acting as a panel pursuant

2. Section 80.8 is added
follows:

§ 80.8 Chairman; designati
els: quorum.

(a) The Chairman shall be
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Energy Commission.
. R. LUEDECKE,
General Manager.

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and procedure and effectiveness thereof will not adversely affect any person, the Commission has found that good cause exists why such amendments should be made effective 30 days after publication in the FEDERAL REGISTER. However, all interested persons who desire to submit written comments and suggestions with respect to these rules should send them to the United States Atomic Energy Commission, Washington 25, D.C., Attention: General Counsel.

Pursuant to the Administrative Procedure Act, Public Law 404, 79th Cong., 2d Sess., Title 10, Code of Federal Regulations, Part 80, is amended as follows, effective 30 days after publication in the FEDERAL REGISTER:

1. Section 80.2(b) is amended to read as follows:

§ 80.2 Definitions.

* * * * *

(b) "Board" means the Patent Compensation Board designated by the Commission pursuant to section 157a. of the Atomic Energy Act of 1954, as amended, or any three or more members thereof acting as a panel pursuant to § 80.8.

2. Section 80.8 is added to read as follows:

§ 80.8 Chairman; designation of panels; quorum.

(a) The Chairman shall be designated by the Commission. The Chairman may, from time to time, with the concurrence of a majority of the members of the Board, divide the Board into two or more panels, each consisting of not less than three members. A majority of the number of members authorized to constitute the Board or a panel thereof shall constitute a quorum of the Board or panel, as the case may be.

(b) Panels shall sit at the times and places and hear the cases assigned as the Board directs and may make any order or render any decision which the Board would have been empowered to make or render if the matter had not been assigned to the panel. Every such order made or decision rendered by a panel shall be made as the order, or rendered as the decision, of the Board.

(Sec. 161, 68 Stat. 948, 42 U.S.C. 2201)

Dated at Germantown, Md., this 3d day of August 1960.

For the Atomic Energy Commission.

R. E. HOLLINGSWORTH,
Acting General Manager.

PART 95—SAFEGUARDING OF RESTRICTED DATA

EXTERNAL TRANSMISSION OF DOCUMENTS AND MATERIAL

Notice is hereby given of amendment of the Commission's regulations relating to the transmission of Restricted Data under this Part. The amendment is designed to permit the transmission of Confidential material by first class mail or certified mail. In addition, the types of express services that may be used for transmitting either Secret or Confidential material are specified. Because the Atomic Energy Commission has issued a substantial number of access permits, and because interested persons will not be adversely affected, the Commission has found that good cause exists why the regulations in this part should be made effective without the customary 30 day period of notice. Effective upon publication in the FEDERAL REGISTER, § 95.33(d) is amended to read:

(*d*) *Methods of transportation.* (1) Secret documents and material shall be transported only by one of the following methods:

(i) Registered mail.

(ii) Railway or air express in "Armed Guard Service" or "Armed Surveillance Service".

(iii) Individuals possessing appropriate AEC security clearance who have been given written authority by their employers.

(2) Confidential documents and material shall be transported by one of the methods set forth in subparagraph (1) of this paragraph or by one of the following methods:

(i) Certified or first-class mail, if approved by the Manager of Operations administering the permit. Certified or first-class mail may not be used in any transmission of Confidential documents to Alaska, Hawaii, the Canal Zone, Puerto Rico, or any United States territory or possession.

(ii) Railway or air express "Protective Signature Service;" railway express "Recorded Tally Service;" airlines "Protective Signature Service;" when available; rail or motor vehicles in sealed car or sealed van service; or services providing equivalent protection.

(iii) Material in less than carload, truckload, or planeload lots, by regular commercial carrier when the container and its contents weigh more than 500 pounds and such container is locked and sealed.

Dated at Germantown, Md., this 11th day of April 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

PART 140—FINANCIAL PROTECTION REQUIREMENTS AND INDEMNITY AGREEMENTS

The following amendments to Part 140 constitute a comprehensive revision to this part.

Notice of proposed issuance of the following rules was published in the FEDERAL REGISTER on May 1, 1959 (24 F.R. 3508). A detailed statement of considerations explaining the provisions of the following amendments was published with the notice of proposed rule making at 24 F.R. 3508. Comments filed by interested persons have been given careful consideration.

Except for §§ 140.3, 140.6, 140.12, 140.15 and 140.17, the provisions of the following amendments are the same as those incorporated in the notice of proposed rule making. Section 140.6 (concerning reports) has been rewritten to clarify the obligations of an indemnified licensee following a nuclear incident and to eliminate the filing of extensive reports by a licensee until the extent of the incident and the need for such reports and records have been determined by the Commission. Minor changes, mainly of a drafting nature, have been made in §§ 140.3(j), 140.12(b)(4)(i), 140.15(a) and 140.17(b).

Sections 140.11 and 140.12 establish the amount of financial protection to be maintained by reactor licensees. They are substantially similar to the corresponding provisions in the proposed rule published on May 1, 1959. Representatives of the Nuclear Energy Liability Insurance syndicates ("NELIA" and "MAELU") have urged that the Commission require, in some cases, the maintenance of higher levels of financial protection than are required under the following rules. Their recommendations are set forth particularly in a letter dated January 22, 1960, and the attachments thereto, from Charles J. Haugh, Vice President, The Travelers Insurance Company. This letter and the attachments are available for public inspection in the Commission's Public Document Room, 1717 H Street NW., Washington 25, D.C. Copies of the aforesaid letter may be obtained upon request to the Director, Division of Licensing and Regulation, U.S. Atomic Energy Commission, Washington 25, D.C.

The Commission plans to re-evaluate the provisions of §§ 140.11 and 140.12 in the light of comments received from the Nuclear Energy Liability Insurance syndicate, and comments received from interested members of the public, not later than December 31, 1960.

All interested persons who desire to submit comments for the consideration of the Commission on the proposals filed by the nuclear energy insurance syndicates and their member companies should send them to the U.S. Atomic Energy Commission, Washington 25, D.C., Attention: Director, Division of Licensing and Regulation within 90 days after publication of this notice in the FEDERAL REGISTER.

Effective 30 days af
the FEDERAL REGISTER.
"Financial Protectio
and Indemnity Agreei
ed to read as follows:

SUBPART A—GENER

AUTHORITY: §§ 140.1 to
under sec. 161, 68 Stat. 948;
interpret or apply sec. 4, Publ
Public Law 85-744.

SUBPART A—GENERAL P

§ 140.1 Purpose.

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Effective 30 days after publication in the FEDERAL REGISTER. 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements," is amended to read as follows:

AUTHORITY: §§ 140.1 to 140.72 issued under sec. 161, 68 Stat. 948; 42 U.S.C. 2201, interpret or apply sec. 4, Public Law 85-256; Public Law 85-744.

SUBPART A—GENERAL PROVISIONS

§ 140.1 Purpose.

The regulations in this part are issued to provide appropriate procedures and requirements for determining the financial protection required of licensees and for the indemnification and limitation of liability of certain licensees and other persons pursuant to section 170 of the Atomic Energy Act of 1954 (68 Stat. 919), as amended.

§ 140.2 Scope.

(a) The regulations in this part apply to each person who is an applicant for or holder of a license issued pursuant to Part 50 of this chapter to operate a nuclear reactor.

(b)(1) Subpart B of this part does not apply to any person subject to Subpart C of this part or D. Subpart C of this part applies only to persons found by the Commission to be Federal agencies. Subpart D of this part applies only to persons found by the Commission to be nonprofit educational institutions with respect to licenses and applications for licenses for the conduct of educational activities.

(2) Any applicant or licensee subject to this part may apply for a finding that such applicant or licensee is subject to the provisions of Subpart C or D of this part. The application should state the grounds for the requested finding. Any application for a finding pursuant to this paragraph may be included in an application for license.

§ 140.3 Definitions.

As used in this part,

(a) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto.

(b) "Commission" means the Atomic Energy Commission or its duly authorized representatives.

(c) "Federal agency" means a Government agency such that any liability in tort based on the activities of such agency would be satisfied by funds appropriated by the Congress and paid out of the United States Treasury.

(d) "Financial protection" means the ability to respond in damages for public liability and to meet the costs of investigating and defending claims and settling suits for such damages.

(e) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

(f) "Nuclear reactor" means any apparatus, other than an atomic weapon, designed or used to sustain nuclear fission in a self-supporting chain reaction.

(g) "Person" means (1) any individual, corporation, partnership, firm, association, trust, estate, public, or private institution, group, Government agency other than the Commission, any State or any political subdivision thereof, or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing.

(h) "Source material" means source material as defined in the regulations contained in Part 40 of this chapter.

(i) "Special nuclear material" means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing, but does not include source material.

(j) "Testing reactor" means a nuclear reactor which is of a type described in § 50.21(c) of this chapter and for which an application has been filed for a license authorizing operation at:

(1) A thermal power level in excess of 10 megawatts; or

(2) A thermal power level in excess of 1 megawatt, if the reactor is to contain:

(i) A circulating loop through the core in which the applicant proposes to conduct fuel experiments; or

(ii) A liquid fuel loading; or

(iii) An experimental facility in the core in excess of 16 square inches in cross-section.

§ 140.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretations of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 140.5 Communications.

All communications concerning the regulations in this part should be addressed to the Atomic Energy Commission, Washington 25, D.C., Attention: Division of Licensing and Regulation.

§ 140.6 Reports.

(a) In the event of bodily injury or property damage arising out of or in connection with the possession or use of the radioactive material at the location or in the course of transportation or in the event any claim is made therefor written notice containing particulars sufficient to identify the licensee and reasonably obtainable information with respect to the time, place, and circumstances thereof, or the nature of the claim shall be furnished by or for the licensee to the Commission as promptly as practicable. The terms "the radioactive material", "the location", and "in the course of transportation" as used in this section shall have the meanings defined in the applicable indemnity agreement between the licensee and the Commission.[1]

[1] A proposed form of indemnity agreement was published in the FEDERAL REGISTER of August 28, 1958 (23 F.R. 6681), for public comment. It is expected that a final form of indemnity agreement will be published at an early date as Appendix B to this part.

(b) The Commissio…
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§ 140.7 Fees.

(a) Each licensee s…
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§ 140.8 Specific exempt…

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958 (23 F.R. 6681), for public
is expected that a final form
agreement will be published as
as Appendix B to this part.

(b) The Commission may require any person subject to this part to keep such records and furnish such reports to the Commission as the Commission deems necessary for the administration of the regulations in this part.

§ 140.7 Fees.

(a) Each licensee shall pay a fee to the Commission at the rate of $30 per year per thousand kilowatts of thermal capacity authorized in its license: *Provided*, That no fee shall be less than $100 per annum for any nuclear reactor. Such fee shall be due for the period beginning with the date on which the applicable indemnity agreement is effective and shall be paid in accordance with billing instructions received from the Commission.

(b) Where a licensee manufactures a number of nuclear reactors each having a power level not exceeding $3\frac{1}{3}$ megawatts for sale to others and operates them at the licensee's location temporarily prior to delivery, the licensee shall report to the Commission the maximum number of such reactors to be operated at that location at any one time. In such cases, the fee shall equal $100 multiplied by the number of reactors reported by the licensee. In the event the number of reactors operated at any one time exceed the estimate so reported, the licensee shall report the additional number of reactors to the Commission and additional charges will be made. If experience shows that less than the estimated number of reactors have been operated, appropriate adjustments in subsequent bills will be made by the Commission.

§ 140.8 Specific exemptions.

The Commission may, upon application by any interested person, grant such exemptions from the requirements of this part as it determines are authorized by law and are otherwise in the public interest.

SUBPART B—PROVISIONS APPLICABLE ONLY TO APPLICANTS AND LICENSEES OTHER THAN FEDERAL AGENCIES AND NONPROFIT EDUCATIONAL INSTITUTIONS

§ 140.10 Scope.

This subpart applies to applicants for and holders of licenses issued pursuant to Part 50 of this chapter authorizing operation of nuclear reactors, except licenses for the conduct of educational activities issued to, or applied for by, persons found by the Commission to be nonprofit educational institutions and except persons found by the Commission to be Federal agencies.

§ 140.11 Amounts of financial protection for certain reactors.

(a) Each licensee is required to have and maintain financial protection—

(1) In the amount of $1,000,000 for each nuclear reactor he is authorized to operate at a thermal power level not exceeding ten kilowatts;

(2) In the amount of $1,500,000 for each nuclear reactor he is authorized to operate at a thermal power level in excess of ten kilowatts but not in excess of one megawatt;

(3) In the amount of $2,500,000 for each nuclear reactor other than a testing reactor or a reactor licensed under section 104b of the Act which he is authorized to operate at a thermal power level exceeding one megawatt but not in excess of ten megawatts; and

(4) In the amount of $60,000,000 for each nuclear reactor he is authorized to operate and which is designed for the production of electrical energy and has a rated capacity of 100,000 electrical kilowatts or more.

(b) In any case where a person is authorized pursuant to Part 50 of this chapter to operate two or more nuclear reactors at the same location, the total financial protection required of the licensee for all such reactors is the highest amount which would otherwise be required for any one of those reactors: *Provided*, That such financial protection covers all reactors at the location.

§ 140.12 Amount of financial protection required for other reactors.

(a) Each licensee is required to have and maintain financial protection for each nuclear reactor for which the amount of financial protection is not determined in § 140.11, in an amount determined pursuant to the formula and other provisions of this section: *Provided*, That in no event shall the amount of financial protection required for any nuclear reactor under this section be less than $3,500,000 or more than $60,000,000.

(b) (1) The formula is:

x=B times P.

(2) In the formula:

x=Amount of financial protection in dollars.
B=Base amount of financial protection.
P=Population factor.

(3) The base amount of financial protection is equal to $150 times the maximum power level, expressed in thermal kilowatts, as authorized by the applicable license.

(4) The population factor (P) shall be determined as follows:

(i) *Step 1.* The area to be considered includes all minor civil divisions (as shown in the 1950 Census of Population, Bureau of the Census, or later data available from the Bureau) which are wholly or partly within a circle with the facility at its center and having a radius in miles equal to the square root of the maximum authorized power level in thermal megawatts.

(ii) *Step 2.* Identify all minor civil divisions according to the same census which are in whole or in part within the circle determined in Step 1. Determine the population of each such minor civil division (according to the same census or later data available from the Bureau of the Census). For each minor civil division, divide its population by the square of the estimated distance to the nearest mile from the reactor to the geographic center of the minor civil division: *Provided*, That no such distance shall be deemed to be less than one mile. If the sum of the quotients thus obtained for all minor civil divisions wholly or partly within the circle is 1000 or less, the population factor is 1. If the sum of these quotients is more than 1000 but not more than 3000, the population factor is 1.1. If the sum of these quotients is more than 3000 but not more than 5000, the population factor is 1.2. If the sum of these quotients is more than 5000 but not more than 7000, the population factor is 1.3. If the sum of these quotients is more than 7000 but not more than 9000, the population factor is 1.4. If the sum of these quotients is more than 9000, the population factor is 1.5.

(c) In any case where a person is authorized pursuant to Part 50 of this chapter to operate two or more nuclear reactors at the same location, the total financial protection required of the licensee for all such reactors is the highest amount which would otherwise be required for any one of those reactors: *Provided*, That such financial protection covers all reactors at the location.

(d) Except in cases where the amount of financial protection calculated under this section is a multiple of $100,000, amounts determined pursuant to this section shall be adjusted to the next highest multiple of $100,000.

§ 140.13 Amount of financial protection required of certain holders of construction permits.

Each holder of a construction permit under Part 50 of this chapter authorizing construction of a nuclear reactor who is also the holder of a license under Part 70 of this chapter authorizing possession and storage only of special nuclear material at the site of the nuclear reactor for use as fuel in operation of the nuclear reactor after issuance of an operating license under Part 50 of this chapter, shall (during the period prior to issuance of the license authorizing operation of the reactor) have and maintain financial protection in

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§ 140.14 Types of f…

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(2) Adequate reso… financial protection r… or § 140.12; or

(3) Such other ty… tection as the Commis… or

(4) Any combinat… going.

(b) In any case w… sion has approved … protection filed by a li… shall not substitute o… protection for another … taining the writte… Commission.

§ 140.15 Proof of fin…

(a)(1) Proof of fi… the case of licens… financial protection in … the form of liabilit… with respect to such … of a copy of the li… policies) together wit… insurers issuing s… that said copy is a tr… ntly effective policy … . The licensee … ncial protection in … clear energy liability … forth in § 140.75.

(2) Such proof m… sist of a copy of … of a nuclear energ… the form set forth … d to the licensee: … policy form has … rers with the Co… rations page shall … certificate by the

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Amount of financial protec-
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aterial at the site of the nuclear
for use as fuel in operation of
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apter, shall (during the period
issuance of the license autho-
eration of the reactor) have and
in financial protection in

amount of $1,000,000. Proof of financial protection shall be filed with the Commission in the manner specified in § 140.15 prior to issuance of the license under Part 70 of this chapter.

§ 140.14 Types of financial protection.

(a) The amounts of financial protection required under this part may be furnished and maintained in the form of:

(1) An effective policy of liability insurance from private sources; or

(2) Adequate resources to provide the financial protection required by § 140.11 or § 140.12; or

(3) Such other type of financial protection as the Commission may approve; or

(4) Any combination of the foregoing.

(b) In any case where the Commission has approved proof of financial protection filed by a licensee the licensee shall not substitute one type of financial protection for another type without first obtaining the written approval of the Commission.

§ 140.15 Proof of financial protection.

(a) (1) Proof of financial protection in the case of licensees who maintain financial protection in whole or in part in the form of liability insurance shall (with respect to such insurance) consist of a copy of the liability policy (or policies) together with a certificate by the insurers issuing such policy stating that said copy is a true copy of a currently effective policy issued to the licensee. The licensee may furnish such financial protection in the form of the nuclear energy liability insurance policy set forth in § 140.75.

(2) Such proof may alternatively consist of a copy of the declarations page of a nuclear energy liability policy in the form set forth in § 140.75 and issued to the licensee: *Provided*, That the policy form has been filed by the insurers with the Commission. The declarations page shall be accompanied by a certificate by the insurers stating that said copy is a true copy of the declarations page of a currently effective policy and identifying the policy (including endorsements) by reference to the policy form which has been filed by them with the Commission.

(3) The Commission will accept any other form of nuclear energy liability insurance as proof of financial protection, if it determines that the provisions of such insurance provide financial protection under the requirements of the Commission's regulations and the Act.

(b) Proof of financial protection in the case of licensees who maintain financial protection in whole or in part in the form specified in § 140.14(a)(2) shall consist of a showing that the licensee clearly has adequate resources to provide the financial protection required under this part. For this purpose the applicant or licensee shall file with the Commission:

(1) Annual financial statements for the three complete calendar or fiscal years preceding the date of filing, together with an opinion thereon by a certified public accountant. The financial statements shall include balance sheets, operating statements and such supporting schedules as may be needed for interpretation of the balance sheets and operating statements.

(2) If the most recent statements required under subparagraph (1) have been prepared as of a date more than 90 days prior to the date of filing, similar financial statements, prepared as of a date not more than 90 days prior to the date of filing, should be included. These statements need not be reviewed by a certified public accountant.

(c) The Commission may require any licensee to file with the Commission such additional proof of financial protection or other financial information as the Commission determines to be appropriate for the purpose of determining whether the licensee is maintaining financial protection as required under this part.

(d) Proof of financial protection shall be subject to the approval of the Commission.

(e) The licensee shall promptly notify the Commission of any material change in proof of financial protection or in other financial information filed with the Commission under this part.

§ 140.16 Commission review of proof of financial protection.

The Commission will review proof of financial protection filed by any licensee or applicant for license. If the Commission finds that the licensee or applicant for license is maintaining financial protection in accordance with the requirements of this part, approval of the financial protection will be evidenced by incorporation of appropriate provision in the license.

§ 140.17 Special provisions applicable to licensees furnishing financial protection in whole or in part in the form of liability insurance.

In any case where a licensee undertakes to maintain financial protection in the form of liability insurance for all or part of the financial protection required by this part,

(a) The Commission may require proof that the organization or organizations which have issued such policies are legally authorized to issue them and do business in the United States and have clear ability to meet their obligations; and

(b) At least 30 days prior to the termination of any such policy, the licensee shall notify the Commission of the renewal of such policy or shall file other proof of financial protection.

§ 140.18 Special provisions applicable to licensees furnishing financial protection in whole or in part in the form of adequate resources.

In any case where a licensee undertakes to maintain financial protection in the form specified in § 140.14(a)(2) for all or part of the financial protection required by this part,

(a) The licensee shall file with the Commission at least annually, before such dates as are specified in the applicable written approval issued by the Commission pursuant to § 140.16, a balance sheet and operating statement prepared and certified by a certified public accountant in accordance with conventional accounting practices.

(b) The Commission may require such licensee to file with the Commission such additional financial information as the Commission determines to be appropriate for the purpose of determining whether the licensee is maintaining financial protection as required by this part.

§ 140.19 Failure by licensees to maintain financial protection.

In any case where the Commission finds that the financial protection maintained by a licensee is not adequate to meet the requirements of this part, the Commission may suspend or revoke the license or may issue such order with respect to licensed activities as the Commission determines to be appropriate or necessary in order to carry out the provisions of this part and of section [illegible] of the Act.

§ 140.20 Indemnity agreements.

(a) The Commission will execute and issue agreements of indemnity pursuant to the regulations in this part or such other regulations as may be issued by the Commission. Such agreements, as to any licensee, shall be effective on:

(1) The effective date of the license (issued pursuant to Part 50 of this chapter) authorizing the licensee to operate the nuclear reactor involved; or

(2) The effective date of the license (issued pursuant to Part 70 of this chapter) authorizing the licensee to possess and store special nuclear material at the site of the nuclear reactor for use as fuel in operation of the nuclear reactor after issuance of an operating license for the reactor,

whichever is earlier. N[illegible] ment, however, shall be [illegible] to September 26, 1957.

(b)(1) The general f[illegible] nity agreement to be ente[illegible] Commission with licens[illegible] this subpart is set fort[illegible] "B".[1] The form of ind[illegible] ment to be entered into b[illegible] sion with any particular [illegible] this part shall contain s[illegible] sions of the form in Appen[illegible] provided for in applic[illegible] regulations or orders of [illegible] sion.

(2) Each licensee who [illegible] an indemnity agreement u[illegible] shall enter into such agree[illegible] ing such indemnity agre[illegible] required by applicable lic[illegible] tions or orders of the Co[illegible]

SUBPART C—PROVISIONS [illegible] ONLY TO FEDERAL AG[illegible]

§ 140.51 Scope.

This subpart applies onl[illegible] issued by the Commission t[illegible] agencies, which have appli[illegible] holders of licenses issued [illegible] Part 50 of this chapter au[illegible] eration of nuclear reacto[illegible]

NOTE: Federal agencies are [illegible] furnish financial protection.

§ 140.52 Indemnity agree[illegible]

(a) The Commission [illegible] agreements of indemnity wi[illegible] eral agency subject to this [illegible] suant to the regulations in [illegible] such other regulations as m[illegible] the Commission. Each [illegible] ment shall contain such p[illegible] as required by law and suc[illegible] provisions as may be i[illegible] therein by the Commission [illegible] regulation. Such agreement[illegible] licensee, shall be effective [illegible]

[1] A proposed form of indemni[illegible] was published in the FEDERAL [illegible] August 28, 1958 (23 F.R. 6681 [illegible] ment. It is expected that [illegible] indemnity agreement will be [illegible] early date as Appendix B to [illegible]

...ever is earlier. No such agreement, however, shall be effective prior to September 26, 1957.

(1) The general form of indemnity agreement to be entered into by the Commission with licensees subject to this subpart is set forth in Appendix "B". The form of indemnity agreement to be entered into by the Commission with any particular licensee under this part shall contain such modifications of the form in Appendix "B" as are provided for in applicable licenses, regulations or orders of the Commission.

(2) Each licensee who has executed an indemnity agreement under this part shall enter into such agreements amending such indemnity agreement as are required by applicable licenses, regulations or orders of the Commission.

SUBPART C—PROVISIONS APPLICABLE ONLY TO FEDERAL AGENCIES

§ 140.51 Scope.

This subpart applies only to persons found by the Commission to be Federal agencies, which have applied for or are holders of licenses issued pursuant to Part 50 of this chapter authorizing operation of nuclear reactors.

NOTE: Federal agencies are not required to maintain financial protection.

§ 140.52 Indemnity agreements.

(a) The Commission will execute agreements of indemnity with each Federal agency subject to this subpart pursuant to the regulations in this part or such other regulations as may be issued by the Commission. Each such agreement shall contain such provisions as are required by law and such additional provisions as may be incorporated therein by the Commission pursuant to regulation. Such agreements, as to any licensee, shall be effective on:

Proposed form of indemnity agreement published in the FEDERAL REGISTER on ... 1958 (23 F.R. 6681), for public comment. It is expected that a final form of indemnity agreement will be published at a later date as Appendix B to this part.

(1) The effective date of the license (issued pursuant to Part 50 of this chapter) authorizing the licensee to operate the nuclear reactor involved; or

(2) The effective date of the license (issued pursuant to Part 70 of this chapter) authorizing the licensee to possess and store special nuclear material at the site of the nuclear reactor for use as fuel in operation of the nuclear reactor after issuance of an operating license for the reactor,

whichever is earlier. No such agreement, however, shall be effective prior to September 26, 1957.

SUBPART D—PROVISIONS APPLICABLE ONLY TO NONPROFIT EDUCATIONAL INSTITUTIONS

§ 140.71 Scope.

This subpart applies only to applicants for and holders of licenses issued for the conduct of educational activities to persons found by the Commission to be nonprofit educational institutions, except that this subpart does not apply to Federal agencies.

NOTE: Financial protection is not required with respect to licenses issued for the conduct of educational activities to persons found by the Commission to be non-profit educational institutions.

§ 140.72 Indemnity agreements.

(a) The Commission will execute agreements of indemnity with each person subject to this subpart in accordance with this part or such other regulations as may be issued by the Commission. Each such agreement shall contain such provisions as are required by law and such additional provisions as may be incorporated therein by the Commission pursuant to regulation. Such agreements, as to any licensee, shall be effective on:

(1) The effective date of the license (issued pursuant to Part 50 of this chapter) authorizing the licensee to operate the nuclear reactor involved; or

(2) The effective date of the license (issued pursuant to Part 70 of this chapter) authorizing the licensee to

possess and store special nuclear material at the site of the nuclear reactor for use as fuel in operation of the nuclear reactor after issuance of an operating license, whichever is earlier. No such agreement shall be effective as of a date earlier than August 23, 1958, except that the Commission may upon good cause found, make such agreement effective as of a date prior to August 23, 1958. In no event may the agreement be effective as of a date prior to September 26, 1957.

Appendix "A"—Form of Insura… Policy (see F.R. Doc. 60-3090 inf…

Appendix "B"—Form of Indem… Agreement (to be added later).

NOTE: The reporting requirements … tained herein have been approved by the … reau of the Budget in accordance with … Federal Reports Act of 1942.

Dated at Germantown, Md., this … day of March 1960.

For the Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

"A"—Form of Insura...
F.R. Doc. 60-3090 ...
"B"—Form of Indem...
(to be added later).

...e reporting requirement... n have been approved by the ... Budget in accordance with the ... orts Act of 1942.

Germantown, Md., this ... rch 1960.

Atomic Energy Commission.

A. R. LUEDECKE,
General Manager.

APPENDIX 9

...NSES AND ACCESS PERMITS APPLICATIONS FILED AND ACTIONS TAKEN

SUMMARY OF LICENSING ACTIONS

Facilities [a]	Permits and Licenses Issued				Permits and Licenses in Effect as of Nov. 30, 1960
	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 Nov. 30, 1960	
...ctors:					
...tion permits	5	0	0	5	7
...tion permit amendments	1	4	5	1	----------
... to operate	1	0	1	1	3
...amendments & authorizations	1	7	7	7	----------
...ctors:					
...tion permits	1	2	0	0	1
...tion permit amendments	1	0	1	0	----------
... to operate	0	0	2	0	2
...amendments & authorizations	0	0	3	6	----------
... Reactors:					
...tion permits	[b] 20	[c] 11	[d] 15	14	[e] 19
...tion permit amendments	5	9	15	10	----------
... to operate (including acquire & operate)	28	19	9	10	45
...amendments	16	17	34	21	----------
...rts:					
... Reactor Licenses	16	5	11	3	(f)
...ctor Licenses	0	2	0	0	(f)
...ctor Licenses	0	1	1	0	(f)
...amendments	6	14	10	13	----------
...periment Facilities:					
...tion permits	10	4	1	2	1
...tion permit amendments	2	2	1	2	----------
... to operate	6	[g] 5	3	2	14
...amendments	1	10	16	14	----------
... Facilities:					
...tion permits	0	0	0	0	0
... to operate	0	0	0	0	0
...enses	0	0	0	1	----------
...enses	148	215	176	190	538
...ense amendments & renewals	21	67	81	127	----------
...ear Material licenses	151	115	73	78	356
...amendments & renewals	92	156	194	232	----------
...erial licenses issued or renewed	4,541	1,303	1,168	1,009	1,175
...erial export licenses	2,456	676	721	644	(f)

...ons to construct and operate are filed simultaneously; conversions from construction permits ... operate are made upon satisfactory completion of construction.
... authorize construction of 36 reactors and modification of 2 reactors.
... authorize construction of 38 reactors.
... authorize construction of 13 reactors and modification of 2 reactors.
... authorize construction of 24 reactors and modification of 1 reactor.
...enses terminate upon completion of shipment.
...enses authorize possession only.

FACILITY LICENSE APPLICATIONS

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 May 4, 1960.
Commonwealth Edison Co., Dresden Station, Grundy County, Ill.	180,000-kilowatt, dual cycle, boiling water reactor.	Apr. 1, 1955	Construction permit May 4, 1956; 45-day license for 1-megawatt [illegible] mal) operation issued [illegible] 28, 1959; amended [illegible] 1959 to expire Dec. [illegible] amended Nov. 16, [illegible] 315-megawatt (thermal) [illegible] eration after Dec. [illegible] amended June 2, [illegible] operation at power [illegible] to, but not in excess of [illegible] steady state power [illegible] 630 megawatts [illegible] amended Oct. 14, [illegible] steady state operation [illegible] megawatts (thermal) [illegible]
Consolidated Edison Co., Westchester County, N.Y.	163,000-kilowatt, pressurized water (plus 112,000 kw of conventional superheater capacity).	Mar. 22, 1955 (date of application)	Construction permit May 4, 1956.
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 May 31, 1960.
Florida West Coast Nuclear Group, Inc., Polk County, Fla.	50,000-kilowatt, high temperature, gas-cooled, heavy water moderated, pressure tube type reactor.	Dec. 10, 1959	Pending.[a]
General Electric Co., Alameda County, Calif.	3,000 to 5,000-kilowatt developmental boiling water reactor.	Jan. 10, 1956 (date of application)	Construction permit May 14, 1956; license [illegible] for criticality tests [illegible] 1957; for power [illegible] Aug. 31, 1957; license [illegible] ment authorizing [illegible] at power levels to [illegible] (thermal) issued [illegible] 1959; amended July [illegible] to authorize operation [illegible] certain internal [illegible] tions and with new [illegible] rangements amended [illegible] 5, 1960 to authorize [illegible] make changes within [illegible] cal specifications [illegible] license amendment [illegible] no unreviewed safety [illegible] tion is involved.
Northern States Power Co., Sioux Falls, S. Dak.	66,000-kilowatt, controlled recirculation boiling water reactor.	Apr. 1, 1959	Construction permit May 12, 1960.
Pacific Gas and Electric Co., Humboldt Bay Power Plant, Eureka, Calif.	50,000-kilowatt, single cycle boiling water reactor.	Apr. 30, 1959	Construction permit Nov. 9, 1960.
Philadelphia Electric Co., Peach Bottom, York County, Pa.	40,000-kilowatt, helium-cooled, graphite moderated, developmental reactor.	July 25, 1960	Pending.
Power Reactor Development Co., Lagoona Beach, Mich.	100,000-kilowatt, fast breeder reactor.	Jan. 7, 1956	Construction permit Aug. 4, 1956.[b]
Saxton Nuclear Experimental Corp., Saxton, Pa.	20,000-kilowatt (thermal) pressurized light water reactor.	July 24, 1959	Construction permit Feb. 11, 1960.
Yankee Atomic Electric Co., Rowe, Mass.	134,000-kilowatt pressurized light water reactor.	July 9, 1956	Construction permit Nov. 4, 1957; [illegible] for 5-megawatt (thermal) [illegible] eration issued July [illegible] amended July [illegible] operation at power [illegible] in excess of [illegible] (thermal).

[a] Action on application withheld at applicant's request pending submission of new technical [illegible]
[b] Circuit Court Order dated June 10, 1960 vacated construction permit; Circuit Court [illegible] decision Aug. 8, 1960, pending appeal by the parties.

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…ICATIONS

…ILED	STATUS
1959	Construction permit … May 4, 1960.
, 1955	Construction permit … May 4, 1956; 45-day … license for 1-megawatt (ther-mal) operation issued … 28, 1959; amended … 1959 to expire Dec. …; amended Nov. 16, … 315-megawatt (thermal) op-eration after Dec. …; amended June 2, … operation at power levels up to, but not in excess of, … steady state power level … 630 megawatts (thermal); amended Oct. 14, … steady state operation at … megawatts (thermal).
22, 1955 (…f appli-…on)	Construction permit … May 4, 1956.
18, 1960	Construction permit … May 31, 1960.
10, 1959	Pending.*
10, 1956 (…of appli-…tion)	Construction permit … May 14, 1956; license … for criticality tests … 1957; for power operation … Aug. 31, 1957; license amend-ment authorizing operation … at power levels to … (thermal) issued … 1959; amended July … to authorize operation … certain internal … tions and with new … rangements amended … 5, 1960 to authorize … make changes within … cal specifications … license amendment … no unreviewed safety … tion is involved.
1, 1959	Construction permit … May 12, 1960.
30, 1959	Construction permit … Nov. 9, 1960.
…y 25, 1960	Pending.
…. 7, 1956	Construction permit … Aug. 4, 1956.*
…ly 24, 1959	Construction permit … Feb. 11, 1960.
…ly 9, 1956	Construction permit … Nov. 4, 1957; … for 5-megawatt (thermal) op-eration issued … amended July … operation at power … in excess of … (thermal).

…iding submission of new technical … …ction permit; Circuit Court …

FACILITY LICENSE APPLICATIONS—Continued

…ANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
TEST REACTORS			
…General Nucle-… San Ramon, Calif.	10,000-kilowatt, light water moderated, pool.	Oct. 22, 1958	Application withdrawn by letter dated Sept. 21, 1959.
…bcock & Wilcox … Lynchburg, Va.	55,000-kilowatt, light water and beryllium moderated reactor.	May 31, 1960	Application withdrawn by letter dated July 11, 1960.
… Electric Co., Ala-… 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.
… Aeronautics and … Administration, …ky, Ohio.	60,000-kilowatt, pressurized water reactor.	Aug. 20, 1956	Construction permit issued July 21, 1958.
…house Electric … 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			
…General Nucle-… San Ramon, Calif. (USNPS).	100-milliwatt Model AGN-201 reactor, serial 100.	May 28, 1956	Construction permit issued Aug. 16, 1956; license issued Oct. 19, 1956.
…General Nucle-… San Ramon, Calif. (… 101 and 102 sold … 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. 23, 1957, Mar. 14, 1957 and Mar. 29, 1957 (amended for 20-watt operation Aug. 22, 1958 (ser. 103).
…General Nucle-… Ramon, Calif. (… other licensees).	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 issuod July 10, 1957; licenses also issued, July 31, 1957, Aug. 23, 1957 and Sept. 20, 1957.
…General Nucle-… Ramon, Calif. (… 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 3, 1958 and June 30, 1958. Application covering construction of remaining six reactors withdrawn by letter Sept. 16, 1960.
…General Nucle-… Ramon, Calif. (… 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.
…General Nucle-… Ramon, Calif. (… licensees).	Fifteen 100-milliwatt Model AGN-201 reactors, serials 126 through 140.	Dec. 2, 1957	Construction permit Feb. 20, 1958. Ten reactors (serials 131 through 140) withdrawn from application by letter Sept. 16, 1960.
--------	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 issued increasing operating level to 20 watts issued Nov. 14, 1958. Application withdrawn by letter Sept. 16, 1960.
--------	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 104 and 105) withdrawn from application by letter Sept. 16, 1960.

FACILITY LICENSE APPLICATIONS—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
	RESEARCH REACTORS—Continued		
American Radiator & Standard Sanitary Corp., Mountain View, Calif.	1-watt (UTR-1) graphite moderated reactor (Argonaut type).	July 12, 1957	Construction permit [illegible] Oct. 31, 1957; license [illegible] May 21, 1958. Reactor [illegible] mantled and exported [illegible] hibition in Japan; [illegible] license terminated [illegible] 1960.
Do	1-watt Exhibition UTR-Model II reactor.	Feb. 2, 1960	Construction permit [illegible] Feb. 29, 1960; license [illegible] Mar. 1, 1960. Reactor [illegible] mantled and exported [illegible] hibition in Egypt and [illegible] stan; facility license [illegible] nated Aug. 4, 1960.
Armour Research Foundation, Chicago, Ill.	100-kilowatt water boiler type reactor.	Jan. 7, 1955	Construction permit [illegible] Mar. 28, 1955; license [illegible] June 12, 1956 for 10 kw [illegible] tion; amended Jan. [illegible] for 100 kw. operation [illegible]
The Babcock & Wilcox Co. Lynchburg, Va.	10-kilowatt pool-type reactor.	Mar. 28, 1958	Construction permit [illegible] Sept. 4, 1958; license [illegible] Sept. 5, 1958.
Battelle Memorial Institute, West Jefferson, Ohio.	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 [illegible] Aug. 5, 1955; license [illegible] Aug. 10, 1956 for [illegible] operation; amended [illegible] 1959 for continuous [illegible] at 2,000 kw. and intermittent [illegible] operation at 3,000 kw.
Catholic University of America, Washington, D.C.	AGN-201 100-milliwatt reactor, serial 101 (purchased from AGN).	July 10, 1957	License issued Nov. [illegible]
Colorado State University, Fort Collins, Colo.	AGN-201 100-milliwatt reactor, serial 109 (purchased from AGN).	July 22, 1957	License issued Sept. [illegible]
Cornell University, Ithaca, N.Y.	10-kilowatt dual core, pool-type reactor (application resubmitted to cover 10-watt pool-type reactor designated the Zero Power Reactor).	Feb. 21, 1958 Jan. 4, 1960	Construction permit [illegible] Nov. 21, 1958; amended [illegible] 15, 1960 to authorize [illegible] tion of Zero Power [illegible]
Do	10-kilowatt TRIGA reactor.	Jan 4, 1960	Construction permit [illegible] June 29, 1960.
Curtiss-Wright Corp. Quehanna, Pa.	1,000-kilowatt pool-type reactor.	Oct. 29, 1956	Construction permit [illegible] June 20, 1957; license [illegible] Apr. 29, 1958 for [illegible] ation; amended for [illegible] operation at power [illegible] 1,000 kw. June [illegible] amended Oct. [illegible] thorizing shutdown [illegible] for 1-year period. [illegible] minated on transfer [illegible] to Penn State [illegible] effective Dec. 12, [illegible]
Daystrom, Inc., West Caldwell, N.J.	10-kilowatt Argonaut-type reactor.	Dec. 11, 1956	Construction permit [illegible] Oct. 11, 1957.[a]
The Dow Chemical Co., Midland, Mich.	1,000 to 10,000-kilowatt liquid metal fuel reactor.	Jan. 31, 1956	Application withdrawn [illegible] letter Oct. 30, [illegible]
Ford Motor Co., Dearborn, Mich.	10 to 100-kilowatt pool-type reactor.	Jan. 17, 1956	Application withdrawn [illegible] letter Oct. 10, [illegible]
General Dynamics Corp., San Diego, Calif.	TRIGA reactor, 250-kilowatt steady state, multi-megawatt pulses.	Nov. 19, 1957	Construction permit [illegible] May 2, 1958; license [illegible] May 3, 1958.
Do	1,000-kilowatt FLAIR reactor (redesignated TRIGA Mark F by applicant).	Mar. 9, 1960	Construction permit [illegible] July 1, 1960; license [illegible] July 1, 1960.
General Electric Co., Alameda County, Calif.	30-kilowatt, light water cooled and moderated, graphite reflected reactor.	July 1, 1957	Construction permit [illegible] Oct. 24, 1957; license [illegible] Oct. 31, 1957 (operation [illegible] pended from Aug. [illegible] Aug. 18, 1959).
Georgia Institute of Technology, Atlanta, Ga.	1,000-kilowattt, tank type, heavy water moderated and cooled reactor.	Feb. 3, 1960	Construction permit [illegible] June 13, 1960.

[a] At applicant's request the construction permit was revoked Feb. 14, 1958, without prejudice [illegible] of new application at later date.

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ONS—Continued

...ED	STATUS
...ued	
...957	Construction permit ... Oct. 31, 1957; licens... May 21, 1958. React... mantled and exported ... hibition in Japan; ... license terminated Feb. ... 1960.
...960	Construction permit ... Feb. 29, 1960; license ... Mar. 1, 1960. Reactor ... mantled and exported ... hibition in Egypt and Paki... stan; facility license ... nated Aug. 4, 1960.
...1955	Construction permit ... Mar. 28, 1955; license ... June 12, 1956 for 10 kw ... tion; amended Jan. 14, ... for 100 kw. operation.
...1958	Construction permit ... Sept. 4, 1958; license ... Sept. 5, 1958.
...1955	Construction permit ... Aug. 5, 1955; license ... Aug. 10, 1956 for ... operation; amended Feb. ... 1959 for continuous op... at 2,000 kw. and inter... operation at 3,000 kw.
...1957	License issued Nov. 15, ...
...1957	License issued Sept. 12, ...
...1958 ...1960	Construction permit ... Nov. 21, 1958; amended ... 15, 1960 to authorize ... tion of Zero Power Reac...
...1960	Construction permit ... June 29, 1960.
...1956	Construction permit ... June 20, 1957; license ... Apr. 29, 1958 for 100 kw ... ation; amended for ... operation at power ... 1,000 kw. June 12, ... amended Oct. 10, ... thorizing shutdown of ... for 1-year period; license ... minated on transfer of ... to Penn State Univ... effective Dec. 12, 19...
..., 1956	Construction permit ... Oct. 11, 1957.[c]
..., 1956	Application withdrawn ... letter Oct. 30, 1957.
..., 1956	Application withdrawn ... letter Oct. 10, 1957.
..., 1957	Construction permit ... May 2, 1958; license ... May 3, 1958.
..., 1960	Construction permit ... July 1, 1960; license ... July 1, 1960.
...1, 1957	Construction permit ... Oct. 24, 1957; license ... Oct. 31, 1957 (operation ... pended from Aug. 14, ... Aug. 18, 1959).
...3, 1960	Construction permit ... June 13, 1960.

...eb. 14, 1958, without prejudice ...

FACILITY LICENSE APPLICATIONS—Continued

...ANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
RESEARCH REACTORS—Continued			
...l Reactor Labora... Inc., Plainsboro ...ship, 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 Univ. to operate the reactor Oct. 24, 1960.
...State University, ... Iowa.	10-kilowatt Argonaut-type reactor (AR&SSC Model UTR-10).	Sept. 8, 1958	Construction permit issued Oct. 12, 1959; license issued Oct. 16, 1959.
...d Aircraft Corp., ...ville, 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.[d]
...	10-megawatt Radiation Effects Reactor.	Oct. 3, 1960	Pending.
...etts Institute of ...ogy, Cambridge,	1,000-kilowatt heavy water moderated reactor.	Feb. 20, 1956	Construction permit issued May 7, 1956; license issued June 9, 1958.
... Naval Medical ..., Bethesda, Md.	TRIGA reactor, 100-kilowatt steady state, multi-megawatt pulses.	July 21, 1960	Construction permit issued Nov. 8, 1960.
...American Aviation, ... Atomics Interna... Division, Canoga ..., Calif.	5-watt solution-type laboratory reactor (Model L-47).	Jan. 24, 1957	Construction permit issued Aug. 2, 1957; license issued Aug. 5, 1957.[e]
...	10-watt solution-type laboratory reactor (Model L-77).	Jan. 20, 1958	Construction permit issued May 17, 1958; license issued May 17, 1958.
...State College, Ral... N.C.	100-kilowatt water boiler type reactor.	June 1, 1955	License issued Oct. 1, 1955.
	Modification for 500-watt operation.	Dec. 13, 1956	Construction permit issued Mar. 6, 1957; amended license for 500-watt operation issued May 1, 1957.
	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.
...State College, Ral... N.C.	10-kilowatt, graphite reflected, heterogeneous, water moderated.	July 21, 1958	Construction permit issued Nov. 26, 1958; license issued March 16, 1960.
... Development ... of America, Pawl... N.Y.	5-watt heavy water moderated and reflected reactor.	Apr. 7, 1958	Construction permit issued Oct. 7, 1958; license issued Oct. 22, 1958.
...State University, ..., Ohio.	10-kilowatt pool-type, light water moderated, graphite reflected reactor.	Nov. 2, 1959	Construction permit Feb. 3, 1960.
... State Univ., ..., Okla.	AGN-201 100-milliwatt reactor, serial 102 (purchased from AGN).	Mar. 20, 1957	License issued Aug. 26, 1957.
... Materials Re... Office, Water... Mass.	1,000-kilowatt pool-type reactor.	Jan. 15, 1957	Construction permit issued Oct. 2, 1957; license issued June 14, 1960.
... State College, ..., Oreg.	AGN-201 100-milliwatt reactor, serial 114 (purchased from AGN).	May 5, 1958	License issued Nov. 13, 1958.
...ia State Uni... University Park,	100-kilowatt pool-type reactor.	May 9, 1955	License issued July 8, 1955; amended for 200-kw-operation May 13, 1960.
...ia State Uni... Quehanna, Pa.	Curtiss-Wright 4,000-kilowatt pool-type reactor.	Oct. 4, 1960	Pending.[f]
...ice University, ..., Tex.	AGN-211 15-watt, pool-type reactor, serial 101 (purchased from AGN).	Aug. 4, 1958	License issued Jan. 8, 1959.
... University, ..., Calif.	10-kilowatt pool-type, light water moderated and reflected reactor.	June 15, 1959	Construction permit Nov. 20, 1959; license issued Dec. 4, 1959.

...d reactor was dismantled and exported to South America for exhibition purposes.

...del L-47 was dismantled by owner, North American Aviation, Inc., and license was terminated ...request on June 30, 1958.

...tiss-Wright reactor (built and previously operated by Curtiss-Wright Corporation) is a gift ...-Wright to Pennsylvania State University. Penn State requests a license for possession only ...t time. License for possession only, issued effective Dec. 12, 1960.

FACILITY LICENSE APPLICATIONS—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
RESEARCH REACTORS—Continued			
Texas A&M College System, College Station, Tex.	AGN-201 100-milliwatt reactor, serial 106 (purchased from AGN).	Mar. 25, 1957	License issued Aug.
Do	100-kilowatt pool-type, light water moderated and cooled reactor.	Mar. 17, 1959	Construction permit Aug. 4, 1959.
Texas Technological College, Lubbock, Tex.	10-kilowatt pool-type, water moderated and cooled reactor.	Feb. 1, 1960	Construction permit 1960.
The Prosperity Co., Inc., Coral Gables, Fla.	Pool-type reactor	Mar. 6, 1956	Incomplete application 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 Oct. 31, 1957.
U.S. Air Force Dawsonville, Ga.	10-Megawatt Radiation Effects Reactor.	Oct. 17, 1960	Pending.[a]
U.S. Naval Hospital, Bethesda, Md.	AGN-201M 5-watt reactor, serial 105 (purchased from AGN).	Mar. 27, 1957	License issued Sept. 13,
U.S. Naval Postgraduate School, Monterey, Calif.	AGN-201 100-milliwatt reactor, serial 100 (purchased from AGN).	Nov. 28, 1956	License issued Apr.
U.S. Naval Research Laboratory, Washington, D.C.	100-kilowatt pool-type reactor.	Apr. 5, 1955	Construction permit Apr. 29, 1955; license Sept. 14, 1956.
Do	Modification for 1,000-kilowatt operation with forced convection cooling.	July 2, 1959	Construction permit Nov. 20, 1959.
Unversity of Akron, Akron, Ohio.	AGN-201 100-milliwatt reactor, serial 104 (purchased from AGN).	Apr. 5, 1957	License issued Sept.
University of Arizona, Tucson, Ariz.	10-kilowatt tank-type reactor (General Atomic TRIGA).	July 16, 1958	Construction permit 1958; license issued 1958.
University of Buffalo, Buffalo, N.Y.	1,000-kilowatt pool-type reactor.	Mar. 11, 1957	Construction permit 1959.
University of California, Los Angeles, Calif.	50-kilowatt water boiler type reactor.	June 2, 1955 (date of application)	Application withdrawn after June 11, 1955.
Do	10-kilowatt Argonaut-type reactor.	July 2, 1959	Construction permit Nov. 16, 1959; license Oct. 3, 1960, for 10-watt operation.
University of California, Berkeley, Calif.	AGN-201 100-milliwatt reactor, serial 112 (purchased from AGN).	Aug. 26, 1957	License issued Nov.
University of Delaware, Newark, Delaware.	AGN-201 100-milliwatt reactor, serial 113.	Mar. 21, 1958	License issued July
University of Florida, Gainesville, Fla.	10-kilowatt Argonaut-type reactor.	Aug. 23, 1957	Construction permit Dec. 23, 1957; license May 21, 1959.
University of Illinois, Urbana, Ill.	100-kilowatt tank-type reactor (General Atomic TRIGA Mark II).	Nov. 16, 1959	Construction permit Apr. 5, 1960; license Aug. 16, 1960.
University of Kansas, Lawrence, Kans.	10-kilowatt tank-type, light water moderated and cooled reactor.	Aug. 24, 1959	Construction permit Apr. 7, 1960.
University of Maine, Orono, Maine.	AGN-201 100-milliwatt reactor, serial 132 (to be purchased from AGN).	Sept. 16, 1958	Pending—application plete.
University of Maryland, College Park, Md.	10-kilowatt pool-type, light water moderated, graphite reflected reactor.	Apr. 11, 1960	Construction permit June 29, 1960; license Oct. 14, 1960.
University of Michigan, Ann Arbor, Mich.	1,000-kilowatt pool-type reactor.	Jan. 12, 1955	Construction permit Feb. 17, 1955; license for 100 kw. operation 1957; amended operation Aug.
University of Missouri, Rolla, Mo.	10-kilowatt pool-type, light water moderated reactor.	Jan. 29, 1959	Construction permit Nov. 20, 1959.

[a] The Radiation Effects Nuclear Reactor was constructed and operated by Lockheed Aircraft Corporation for the Air Force pursuant to the provisions of Section 91 b. of the Atomic Energy Act of 1954. Under a lease arrangement with the Air Force Lockheed proposes to operate the reactor for other government and has requested a Class 104c license. The Air Force has requested a 5-year license for possession of the facility.

FACILITY LICENSE APPLICATIONS—Continued

...ANT AND LOCATION OF FACILITY	DESCRIPTION OF FACILITY	DATE FILED	STATUS
	RESEARCH REACTORS—Continued		
...sity of Oklahoma, ...man, Okla.	5-watt laboratory reactor (Atomics International.)	Aug. 30, 1957	Application withdrawn by letter Aug. 22, 1958.
Do.	AGN-211 15-watt, pool-type reactor, serial 102 (purchased from AGN).	July 25, 1958	License issued Dec. 29, 1958.
...sity of Tennessee ...ville, Tenn.	10-kilowatt heavy water moderated reactor.	Sept. 5, 1958	Application withdrawn by letter May 2, 1960.
...sity of Utah, Salt ...City, Utah.	AGN-201 100-milliwatt reactor, serial 107 (purchased from AGN).	June 24, 1957	License issued Sept. 12, 1957.
...sity of Virginia, ...arlottesville, Va.	1,000-kilowatt pool-type reactor.	Mar. 29, 1957	Construction permit issued Sept. 13, 1957; license issued June 24, 1960.
...sity of Washington, ...ttle, Wash.	10-kilowatt Argonaut-type reactor.	June 15, 1959	Construction permit Oct. 13, 1959.
...sity of Wisconsin, ...dison, Wis.	10-kilowatt pool-type, light water moderated reactor.	Jan. 27, 1960	Construction permit issued June 7, 1960; license issued Nov. 23, 1960.
...sity of Wyoming, ...amie, Wyo.	AGN-201 100-milliwatt reactor, serial 111.	Aug. 21, 1957	Application withdrawn by letter Nov. 3, 1958.
Do.	10-watt laboratory reactor (Atomics International Model L-77).	Nov. 14, 1958	Construction permit issued Feb. 24, 1959; license issued Feb. 25, 1959.
...derbilt University ...shville, Tenn.	AGN-201 100-milliwatt reactor, serial 116.	Jan. 30, 1958	Application withdrawn by letter Sept. 28, 1959.
... Administration ...spital, Omaha, Nebr.	10-kilowatt tank-type reactor.	Apr. 10, 1959	Construction permit issued June 24, 1959; license issued June 26, 1959.
... Polytechnic In... ... 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.
... Reed Army Insti... of Research Wash... D.C.	50-kilowatt homogeneous solution-type reactor (Atomics International Model L-54).	May 20, 1959	Construction permit issued Jan. 6, 1960.
...ington State Univ. (...erly State College ... Washington) Pull... Wash.	100-kilowatt pool-type reactor.	June 22, 1956	Construction permit issued July 8, 1959.
... Virginia University ...gantown, W. Va.	AGN-211 75-watt, pool-type reactor, srial 103.	Mar. 30, 1959	Construction permit issued June 19, 1959; license issued July 28, 1959.
... Polytechnic In... ... Worcester, Mass.	1-kilowatt pool-type reactor.	May 1, 1959	Construction permit issued Nov. 23, 1959; license issued Dec. 16, 1959.
	CRITICAL EXPERIMENT FACILITIES		
...Products, Inc., Sche...ady, N.Y.	Various critical experiments	Oct. 13, 1958	License issued March 25, 1959.[h]
...Chalmers Mfg. Co., ...dale, Wis.	Northern States Power Co. critical experiments.	June 16, 1958	Construction permit issued Nov. 13, 1958; license issued Nov. 3, 1959.
... Babcock & Wilcox ... Lynchburg, Va.	Consolidated Edison Co. critical experiments and NMSR critical experiments.	Oct. 27, 1955	Construction permit issued Dec. 9, 1955; license issued Mar. 20, 1957; amended to authorize additional experiments Jan. 24, 1958, May 28, 1958, Apr. 16, 1959, Oct. 12, 1959, Dec. 29, 1959, Oct. 25, 1960 and Nov. 28, 1960.
-------	Critical experiments for Nuclear Merchant Ship Reactor (NMSR).	Feb. 1, 1957	Construction permit issued Oct. 2, 1957; license issued Jan. 22, 1958; amended to authorize additional experiments May 7, 1959 and June 25, 1959.
-------	Critical experiments for Liquid Metal Fuel Reactor Experiment (LMFRE).	May 20, 1958	Construction permit issued Sept. 24, 1958; license issued Sept. 24, 1958.
... Memorial Insti... West Jefferson,	-------	Oct. 28, 1955	Construction permit issued Dec. 28, 1955; license (to possess only) issued Jan. 16, 1958.

...ly constructed in 1956 under contract with and for the account of the Atomic Energy Commission ...authorizes conduct of private work.

FACILITY LICENSE APPLICATIONS—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
	CRITICAL EXPERIMENT FACILITIES—Continued		
General Dynamics Corp., San Diego, Calif.	Critical experiments for General Dynamics research reactors.	Oct. 25, 1956	Construction permit June 18, 1957; licen[illegible] Aug. 13, 1957; amen[illegible] additional experimen[illegible] 26, 1957, Feb. 3, 195[illegible] 1958 and July 18, 19[illegible]
General Electric Co., Alameda County, Calif.	Critical experiments for Commonwealth Edison reactor.	Mar. 27, 1956	Construction permit June 29, 1956; licens[illegible] Aug. 30, 1957; amen[illegible] broaden scope of [illegible] May 29, 1959 and Jun[illegible] amended for addi[illegible] periments Oct. 4, 19[illegible]
Do	Nuclear checkout tests for Spanish Research Reactor.	June 14, 1957	Construction permit Sept. 20, 1957; licens[illegible] Oct. 16, 1957 (tests [illegible] and license expired M[illegible] 1958).
Lockheed Aircraft Corp., Palo Alto, Calif.		June 20, 1956	Construction permit Mar. 14, 1957 (expired [illegible] 30, 1957).[j]
Lockheed Aircraft Corp., Dawsonville, Ga.	Various critical experiments	Oct. 3, 1960	Pending.
The Martin Co., Middle River, Md.	Martin Power Reactor (MPR) and Engineering Research and Development Lab. (ERDL) critical experiments.	Oct. 26, 1956	Construction permit May 13, 1957; licens[illegible] Dec. 6, 1957 for MPR [illegible] ments amended for E[illegible] experiments June [illegible] amended for addition[illegible] iments Apr. 30, 19[illegible] 27, 1959, Mar. 8, 19[illegible] 1960 and June 7, 1960.
Do	Liquid Fluidized Bed Reactor (LFBR) critical experiments.	Jan. 4, 1960	Construction permit May 13, 1960.
National Aeronautics and Space Administration, Cleveland, Ohio.	Series of critical experiments	July 8, 1957	Construction permit Jan. 22, 1958; licens[illegible] Jan. 5, 1959.
North American Aviation, Inc.	Critical experiments relating to Advanced Epithermal Thorium Reactor (AETR) program.	Aug. 20, 1959	Construction permit Dec. 24, 1959; licens[illegible] Oct. 3, 1960.
Nuclear Development Corp. of America, Pawling, N.Y.		Mar. 14, 1956	Construction permit June 11, 1956; licens[illegible] possess only) issued Ja[illegible] 1958.
U.S. Air Force, Dawsonville, Ga.		Oct. 17, 1960	Pending.[k]
Westinghouse Electric Corp., Waltz Mill, Pa.	CRX Facility—Yankee critical experiments.	Sept. 21, 1956	Construction permit Oct. 17, 1957; license [illegible] for Yankee experiments [illegible] 25, 1957, with amendment[illegible] for additional experiments June 30, 1958 and Au[illegible] 1958; license amended [illegible] BR-3 experiments Oc[illegible] 1958, with amendment[illegible] additional experiments [illegible] 12, 1959 and Jan. [illegible] license amended [illegible] region experiments De[illegible] 1958, with amendment[illegible] additional experiments [illegible] 3, 1959 which also [illegible] RFMF experiments. [illegible] amended for "Loose La[illegible] experiments July [illegible]
	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 June 14, 1958; license [illegible] June 17, 1958, amended [illegible] additional experiments [illegible] 7, 1959 and Oct. 2[illegible]
Do	LRX Facility—Carolinas Virginia Tube Reactor critical experiments.	Dec. 23, 1959	Construction permit Apr. 26, 1960; license [illegible] May 3, 1960.

[i] Facility dismantled and license terminated Mar. 15, 1960 at licensee's request.
[j] Plans to construct facility as originally designed abandoned, per Lockheed letter dated Feb. 1[illegible]
[k] See footnote g. The same information applies to both the Radiation Effects Reactor and th[illegible] experiment facility.

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FACILITY LICENSE APPLICATIONS—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
PRODUCTION FACILITIES			
...ker Corporation, ...Cynwyd, Pa.	Gas Centrifuge Plant	Mar. 29, 1960	Pending—Application incomplete.
...estcliffe Development, Inc., Pittsburg,	Multi-stage gas centrifuge production facility for the separation of isotopes of uranium.	July 14, 1959	Pending—Application incomplete.[1]
EXPORT LICENSES			
... Industries, Inc., ...York, N.Y.	1-watt pool-type, light water cooled and moderated research reactor for export to Tecnicas Hispano Americanas S.A., Madrid, Spain.	Feb. 4, 1958	Application withdrawn.
...General Nucleonics ...mon, Calif.	100-milliwatt AGN-201 reactor, serial 110, for export to Laboratoires R. Derveaux, Boulogne, France.	July 9, 1957	Application withdrawn.
	100-milliwatt AGN-201 reactor or AGN-211 pool-type reactor for export to Government of Belgium for exhibit at 1958 World's Fair, Brussels, Belgium.	Dec. 9, 1957	Application withdrawn.
	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.
	100-milliwatt AGN-201 reactor, serial 111, for export to Universite de Geneve, Geneva, Switzerland.	Apr. 24, 1958	Application withdrawn.
	20-watt AGN-201P reactor, serial 121, for export to University of Zurich, Zurich, Switzerland.	Oct. 16, 1958	Application withdrawn.
...almers Mfg. Co., ...kee, Wis. (for ...CF 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.
	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.
	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.
...Intercontinental ...& Service Co., ...k, 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.
...Machine & ...ry Co., New ...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.
	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.
	1,000-kilowatt pool-type research reactor for export to Hamilton College, McMaster University, Hamilton, Canada.	May 17, 1957	License issued Aug. 27, 1957.

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...NS—Continued

	Status
	...ontinued
	Construction permit ... June 18, 1957; license ... Aug. 13, 1957; amended ... additional experiments ... 26, 1957, Feb. 3, 1958, June ... 1958 and July 18, 1958.
	Construction permit ... June 29, 1956; license ... Aug. 30, 1957; amended ... broaden scope of activities ... May 29, 1959 and June 3, ... amended for additional experiments Oct. 4, 19...
	Construction permit ... Sept. 20, 1957; license ... Oct. 16, 1957 (tests completed and license expired May ... 1958).
...6	Construction permit ... Mar. 14, 1957 (expired ... 30, 1957).
...0	Pending.
...56	Construction permit ... May 13, 1957; license ... Dec. 6, 1957 for MPR ... ments amended for ... experiments June 12, ... amended for additional experiments Apr. 30, 1959, ... 27, 1959, Mar. 8, 1960, ... 1960 and June 7, 1960.
...60	Construction permit ... May 13, 1960.
...957	Construction permit ... Jan. 22, 1958; license ... Jan. 5, 1959.
...959	Construction permit ... Dec. 24, 1959; license ... Oct. 3, 1960.
...956	Construction permit ... June 11, 1956; license ... possess only) issued Jan. ... 1958.
...960	Pending.
...1956 / 1958 / 1958 / 1959 / 1959	Construction permit ... Oct. 17, 1957; license ... for Yankee experiments ... 25, 1957, with amendments for additional experiments ... June 30, 1958 and Aug ... 1958; license amended ... BR-3 experiments Oct ... 1958, with amendments ... additional experiments ... 12, 1959 and Jan. ... license amended for ... region experiments ... 1958, with amendments ... additional experiments ... 3, 1959 which also ... RFMF experiments ... amended for "Loose Lattice" experiments July 10, 19...
...1957	Construction permit ... June 14, 1958; license ... June 17, 1958, amended ... additional experiments ... 7, 1959 and Oct. 29, 19...
...1959	Construction permit ... Apr. 26, 1960; license ... May 3, 1960.

...nsee's request.
...Lockheed letter dated Feb. 11, ...
...iation Effects Reactor and the ...

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.—Continued	1,000-kilowatt pool-type research reactor for export to Junta de Energia Nuclear, Lisbon, Portugal.	July 22, 1957	License issued Sept. 13, [illegible]
Do	1,000-kilowatt pool-type research reactor for export to Greek Atomic Energy Commission, Athens, Greece.	May 7, 1957	License issued Sept. 23, [illegible]
Do	1,000-kilowatt pool-type research reactor for export to Societa Ricerche Impianti Nucleari, Milan, Italy.	July 3, 1957	License issued Dec. 6, [illegible]
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, [illegible]
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, [illegible]
Do	5,000-kilowatt pool-type research reactor for export University of Teheran, Teheran, Iran.	Apr. 20, 1959	License issued Aug. 5, [illegible]
Do	1,000-kilowatt pool-type research reactor for export to Turkish Atomic Energy Commission, Istanbul, Turkey.	June 10, 1959	License issued Sept. 4, [illegible]
American Radiator & Standard Sanitary Corp., 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, [illegible]
Do	0.1 watt water-moderated, graphite-reflected research reactor for export to Kinki University, Fuse, Osaka, Japan.	Oct. 7, 1960	Pending.
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. [illegible]
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 [illegible]
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. [illegible]
Foster-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. [illegible]
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. [illegible]

FACILITY LICENSE APPLICATIONS—Continued

Applicant and Location of Facility	Description of Facility	Date Filed	Status
	EXPORT LICENSES—Continued		
…Dynamics Corp., …Diego, Calif.—Con.	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-kilowatt 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, Tokyo, 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.
…Electric Co., New …N.Y.	3,000-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.
…Electric Co. …N.Y.	150,000-kilowatt (electrical) boiling water type power reactor for export to Societa Elettronucleare Nazionale (SENN), Rome, Italy.	Apr. 5, 1960	Pending.
…ental Chemical …New York, N.Y.	50-kilowatt solution-type research reactor (Atomics Int'l. Model L-54) for export to Farbwerke Hoechst AG, Frankfurt, Germany.	Apr. 1, 1957	License issued June 11, 1957.
…Company, Los …Calif.	500-watt solution-type research reactor (Atomics Int'l. Model L-55) for export to the Danish Atomic Energy Commission, Christiansborg, Copenhagen, Denmark.	Jan. 17, 1957	License issued Apr. 4, 1957.

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 Int'l. Model L-54) for export to the Senate of the Land Berlin, Berlin, Germany.	Mar. 28, 1957	License issued Sept. [illegible]
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. [illegible]
Marubeni-Iida Co. (N.Y.), Inc., New York, N.Y.	50-kilowatt solution-type research reactor (Atomics Int'l. Model L-54) for export to The Japan Atomic Energy Research Institute, Tokyo, Japan.	Sept. 13, 1956	License issued Nov. [illegible]
Mitsubishi International Corporation, 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. [illegible]
S. A. Innocente Mangili Adriatica, Inc., New York, N.Y.	50-kilowatt solution-type research reactor (Atomics Int'l. Model L-54) for export to Politecnico Di Milano, Milan, Italy.	June 2, 1958	License issued Aug. [illegible]

Business or Occupation of Access Permit Holders

	Dec. 31, 1959	Nov. 30, 1960
Aircraft and/or Components	32	30
Beverage Industry	1	1
Chemical-General	70	56
Chemical-Pharmaceutical	4	3
Chemical-Processing Equipment	11	12
Coal Industry	3	2
Communications	1	1
Consultants	77	66
Educational Institutions	25	27
Electronic Industry	36	19
Engineering-Construction	40	32
Engineering-Consulting	86	48
Engineering-Design	38	54
Federal, State, and City Governments or Departments	45	32
Financial Organizations	11	8
Food Companies	1	1
Information Services	15	14
Instrument Manufacturer	56	47
Insurance Companies	82	70
Lawyers and Public Accountants	31	26
Machinery-General	33	27
Machinery-Special	26	21
Metal Products Manufacture	122	101

Mining and Refining	[illegible]	[illegible]
Motor Vehicles and/or Components	[illegible]	[illegible]
Paper and Pulp Companies	[illegible]	[illegible]
Petroleum and Petroleum Products	[illegible]	[illegible]
Printing and Publishing	[illegible]	[illegible]
Professors, Teachers, and Scientists	[illegible]	[illegible]
Railroads and Railway Equipment	[illegible]	[illegible]
Research-General	[illegible]	[illegible]
Research-Medical	[illegible]	[illegible]
Rubber and Rubber Products	[illegible]	[illegible]
Scrap and Waste Disposal	[illegible]	[illegible]
Shipbuilding and/or Components	[illegible]	[illegible]
Special Carriers and Warehousing	[illegible]	[illegible]
Stone, Clay, and Glass Products	[illegible]	[illegible]
Tobacco and Tobacco Products	[illegible]	[illegible]
Unions, Trade Associations, Chambers of Commerce, and Manufacturers' Representatives	[illegible]	[illegible]
Utilities	[illegible]	[illegible]
Weapons, Explosives, and Propellants	[illegible]	[illegible]
Others (not elsewhere classifiable)	[illegible]	[illegible]
Total [1]	[illegible]	[illegible]

[1] Some Permittees have been classified in more than one category.

NS—Continued

	Status
	License issued Sept. 7, 19..
	License issued Dec. 17, 19..
..6	License issued Nov. 2, 19..
..57	License issued Oct. 11, 19..
58	License issued Aug. 11, 19..

'ermit Holders

-fining
. and/or Components
.p Companies
Petroleum Products
ublishing
.chers, and Scientists
Railway Equipment
ral
ical
ubber Products
.ste Disposal
nd/or Components
.s and Warehousing
.nd Glass Products
Tobacco Products
e Associations, Chambers of Commerce, and Manufacturers' Representatives
ntatives
plosives, and Propellants
sewhere classifiable

Access Permit Holders by Principal Fields of Interest

	Dec. 31, 1959	Nov. 30, 1960		Dec. 31, 1959	Nov. 30, 1960
...Nuclear)	0	0	Ore Refining and Production of Feed Materials	63	43
...Processing and Equipment	46	41	Radiation Hazards and Effects	47	35
...(except Reactor Compo-[nents]	65	49	Radioactive Waste	41	29
...	186	145	Reactor-Central Station	190	146
...Thermonuclear Field	24	22	Reactor-Components	40	31
...Construction of Atomic	78	67	Reactor-Heating	4	4
...Facilities	10	9	Reactor-Other	22	20
...Systems	24	21	Reactor-Propulsion	41	35
...Fabrication / ...Nuclear Research and Devel-[opment]	60	53	Reactor-Research	16	14
...	29	25	Shield Materials	17	13
...Services	78	61	Special Materials	89	11
...	85	73	Surveys for Potential Use or Need	21	16
...Evaluation	12	8	Training and Education	14	12
...and Banking	70	52	Transportation and Storage	6	6
...Production and Utilization	30	25	Weapons and Components	0	1
...and Accounting	12	11	Others (Not Elsewhere Classifiable)	9	7
			Total	1,429	1,145

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

Access Permit Holders by Geographic Areas

	Dec. 31, 1959	Nov. 30, 1960		Dec. 31, 1959	Nov. 30, 1960
...al	118	109	West South Central	54	41
...antic	432	357	Mountain	37	31
...Central	256	192	Pacific	138	121
...Central	68	50	Hawaii, Alaska, and Puerto Rico	5	4
...tic	132	104			
...Central	28	23	Total	1,268	1,032

...Standard Department of Commerce Areas.

...er of Permittees Having Access to Secret Restricted Data by Categories

	Dec. 31, 1959	Nov. 30, 1960		Dec. 31, 1959	Nov. 30, 1960
...General	466		Particle Accelerators and High Voltage Machines	187	
...Instrumentation and Radio-...	515		Physics and Mathematics	503	
...Separation Processes for ...and Uranium	379		Plutonium Production		12
...Transuranic Elements	249		Radiation Effects on Reactor Materials	546	
...Thermonuclear Processes	102		Radioactive Waste	548	
...ards	406		Reactors-Power	592	
...Element Technology	3		Reactors-Production	322	
...Technology	1		Reactors-Research and Testing	513	
...Separations Process Techno-[logy]	5		Savannah River-Fuel Element Technology	2	
...ry	577		Savannah River-Reactor Technology	1	
...	497		Savannah River-Separations Process Technology	5	
...nt	98		Technology-Feed Materials	279	
...Ceramics	572		Technology-Plutonium	267	
...Materials	33	693	Technology-Tritium	60	
...gy					

...November 30, 1960, 540 permittees had 500 employees or less, while 492 had over 500 employees. ...31, 1959, permittees with 500 or less employees numbered 583, while 685 had over 500 em-

Number of Access Authorizations Granted to Personnel or Permittees for Access to Secret and Confidential Restricted Data

	Total as of Dec. 31, 1959
Q(X) Access Authorizations:	
New authorizations granted	10,717
Authorizations reinstated	2,477
Authorizations extended	6,465
Total	19,659
Authorizations terminated	4,936
Active Authorizations	14,723

For Access to Confidential Restricted Data

	Total as of Dec. 31, 1959
L(X) Access Authorizations:	
New authorizations granted	9,906
Authorizations reinstated	826
Authorizations extended	1,737
Total	12,469
Authorizations terminated	3,020
Active Authorizations	9,449

APPENDIX 10

Summary of Formal Hearings

...nce Industrial X-ray Laboratories, Inc., Los Angeles, Calif.

...ter hearings in 1959, an intermediate decision was rendered by the Hear... Examiner on January 12, 1960, ordering that a byproduct material license ...issued to Advance provided that it furnish satisfactory information as to ...ifications of personnel, organization, and specified procedures and forms. ...order provided also that the license require Advance to submit on a monthly ...a list of radiographic jobs to be performed. In the absence of exceptions, ...intermediate decision became final on February 2, 1960. Subsequently, a ...was issued to Advance, with an expiration date of June 30, 1961.

...nas Virginia Nuclear Power Associates, Inc., Parr, S.C.

...hearing was held in Germantown, Md., on February 23 and 26, 1960, on a ...uction permit application filed by Carolinas Virginia. On April 12, 1960, ...Presiding Officer issued his Intermediate Decision approving issuance of a ...ional construction permit for the proposed nuclear steam generating plant ...outh Carolina. Since no exceptions were filed and the Commission did not ...ate review of its own motion, the decision became final and the construction ...it was issued on May 4, 1960.

...of Piqua, Piqua, Ohio.

...January 7, 1960, the Presiding Officer issued his Intermediate Decision ...authorized Atomics International Division, North American Aviation, Inc. ...eed with construction of the reactor. In the absence of any exceptions ...filed, the decision became final on January 28, 1960 (the hearing in the ...was held on November 20, 1959).

...wise Marine Disposal Company, Long Beach, Calif.

...is is a proceeding to revoke the waste disposal license of Robert Boswell, ...business as Coastwise Marine Disposal Company. The proceeding was ...t pursuant to an order to show cause dated April 13, 1960. On April 29, ...the Presiding Officer issued an order granting the request of the city of ...Beach, Calif., in which Boswell's facility is located, to intervene within ...framework of the issues specified for consideration by the Commission. ...on an investigation which revealed certain additional alleged violations, ...Commission on May 5, 1960, ordered that the license be suspended insofar ...authorized the receipt of byproduct, source or special nuclear material ...with regard to material then in transit to the licensee. Under the order ...licensee was required to cease and desist from any further disposal of ...al except after obtaining specific written authorization from the Com... or except in the immediate presence and with the approval of a ...ission inspector. The hearing was held in Long Beach on May 9, 10 and ...60.

...May 23, 1960, the licensee filed a motion to relieve him from the suspension ...by the order of May 5, 1960. This motion was opposed by the staff and ...nied by an order of the Presiding Officer dated June 7, 1960. On June ... the licensee filed a motion to reopen the proceeding for the purpose ...ing proof as to the status of one of his customers with whom he alleged that certain drums having excessive radiation levels had originated. The motion was opposed by the staff and was denied by an order of the Presiding Officer dated July 19, 1960. However, the Presiding Officer requested further information concerning the relationship between certain customers and the Commission. On August 1, 1960, the staff filed its proposed findings and conclusions and brief.

On August 5, 1960, the licensee filed a document in support of its contention that the proceeding should be reopened and requested that the licensee be authorized to engage in controlled and limited operations of waste disposal until the final determination of this matter. On August 24, 1960, the staff filed a memorandum in opposition to the Licensee's Application of August 5, 1960. On August 30, 1960, the staff filed documents which constitute the present form of the contract between the Commission and the Regents of the University of California and asked that the documents be made a part of the record of the case. Subsequently, these documents were made a part of the record in the case.

On September 28, 1960, the Presiding Officer on the request of the licensee extended the time for the filing by the licensee of its finding and conclusions and brief until October 10, 1960. Time for the staff's reply was extended to October 25, 1960. On December 16, 1960, the Presiding Officer issued his Immediate Decision which ordered that the Coastline license be revoked and terminated and stated that exceptions must be filed by January 6, 1961.

Commonwealth Edison Co., Dresden, Ill.

On April 28, 1960, Commonwealth filed a report of test operations of the reactor as required by the Supplemental Intermediate Decision of November 12, 1959, which authorized test operations at limited power levels of up to 315 thermal megawatts (50% of design power). Following a hearing on the matter held May 4 and 6, 1960, at Germantown, Md., the Presiding Officer on May 16, 1960, issued his Second Supplemental Intermediate Decision authorizing operation of the Commonwealth Edison reactor at power levels of up to 630 mw (thermal) but not in excess of that level or at steady state operations at that power level. On August 2, 1960, the licensee filed Report No. 4, "Full Rated Power Test Operations of the Dresden Reactor," in accordance with license DPR-2, as amended, issued on June 2, 1960. On September 26 and 27, 1960, a hearing was held to consider the Report No. 4 and other relevant matters, including the question whether the Commission should consent to a lien on the company's facilities at the Dresden Nuclear Power Station. On October 11, 1960, the Hearing Examiner issued a Third Supplemental Intermediate Decision, which authorized power operations at the Dresden plant to power levels up to [illegible] MWT. This decision also gave the Commission's consent to the attachment of a lien on the facility. On October 14, 1960, the license was issued pursuant to the decision, for a full term of years to 1996.

By telegram dated November 16, 1960, Commonwealth reported a malfunction of the control rod drive mechanism. On November 17, 1960, the AEC Staff filed with the Commission a "Motion to Extend Period for Commission Review" until December 16, 1960, subject to such further extension as may be necessary in order to permit investigation and development of the facts disclosed in the Commonwealth telegram and permit determination of their relevance to issuance of the operating license to Commonwealth Edison. By memorandum dated November 22, 1960, Commonwealth amplified their telegram of November 16, and on November 23d the staff filed a memorandum supporting their motion to extend the period for Commission review. On November 23, 1960, following the

...of oral argument, the Commission granted the AEC Staff's motion and order ...extension of the period for Commission review to and until December 16, 1960. ...it became clear that the investigation would extend beyond December 16, ...Commission staff moved that the Commission further extend the review ...until January 31, 1960. On December 14, 1960, the Commission granted ...staff motion.

...mers Power Co., Big Rock Point, Mich.

...February 19, 1960, Notice of Hearing was issued on the construction permit ...ication for a 75 megawatt (electrical) high power density, boiling water ...tor proposed for construction by Consumers. On March 22, 1960, the State ...Michigan Department of Health filed with the Presiding Officer a Statement ...Position regarding the proposed project. A Statement of Position and request ...limited appearance was submitted on March 23, 1960, by the Michigan Water ...urces Commission. On March 24, 1960, the Attorney General of the State ...Michigan filed a Petition for Intervention. By telegram dated March 25, ...the Presiding Officer notified the State of Michigan, by its Attorney Gen... that the Petition for Intervention was granted, and that the State of ...igan Water Resources Commission could enter a limited appearance; on ...rch 28, 1960, the Presiding Officer issued his formal Order for Intervention ...Limited Participation. The hearing in the matter took place March 29, ...in Germantown, Md., at which time the limited appearance of the Michigan ...Department of Health was permitted. On May 6, 1960, the Presiding ...er issued his Intermediate Decision authorizing issuance of a provisional ...struction permit for a reactor with an initial capacity of 50,000 electrical ...watts, and an ultimate design capacity of 75,000 kilowatts (electrical). The ...sion became final on May 28, 1960, and the construction permit was issued ...May 31, 1960.

...October 17, 1960, Consumers filed an application for amendment to their ...mit regarding the addition of technical specifications for reactor containment. ...earing on the proposed amendment was held on December 13, at which time ...Hearing Examiner ordered that the applicant's motion for postponement of ...ing be granted and that the hearing in the proceeding be convened at a ...to be specified in a subsequent order.

...ral Electric Co., Pleasanton, Calif.

...February 24, 1960, a Notice of Hearing on Application for Amendment to ...ation Facility License was issued. The hearing was commenced on April 5, ...and on April 6, 1960, was recessed to reconvene on May 2, 1960. At the re... of the licensee, the hearing was postponed until May 23, 1960. On June 14, ...the Presiding Officer issued his Intermediate Decision, authorizing the ...tion of the Vallecitos Boiling Water Reactor with certain internal modifica... with a new fuel arrangement including a new type of control rod and ...ed rod activators and with both turbine-and-electrical-driven coolant cir... pumps. In the absence of exceptions, or Commission review on its own ..., the decision was to have become final on July 6, 1960. On June 30, 1960, ...ral Electric advised the Presiding Officer and the Commission that it would ...ceptions to the Intermediate Decision in regard to the issue of the pro... to be followed by the licensee before making changes in the reactor ...method of operation. The licensee also requested that the license amend... authorized in the Intermediate Decision be made effective immediately, or ...July 6, 1960, notwithstanding the filing of exceptions. By order dated ...1960, the Commission designated July 6, 1960, as the effective date of the Intermediate Decision and ordered that the amendment to the license be issued as of that date. On July 2, 1960, General Electric filed its exceptions to the Presiding Officer's Intermediate Decision. On July 25, 1960, the staff filed a brief with respect to the exceptions. On July 30, 1960, the licensee filed a reply brief. On August 18, 1960, the Commission issued a Memorandum and Order which denied the licensee's exceptions to the Intermediate Decision with respect to the change procedures, and ordered that certain modifications be made to Amendment 14 to license DPR–1. On August 20, 1960, the licensee filed a petition for reconsideration of the final decision stated in the Commission's Memorandum and Order dated August 18, 1960. On September 7, 1960, the staff filed a memorandum in answer to the licensee's petition for reconsideration. By order issued September 27, 1960, the Commission agreed to consider its Memorandum and Order and set October 10, 1960, as the date and place for oral arguments on the licensee's petition for reconsideration. On October 10, 1960, the Commission heard oral argument on the petition for reconsideration. On October 7, the staff had filed a draft of a proposed license which was concurred in by the licensee. On November 2, the Commission issued a Memorandum and Order which directed the issuance of a license amendment incorporating a change procedure which had been jointly proposed by Commission staff and the licensee. Under the amended license, the licensee has freedom to make changes within the limits of the technical specifications, provided no unreviewed safety question is involved. Any change involving unreviewed safety questions and all changes in the technical specifications must be referred to the Commission. The Director, Division of Licensing and Regulation, may authorize such changes if they present no significant new hazards considerations. Otherwise, referral to the Advisory Committee on Reactor Safeguards and scheduling of a public hearing is required.

Houston Gamma Ray Company, Houston, Tex.

Houston Gamma Ray is the holder of a byproduct material license authorizing the use of byproduct material in radiography. The activities of the company had been inspected on three previous occasions, after which alleged violations of the regulations and license conditions had been brought to the attention of the licensee by notices issued pursuant to 10 CFR 2. The fourth inspection of the company's activities was conducted in August and September, 1960, and disclosed several alleged willful violations of the regulations and conditions of the license. Accordingly, on September 19, 1960, AEC issued an order to show cause why license should not be revoked at a hearing to be held in Houston, Tex., on October 11, 1960.

The licensee requested that the hearing date be postponed. By an order dated October 4, 1960, the Hearing Examiner scheduled the hearing for October 2[illegible], 1960. On October 6, 1960, the licensee's answer to the order to show cause was filed.

On October 20, 1960, a stipulation was filed by counsel for the AEC staff and for the licensee reciting that the license would be revoked, the application for license renewal denied, and that a new application for a new license would be considered by the AEC after one year upon a showing that the licensee had provided adequate safeguards to prevent the occurrence of any violations.

The Presiding Officer entered an order pursuant to the stipulation of October 2[illegible], 1960, together with a memorandum specifying that the stipulation was in no way a limitation on the AEC in reviewing any applications filed by the licensee after one year.

Industrial Waste Disposal Corporation, Houston, Tex.

After the hearing which was held on January 22 and 23, 1959, the AEC Hearing Examiner issued an Intermediate Decision on May 29, 1959, and directed that a license be issued to the applicant for the storage, transportation, and disposal of low level, radioactive waste material in the Gulf of Mexico.

Exceptions to the Intermediate Decision were filed by the intervenors, including the State of Texas which had been permitted to intervene on September 3, 1959. On January 13, 1960, the AEC staff filed a copy of a letter from the Ambassador of Mexico to the Acting Secretary of State, dated December 16, 1959, by which Mexico expressed its opposition to the disposal of radioactive wastes in the Gulf of Mexico. On January 15, 1960, the United States Department of the Interior submitted to the Presiding Officer a copy of its negative reply to the Harris County, Tex., resolution requesting intervention in the matter by the Department. Extensive oral arguments on the part of all of the parties were heard by the Commission on January 20, 1960, at the Commission's headquarters in Germantown, Md.

The Commission issued its decision on June 22, 1960. The Commission found that the applicant was entitled to receive a byproduct material license for the receipt and storage of packaged low level waste material. As to the disposal of waste at sea, the Commission remanded the case to the Hearing Examiner for further proceedings to take testimony concerning the integrity of containers for their disposal in the Gulf of Mexico, and concerning such other material matters as the Examiner might permit.

The intervenor, Harris County, filed its petition for review of the Commission's order in the Court of Appeals for the Fifth Circuit on August 19, 1960. The petition for review contained an application for interlocutory stay of the Commission's order which was opposed by the Commission, and by Industrial Waste Disposal Corp., and was denied by the Fifth Circuit on September 14, 1960.

The Commission transmitted to the Court a certified list of material in the record filed on September 22, 1960, and proposed to the parties the filing of a joint motion to set procedures and time schedule. On the Clerk's request, the Commission transmitted the entire certified record to the Court on November 2, 1960.

... Development, Inc., Edgemont, S. Dak.

On November 13, 1959, the licensee requested a formal hearing with respect to the November 2, 1959 order, citing the licensee for alleged failure to make surveys to determine airborne radioactivity and external radiation levels, and requiring the licensee to bring the mill operation into compliance with Commission regulations. A notice of hearing, issued November 30, 1959, provided for a hearing on January 7, 1960. The date of hearing was subsequently postponed, and the hearing was held on May 17, 18, and 19, 1960. A brief was filed by the staff on July 25, 1960. The licensee submitted its brief on August 29, 1960. The Staff's reply brief was filed on September 21, 1960. On November 25, 1960, the Presiding Officer issued an Intermediate Decision which ordered the licensee to institute a program to assure that adequate surveys are made and corrective action taken. Exceptions were filed in December and briefs submitted by both parties.

National Aeronautics and Space Administration, Sandusky, Ohio.

A notice dated September 13, 1960, October 18, 1960, was set as the hearing date for consideration of issuance of an operating license for the NASA 60 megawatt (thermal) test reactor located at the NASA Plum Brook Facility, Sandusky, Ohio.

On October 4, 1960, the applicant filed an answer to the notice of hearing and motion for continuance on the ground that the applicant will not be able to complete construction by October 18, 1960. On October 7th, the staff informed the Examiner that it had no objection for continuance of the hearing scheduled for October 18, 1960. The hearing was held on October 18, 1960, and was recessed to reconvene on December 14, 1960. On October 19th, the Examiner issued an order postponing the hearing to December 14, 1960.

The hearing was convened on December 14 and recessed until December 16. On the later date, witnesses testified on behalf of the applicant and the AEC Staff. The applicant indicated that since construction of the facility was not complete, only a provisional operating license authorizing initial loading of fuel and low power operation to 100 kilowatts (thermal) was being sought, pursuant to Section 50.57 of the Commission's regulations. The Examiner will issue an Intermediate Decision after filing of proposed findings and conclusions by the parties.

Northern States Power Co., Sioux Falls, S. Dak.

In accordance with the Notice of Hearing issued January 7, 1960, a hearing was held on February 15 and 16, 1960 to consider issuance of a provisional construction permit to Northern States. On April 21, 1960, the Presiding Officer issued his Intermediate Decision authorizing the issuance of a provisional construction permit for the 62 megawatt (electrical) "Pathfinder" reactor. The Decision became final and the construction permit was issued on May 12, 1960.

Nuclear Engineering Company, Inc., 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. Officials of the State of California have objected to the conduct of further operations by the licensee at the site near Antioch. The decision of the Presiding Officer on the matter is pending.

Pacific Gas and Electric Company, Eureka, Calif.

A hearing was held on August 24–26, 1960, to consider a construction permit for the proposed nuclear reactor at the licensee's Humboldt Bay Power Plant. The hearing originally scheduled for April 14, 1960, was postponed at the request of the applicant to allow the applicant to conduct further tests regarding the proposed reactor. An intermediate decision issued on October 17, 1960, became final on November 8, 1960, and ordered that a construction permit substantially in the form attached thereto be issued. The construction permit was issued on November 9, 1960.

Power Reactor Development Company, Lagoona Beach, Mich.

A summary of the status of this case is set forth in the section on Licensing Regulations and Indemnification.

Puerto Rico Water Resources Authority, Rincon, Puerto Rico.

A hearing on the construction of a reactor to be constructed for the Puerto Rico Water Resources Authority at a site near Rincon, Puerto Rico was held at San Juan, Puerto Rico on April 27, 1960. On June 28, 1960, the Presiding Officer issued his Intermediate Decision which authorized construction of the

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Nuclear Super Heater (BONUS) Power Plant. The decision became on July 19, 1960.

Cooperatives Power Association, Elk River, Minn.

Intermediate Decision of the Presiding Officer issued December 18, 1959, final January 9, 1960. The decision authorized construction of the Elk reactor, which was considered during the hearing held November 10, 1959. notice dated November 17, a hearing on the operating authorization for thousand ekw facility was scheduled for December 20. By order dated ember 9, the Presiding Officer granted the applicants' request that the hearing ferred until March 7, 1961.

Inspection Company, Sarnia, Ontario, Dominion of Canada.

rnia is the holder of a license permitting the use of byproduct material in graphy. An inspection of the licensee's activities in the United States several alleged violations of the Commission's regulation and conditions license dealing primarily with the alleged failure of the licensee to provide ate supervision and inspection of the employees using byproduct material. dingly, the Commission issued an order to show cause dated June 21, 1960, ding that the licensee conduct no further radiography operations unless operations were conducted by or under the supervision of individuals ically approved by the Commission, that 48-hour notice of the beginning each operation in the United States be given to the Commission, and the show cause why these requirements should not be imposed.

June 28, 1960, the licensee filed an answer. On July 6, 1960, the staff for a prehearing conference for the purpose of clarifying the licensee's as stated in its answer. Subsequently, by a letter dated July 7, 1960, a ance of the hearing was requested by counsel newly retained by the . On July 20, 1960, an amendment to the answer was filed in which licensee stated that it consents to the entry of an order by the Hearing iner containing the restrictions set forth in the order of June 21, 1960. an order dated July 22, 1960, the case was continued indefinitely. At the of the Presiding Officer the parties prepared a final order dismissing proceeding. This order was submitted to the Presiding Officer with a ation by the parties on October 5, 1960. A final order dated October 11, was entered by the Presiding Officer pursuant to the stipulation.

Nuclear Experimental Corporation, Saxton, Pa.

January 21, 1960, the Presiding Officer issued his Intermediate Decision izing construction of Saxton Reactor. (A hearing had been held on ber 15, 1959). The construction permit was issued on February 11, 1960.

Trucking Company, New Britain, Conn.

aring was held in New Britain, Conn., on June 3, 1959, to consider the of a requested license amendment which would authorize the applicant age and store byproduct and source material at a site in that city. In ceeding the Mayor of the city of New Britain was permitted to intervene alf of himself and the city. Algert F. Politis was permitted to inter- behalf of himself and others. This hearing was recessed to reconvene 24, 1959, to permit intervenors to obtain expert testimony and assistance the application. Subsequent postponements of the hearing were made request of the intervening objectors in order that they might complete preparation. The hearing was scheduled to reconvene on February 9, 1960, but was postponed at the request of staff because the staff had been informed of certain changes in the licensee's organization. The hearing was further postponed on the request of the intervening objectors. The hearing reconvened on June 14, and 15, 1960. After the filing of briefs and proposed findings and conclusions by the parties, the Presiding Officer requested that the staff file a supplemental brief since the intervenor's brief covered several matters not previously considered in the staff's brief. This supplemental brief was filed by the staff on September 28, 1960. On October 18, 1960, the Presiding Officer asked the intervening objectors if they desired to file a reply brief to the staff's supplemental brief. A brief was filed by Mr. Politis on November 17, 1960. Filings are now completed, and a decision by the Presiding Officer is pending.

X-Ray Engineering Company, Burlingame, Calif.

A hearing in the matter had been held December 2–4, 1959, to consider an Order to Show Cause and Order Suspending Licensed Operations, issued to X-Ray by the Commission on October 19, 1959. On February 6, 1960, X-Ray filed a motion with the Presiding Officer requesting amendment to its license regarding the type of equipment used in its operations. The AEC staff filed objections to the licensee's request. On February 19, 1960, the Presiding Officer issued an Order Granting Request for Amendment of License by Substitution of Equipment, and Denying Request for Amendment of Order Which Suspended Certain Licensed Operations.

The Hearing Examiner delivered his intermediate decision on July 19, 1960, in which a revocation of license was ordered. With one exception, he found that all violations alleged by the Staff were willful, and that the licensee in its letter of September 11, 1959, falsified its report of compliance.

The licensee filed exceptions to the intermediate decision and a supporting brief on August 28, 1960. The staff filed its brief in opposition on September 12, 1960. By stipulation it was agreed between staff and licensee that the licensee should have until October 12, 1960, to file a reply brief.

On November 18, 1960, the Commission sustained the Intermediate Decision and directed that the company could file a new license application which would receive timely consideration contingent upon a demonstration that adequate provision for the public health and safety will be provided and maintained and complete compliance with Commission regulations. The applicant sought a stay of the order of revocation until such an application for license could be filed. The Commission denied the motion for stay.

Yankee Atomic Electric Company, Rowe, Mass.

On March 3 and 4, 1960, a hearing was held in Germantown, Md., on an application for removal of the provisional terms in the construction permit issued to Yankee in connection with the 110 megawatt (electrical) power reactor under construction at Rowe, Massachusetts. On April 22, 1960, the Presiding Officer issued his Intermediate Decision granting conditional approval of certain technical specifications regarding the reactor; final approval to await presentations of further evidence. The decision became final on May 17, 1960.

On May 18, 1960, the Commission issued an Order, in response to the applicant's motion, permitting the Presiding Officer to provide that any intermediate decision and order subsequently issued be made immediately effective. The hearing to consider issuance of the facility license was held on May [illegible] and 26, 1960. The hearing was successively adjourned to June 15, June 28, and July 8, 1960. On July 9, 1960, the Presiding Officer issued the Second Intermediate

Decision which ordered issuance of an interim license authorizing operation of the reactor at power levels not in excess of 5 MW (thermal) solely for the purpose of initial fuel loading and low-power testing. On July 19, 1960, the Presiding Officer issued the Third Intermediate Decision, which ordered issuance of a license authorizing power operations to 392 megawatts (thermal) subject to a further hearing to be held to review operations at such power level. A license in the form specified was issued on July 29, 1960.

On August 8, 1960, Yankee filed an exception to the Third Intermediate Decision with respect to the requirement that all proposed changes in the technical specifications be subject to a public hearing. On August 18, 1960, the Commission denied the exception and remanded the matter to the Hearing Examiner for further proceedings and appropriate decision with respect to the scope of the technical specifications, and other relevant matters. On November 15, 1960, Yankee filed a motion asking that the hearing be reconvened to conform the provisions of the license to the views expressed by the Commission in the Memorandum and Order dated November 2, 1960, in Docket No. 50–18 (General Electric-Vallecitos Boiling Water Reactor). A hearing was scheduled for December 12, 1960, convened on that date and recessed to December 13, 1960, when it was reconvened. Proposed findings and conclusions have been filed by Yankee and the Staff, and a decision by the Hearing Examiner is pending.

APPENDIX 11

Memorandum to President From FRC on Radiation Protection Guidance for Federal Agencies

MEMORANDUM FOR THE PRESIDENT

SUBJECT: Radiation Protection Guidance for Federal Agencies

Pursuant to Executive Order 10831 and P.L. 86–373 the Federal Radiation Council has made a study of the hazards and use of radiation. We herewith transmit our first report to you concerning our findings and our recommendations for the guidance of Federal agencies in the conduct of their radiation protection activities.

It is the statutory responsibility of the Council to ". . . advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States . . ."

Fundamentally, setting basic radiation protection standards involves passing judgment on the extent of the possible health hazard society is willing to accept in order to realize the known benefits of radiation. It involves inevitably a balancing between total health protection, which might require foregoing any activities increasing exposure to radiation, and the vigorous promotion of the use of radiation and atomic energy in order to achieve optimum benefits.

The Federal Radiation Council has reviewed available knowledge on radiation effects and consulted with scientists within and outside the Government. Each member has also examined the guidance recommended in this memorandum in light of his statutory responsibilities. Although the guidance does not cover all phases of radiation protection, such as internal emitters, we find that the guidance which we recommend that you provide for the use of Federal agencies gives appropriate consideration to the requirements of health protection and the beneficial uses of radiation and atomic energy. Our further findings and recommendations follow.

Discussion

The fundamental problem in establishing radiation protection guides is to allow as much of the beneficial uses of ionizing radiation as possible while assuring that man is not exposed to undue hazard. To get a true insight into the scope of the problem and the impact of the decisions involved, a review of the benefits and the hazards is necessary.

It is important in considering both the benefits and hazards of radiation to appreciate that man has existed throughout his history in a bath of natural radiation. This background radiation, which varies over the earth, provides a partial basis for understanding the effects of radiation on man and serves as an indicator of the ranges of radiation exposures within which the human population has developed and increased.

The Benefits of Ionizing Radiation

Radiation properly controlled is a boon to mankind. It has been of inestimable value in the diagnosis and treatment of diseases. It can provide sources of

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energy greater than a
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The Hazards of Ioni

Ionizing radiation i
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irradiation.
4. The delayed effe
familiar pathol
5. Delayed effects i
generations), i
growth and dev
6. The child, the inf
radiation than
7. The various orga
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9. If one assumes a
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Basic Biological Assun

There are insufficien
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with respect to the biol
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below which there is
deration, in addition
relation between biolog
approach to the formul
The lack of adequate
research be undertaken
evaluating biological ri
the Council are sponso

...greater than any the world has yet had available. In industry, it is used ... tool to measure thickness, quantity or quality, to discover hidden flaws, ... liquid flow, and for other purposes. So many research uses for ionizing ... have been found that scientists in many diverse fields now rank radia... with the microscope in value as a working tool.

... Hazards of Ionizing Radiation

...ionizing radiation involves health hazards just as do many other useful tools. ...ific findings concerning the biological effects of radiation of most immediate ... to the establishment of radiation protection standards are the following:

- Acute doses of radiation may produce immediate or delayed effects, or both.
- As acute whole body doses increase above approximately 25 rems (units of radiation dose), immediately observable effects increase in severity with dose, beginning from barely detectable changes, to biological signs clearly indicating damage, to death at levels of a few hundred rems.
- Delayed effects produced either by acute irradiation or by chronic irradiation are similar in kind, but the ability of the body to repair radiation damage is usually more effective in the case of chronic than acute irradiation.
- The delayed effects from radiation are in general indistinguishable from familiar pathological conditions usually present in the population.
- Delayed effects include genetic effects (effects transmitted to succeeding generations), increased incidence of tumors, lifespan shortening, and growth and development changes.
- The child, the infant, and the unborn infant appear to be more sensitive to radiation than the adult.
- The various organs of the body differ in their sensitivity to radiation.
- Although ionizing radiation can induce genetic and somatic effects (effects on the individual during his lifetime other than genetic effects), the evidence at the present time is insufficient to justify precise conclusions on the nature of the dose-effect relationship at low doses and dose rates. Moreover, the evidence is insufficient to prove either the hypothesis of a "damage threshold" (a point below which no damage occurs) or the hypothesis of "no threshold" in man at low doses.
- If one assumes a direct linear relation between biological effect and the amount of dose, it then becomes possible to relate very low dose to an assumed biological effect even though it is not detectable. It is generally agreed that the effect that may actually occur will not exceed the amount predicted by this assumption.

... Biological Assumptions

...ere are insufficient data to provide a firm basis for evaluating radiation ... for all types and levels of irradiation. There is particular uncertainty ... respect to the biological effects at very low doses and low-dose rates. It is ...prudent therefore to assume that there is a level of radiation exposure ... which there is absolute certainty that no effect may occur. This con...ation, in addition to the adoption of the conservative hypothesis of a linear ... between biological effect and the amount of dose, determines our basic ...ach to the formulation of radiation protection guides.

...e lack of adequate scientific information makes it urgent that additional ...rch be undertaken and new data developed to provide a firmer basis for ...ating biological risk. Appropriate member agencies of the Federal Radia... Council are sponsoring and encouraging research in these areas.

Recommendations

In view of the findings summarized above the following recommendations are made:

It is recommended that:

1. There should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure. Activities resulting in man-made radiation exposure should be authorized for useful applications provided the recommendations set forth herein are followed.

It is recommended that:

2. The term "Radiation Protection Guide" be adopted for Federal use. The term is defined as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable.

It is recommended that:

3. The following Radiation Protection Guides be adopted for normal peacetime operations.

TYPE OF EXPOSURE	CONDITION	DOSE (rem)
Radiation Worker:		
(a) Whole body, head and trunk, active blood forming organs, gonads, or lens of eye	Accumulated dose	5 times the number of years beyond age 18.
	13 weeks	3.
(b) Skin of whole body and thyroid	Year	30.
	13 weeks	10.
(c) Hands and forearms, feet and ankles	Year	75.
	13 weeks	25.
(d) Bone	Body burden	0.1 microgram of radium-226 or its biological equivalent.
(e) Other organs	Year	15.
	13 weeks	5.
Population:		
(a) Individual	Year	0.5 (whole body).
(b) Average	30 year	5 (gonads).

The following points are made in relation to the Radiation Protection Guides herein provided:

(1) For the individual in the population, the basic Guide for annual whole body dose is 0.5 rem. This Guide applies when the individual whole body doses are known. As an operational technique, where the individual whole body doses are not known, a suitable sample of the exposed population should be developed whose protection guide for annual whole body dose will be 0.17 rem per capita per year. It is emphasized that this is an operational technique which should be modified to meet special situations.

(2) Considerations of population genetics impose a per capita dose limitation for the gonads of 5 rems in 30 years. The operational mechanism described above for the annual individual whole body dose of 0.5 rem is likely in the immediate future to assure that the gonadal exposure Guide (5 rem in 30 years) is not exceeded.

(3) These Guides do not differ substantially from certain other recommendations such as those made by the National Committee on Radiation Protection and Measurements, the National Academy of Sciences, and the International Commission on Radiological Protection.

(4) The term "maximum permissible dose" is used by the National Committee on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP). However, this term is often misunderstood. The words "maximum" and "permissible" both have unfortunate connotations not intended by either the NCRP or the ICRP.

(5) There can be no single permissible or acceptable level of exposure without regard to the reason for permitting the exposure. It should be general practice to reduce exposure to radiation, and positive efforts should be carried out to fulfill the sense of these recommendations. It is basic that exposure to radiation should result from a real determination of its necessity.

(6) There can be different Radiation Protection Guides with different numerical values, depending upon the circumstances. The Guides herein recommended are appropriate for normal peacetime operations.

(7) These Guides are not intended to apply to radiation exposure resulting from natural background or the purposeful exposure of patients by practitioners of the healing arts.

(8) It is recognized that our present scientific knowledge does not provide a firm foundation within a factor of two or three for selection of any particular numerical value in preference to another value. It should be recognized that the Radiation Protection Guides recommended in this paper are well below the level where biological damage has been observed in humans.

...recommended that:

...rent protection guides used by the agencies be continued on an interim basis for organ doses to the population.

...mmendations are not made concerning the Radiation Protection Guides ...dividual organ doses to the population, other than the gonads. Unfor...ly, the complexities of establishing guides applicable to radiation expo... of all body organs preclude the Council from making recommendations ...ing them at this time. However, current protection guides used by ...encies appear appropriate on an interim basis.

...commended that:

...e term "Radioactivity Concentration Guide" be adopted for Federal use. This term is defined as the concentration of radioactivity in the environment which is determined to result in whole body or organ doses equal to the Radiation Protection Guide.

...in this definition, Radioactivity Concentration Guides can be determined after the Radiation Protection Guides are decided upon. Any given ...ctivity Concentration Guide is applicable only for the circumstances ... which the use of its corresponding Radiation Protection Guide is ...priate.

...mmended that:

... Federal agencies, as an interim measure, use radioactivity concen...tion guides which are consistent with the recommended Radiation Pro...tion Guides. Where no Radiation Protection Guides are provided, Fed...al agencies continue present practices.

...ecific numerical recommendations for Radioactivity Concentration ...re provided at this time. However, concentration guides now used by ...cies appear appropriate on an interim basis. Where appropriate radio-

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activity concentration guides are not available, and where Radiation Protection Guides for specific organs are provided herein, the latter Guides can be used by the Federal agencies as a starting point for the derivation of radioactivity concentration guides applicable to their particular problems. The Federal Radiation Council has also initiated action directed towards the development of additional Guides for radiation protection.

It is recommended that:

7. The Federal agencies apply these Radiation Protection Guides with judgment and discretion, to assure that reasonable probability is achieved in the attainment of the desired goal of protecting man from the undesirable effects of radiation. The Guides may be exceeded only after the Federal agency having jurisdiction over the matter has carefully considered the reason for doing so in light of the recommendations in this paper.

The Radiation Protection Guides provide a general framework for the radiation protection requirements. It is expected that each Federal agency, by virtue of its immediate knowledge of its operating problems, will use these Guides as a basis upon which to develop detailed standards tailored to meet its particular requirements. The Council will follow the activities of the Federal agencies in this area and will promote the necessary coordination to achieve an effective Federal program.

If the foregoing recommendations are approved by you for the guidance of Federal agencies in the conduct of their radiation protection activities, it is further recommended that this memorandum be published in the Federal Register.

ARTHUR S. FLEMMING
Chairman, Federal Radiation Council

The recommendations numbered "1" through "7" contained in the above memorandum are approved for the guidance of Federal agencies, and the memorandum shall be published in the Federal Register.

DWIGHT D. EISENHOWER
May 13, 1960

APPENDIX 12

…AR REACTORS BUILT, BUILDING, OR PLANNED IN THE UNITED STATES AS OF DECEMBER 1, 1960

…compilation contains information about facilities built, building, or …d in the United States as of December 1, 1960, which are capable of sus… a nuclear chain reaction. Certain projects relating to military systems … listed in detail because of their classified nature.

…formation is presented in five parts, each of which is categorized by primary …tion or purpose. The major parts—civilian, military, production, and export, … as well as such categories as power, propulsion and process heat—are self-…atory. The major parts of the tabulation are:

I Civilian Reactors (Domestic).
II Military Reactors.
III Production Reactors.
IV Reactors for Export.
V Critical Assembly Facilities.

…rious classes of reactors within the several parts are defined as follows:

…actor Experiment. A reactor in the research and development program, …ally producing less than 10 Mw(t), designed for the limited purpose of test-… technical feasibility of a reactor concept or some unique reactor feature or … of equipment. (Part I, Section 2A.2)

…perimental Reactor. A relatively complete reactor plant designed, engi-…ed, constructed, and operated to provide the technical basis for the design … large-scale nuclear power plant. Design flexibility permits changes to …-out different aspects of reactor technology. Electrical or power genera-… may or may not be included as part of the plant. (Part I, Section 2A.1)

…totype Reactor Plant. A nuclear power plant of any size designed, con-…ted, and operated principally for the purpose of proving-out economical … technical aspects of a future commercial nuclear power plant of the same … The generation of significant quantities of electricity, mechanical power, … process heat is usually a function of such a plant. Prototypes (40 to 50 …) and larger) for large central station plants are listed in Part I, Section … Prototypes for small utility stations (smaller than 40 Mw(e)) are listed …rt I, Section 1A.2.

…mercial Reactor Plant. A nuclear facility constructed and operated … a license issued under Section 103 of the Atomic Energy Act of 1954 and …ble of producing steam for the generation of electricity, propulsion, and … or process heat applications at costs as low as a nonnuclear plant built … same site. (No reactors presently in the category)

…ral Irradiation Test Reactor. The general-test-reactor category includes … those reactors having (1) a thermal output of 10,000 kw or more; (2) test … experimental facilities within, or in close proximity to, the core; and … use of nuclear radiation for testing the life or performance of reactor …ents as its major function. (Part I, Section 3A.1–2 and Part IV, Sec-…A)

Other Test Reactors. A reactor which is in general an integral part of test performance which has kinetic or short-duration high power excursions which is designed for special testing purposes. (Part I, Section 3B and Part II, Section 3A)

Research Reactor. Any reactor whose nuclear radiations are used primarily as a research tool for basic or applied research regardless of operating level. May include facilities for testing reactor materials. (Part I, Section 3C, Part II, Section 3B and Part IV, Section 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 arbitrarily limited to 10 kw. (Part I, Section 3D and Part IV, Section 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 arrangements 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 variation 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 these abbreviations, as well as those for designers, shipbuilders, and facility operators, are given in the table on page 435.

Startup dates refer to the year of first criticality. Estimated dates for projects not yet in service, based on the best available information, are included; 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 ordered or construction contract awarded, whichever is first.
2. Non-Federal Government reactors in the United States—when a 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 in the *planned* category under the following circumstances:

1. Federal Government reactors—when publicly announced or development work is started.
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, whichever is

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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 construction design and development on the basis of a letter of intent.

Statistical Summary on page 437 excludes critical facilities. All other ... are summarized. Dismantled reactors in these categories are included ... such facilities have made significant contributions to reactor technology.

... CONTRACTORS, DESIGNERS, SHIPBUILDERS, AND FACILITY OPERATORS FOR WHICH ABBREVIATIONS APPEAR IN TABLES

	Allis-Chalmers Mfg. Co.
	ACF Industries, Inc. (Absorbed by AC).
	Aerojet-General Corp.
	Aerojet-General Nucleonics, a Subsidiary of Aerojet-General Corp.
	Atomics International, a Division of North American Aviation, Inc.
	Alco Products, Inc.
	AMF Atomics, Inc., a Division of American Machine & Foundry Co.
	Argonne National Laboratory, operated by the University of Chicago.
...GE	Aircraft Nuclear Propulsion Department, Generel Electric Co.
	American Radiator & Standard Sanitary Corp.
	The Bendix Corp.
	Shipbuilding Division, Bethlehem Steel Co.
	Blaw-Knox Co.
	Brookhaven National Laboratory, operated by Associated Universities, Inc.
	The Babcock and Wilcox Co.
	Combustion Engineering, Inc.
	Clinton Laboratory of the Manhattan Engineering District.
	Convair Division, General Dynamics Corp.
	Nucledyne Corp. of Chicago, a Division of Cook Electric Co.
	Curtiss-Wright Corp.
	Daystrom, Inc.
	E. I. du Pont de Nemours & Co.
	Ebasco Services Inc.
	Electric Boat Division, General Dynamics Corp.
	The Fluor Corporation, Ltd.
	Foster Wheeler Corp.
	General Atomic Division, General Dynamics Corp.
	General Electric Co.

GNE	General Nuclear Engineering Corp., a Subsidiary of Combustion Engineering, Inc.
HKF	H. K. Ferguson Co.
Ingalls	Ingalls Shipbuilding Corp.
KE	Kaiser Engineers, a Division of Henry J. Kaiser Co.
LASL	Los Alamos Scientific Laboratory, operated by the University of California.
Lockheed	Lockheed Aircraft Corp.
Mare Island	Mare Island Naval Shipyard.
Martin	Martin Co.
Maxon	Maxon Construction Company, Inc.
Met. Lab	Metallurgical Laboratory of the Manhattan Engineer District.
NASA	National Aeronautics and Space Administration.
NDA	Nuclear Development Corp. of America.
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 and Whitney Aircraft Division, United Aircraft Corp.
Sandia	Sandia Laboratory, operated by Sandia Corp., a subsidiary of Western Electric Co.
SL	Sargent and Lundy.
UCLRL	University of California Lawrence Radiation Laboratory
West	Westinghouse Electric Co.
Vitro	Vitro Engineering Division, Vitro Corp. of America

STATISTICAL SUMMARY

	Operated, later dismantled	Operable	Being built	Planned
Civilian Reactors:				
1. Power Reactor Prototypes:				
1.1 Prototypes, Large Central Station Plants	----	3	6	5
1.2 Prototypes, Small Central Station Plants	----	----	4	1
1.3 Prototypes, Maritime Propulsion (Seagoing)	----	----	1	----
2. Experimental Reactors and Reactor Experiments:				
2.1 Experimental Power Reactors (Generate Electricity)	----	3	4	----
2.2 Power Reactor Experiments (token electrical production, if any)	5	4	4	----
2.3 Maritime Propulsion Experiments	----	----	----	1
2.4 Space Propulsion Experiments (Rover)	3	----	----	1
2.5 Process Heat Experiments	----	----	----	2
3. Test, Research and Teaching Reactors:				
3.1 General Irradiation Test (Government Owned)	----	2	1	1
3.2 General Irradiation Test (Privately Owned)	----	2	----	----
3.3 Special Test	----	9	3	----
3.4 Research	4	26	9	2
3.5 Teaching	3	35	16	2
Total Civilian	15	84	48	14
Military Reactors:				
1. Defense Power Reactor Applications:				
1.1 Electric Power Reactors, Remote Installations	----	1	2	----
1.2 Propulsion Reactors (Naval)	1	14	45	----
2. Developmental Power Reactors:				
2.1 Electric Power Reactor Experiments and Prototypes	----	3	2	1
2.2 Systems for Nuclear Auxiliary Power (SNAP)	----	1	2	4
2.3 Naval Propulsion Reactor Prototypes	1	5	1	1
2.4 Aircraft Propulsion Reactor Experiments	2	2	1	1
2.5 Missile Propulsion Reactor Experiments	----	----	1	2
3. Test and Research:				
3.1 Testing Reactors	1	5	3	----
3.2 Research Reactors	----	2	2	4
Total Military	5	33	59	13
Production Reactors:				
1. Material Production	----	13	1	----
2. Process Development	----	5	----	----
Total Production	----	18	1	----
Reactors for Export:				
1. Power Reactors:				
1.1 Central Station Electric Power	----	1	3	2
1.2 Propulsion	----	----	1	----
2. Test, Research and Teaching Reactors:				
2.1 General Irradiation Test	----	2	1	----
2.2 Research	----	13	8	2
2.3 Teaching	----	12	7	5
Total export	----	28	20	9

Part I—CIVILIAN REACTORS (Domestic)

1. Power

A. Central Station Electric

A.1. Large Plant Prototypes

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Startup
Operable:						
Shippingport Atomic Power Station (AEC and Duquesne Light Co.[2]	Shippingport, Pa	West	Pressurized water	60,000	231,000	1957
Dresden Nuclear Power Station (Commonwealth Edison Co.).	Morris, Ill	GE	Boiling water	180,000	626,000	1959
Yankee Atomic Electric Co[3,4]	Rowe, Mass	West	Pressurized water	110,000	392,000	1960
Being built:						
Consolidated Edison Co. Thorium Reactor[5]	Indian Point, N.Y	B&W	Pressurized water	255,000	795,000	1961
Enrico Fermi Atomic Power Plant (Power Reactor Development Co.).[4,6]	Lagoona Beach, Mich	Owner	Fast breeder	94,000	300,000	1961
Hallam Nuclear Power Facility, Sheldon Station (AEC and Consumers Public Power District.).[3]	Hallam, Nebr	AI	Sodium graphite	75,000	254,000	1962
Northern States Power Co. Pathfinder Plant[3,7]	Sioux Falls, S. Dak	AC	Boiling water, nuclear superheat.	62,000	203,000	1962
Consumers Power Company[3]	Big Rock Point, Mich	GE	Boiling water	50,000	240,000	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	115,000	1963
Improved Cycle Boiling Water Reactor Prototype (AEC and Cities of Los Angeles and Pasadena Departments of Water and Power)[8]	Haskel Canyon, Los Angeles County, Calif.	AC	Boiling water	50,000	----	1964
Organic Cooled Reactor Prototype (AEC)	----	----	Organic cooled	50,000	----	1964
East Central and Florida West Coast Nuclear Groups[3]	Polk County, Fla	GNE	Gas cooled, heavy water moderated.	50,500	159,700	1965
Southern California Edison	Southern California	West	Pressurized water	360,000	----	1965

REACT

Name and/or owner	Location	Principal nuclear contractor	Type	Power[1] Net kw(e)	Power[1] Kw(t)	Startup
Being built:						
Rural Cooperative Power Association and AEC[3,9]	Elk River, Minn	AC	Boiling water	22,000	73,000	1961
City of Piqua and AEC[3]	Piqua, Ohio	AI	Organic cooled and moderated.	11,400	45,500	1961
Carolinas-Virginia Tube Reactor (Carolinas-Virginia Nuclear Power Associates, Inc.[3,10]	Parr, S.C	West	Pressure tube, heavy water	16,950	60,500	[illegible]

Electric Co.).						
Planned:						
High Temperature Gas Cooled Reactor [3] (Philadelphia Electric Co.).	Peach Bottom, Pa.	GDC	Gas cooled, graphite moderated.	[illegible]		
Improved Cycle Boiling Water Reactor Prototype (AEC and Cities of Los Angeles and Pasadena Departments of Water and Power) [8]	Haskel Canyon, Los Angeles County, Calif.	AC	Boiling water	50,000		1964
Organic Cooled Reactor Prototype (AEC)			Organic cooled	50,000		1964
East Central and Florida West Coast Nuclear Groups [8]	Polk County, Fla.	GNE	Gas cooled, heavy water moderated.	50,500	159,700	1965
Southern California Edison	Southern California	West	Pressurized water	360,000		1965

Name and/or owner	Location	Principal nuclear contractor	Type	Power: Net kw(e)	Power: Kw(t)	Startup
Being built:						
Rural Cooperative Power Association and AEC [3,9]	Elk River, Minn.	AC	Boiling water	22,000	73,000	1961
City of Piqua and AEC [3]	Piqua, Ohio	AI	Organic cooled and moderated.	11,400	45,500	1961
Carolinas-Virginia Tube Reactor (Carolinas-Virginia Nuclear Power Associates, Inc.[3,10]	Parr, S.C.	West	Pressure tube, heavy water	16,950	60,500	1962
Boiling Reactor Nuclear Superheat Project (AEC and Puerto Rico Water Resources Authority).[8]	Punta Higuera, P.R.	GNEC	Boiling water, internal nuclear superheat.	16,300	50,000	1962
Planned:						
Small Size Nuclear Power Plant (AEC and undetermined utility organization.[3,11]			Pressurized water	20,500	61,000	1962

B. Propulsion (Maritime)

B.1. Maritime Seagoing Prototypes

Name and/or owner	Nuclear designer	Shipbuilder	Type	Shaft maximum horsepower	Power kw(t)	Start-up
Being built:						
Nuclear Ship Savannah (AEC and Maritime Administration)	B&W	NYSC	Pressurized water	22,000	69,000	1961

See footnotes at end of table.

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	Net kw(e)	Kw(t)	Start-up
Operable:							
Experimental Boiling Water Reactor [12]	EBWR	Argonne, Ill	ANL	Boiling water	4,500	100,000	1956
Vallecitos Boiling Water Reactor (General Electric Co. 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	1961
Boiling Reactor Experiment No. 5	BORAX-5	NRTS, Idaho	ANL	Boiling water	2,650	20,000	1961
Saxton Nuclear Experimental Reactor Project (Privately owned).		Saxton, Pa	West	Pressurized water	3,250		1961
Experimental Gas Cooled Reactor (AEC and Tennessee Valley Authority) [13]	EGCR	Oak Ridge, Tenn	KE-ACF	Gas cooled, graphite moderated	22,300	84,300	1962

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	Dismantled
Operated, Later Dismantled:								
Boiling Reactor Experiment No. 1	BORAX-1	NRTS, Idaho	ANL	Boiling water	No electricity.	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 Experiment No. 1 [14]	LAPRE-1	Los Alamos, N. Mex	LASL	Aqueous homogeneous (phosphoric acid)	No elec-	2,000	1956	1957
Boiling Reactor Experiments [14]	BORAX-2, ...							

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Net kw(e)	Kw(t)	Start-up
Operable:							
Experimental Boiling Water Reactor [12]	EBWR	Argonne, Ill.	ANL	Boiling water	4,500	100,000	1956
Vallecitos Boiling Water Reactor (General Electric Co. 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	1961
Boiling Reactor Experiment No. 5	BORAX-5	NRTS, Idaho	ANL	Boiling water	2,650	20,000	1961
Saxton Nuclear Experimental Reactor Project (Privately Owned).		Saxton, Pa.	West	Pressurized water	3,250		1961
Experimental Gas Cooled Reactor (AEC and Tennessee Valley Authority)	EGCR	Oak Ridge, Tenn.	KE-ACF	Gas cooled, graphite moderated.	22,300	84,300	1962

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power: Net kw(e)	Power: Kw(t)	Start-up	Dismantled
Operated, Later Dismantled:								
Boiling Reactor Experiment No. 1	BORAX-1	NRTS, Idaho	ANL	Boiling water	No electricity.	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 Experiment No. 1 [14]	LAPRE-1	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid).	No electricity.	2,000	1956	1957
Boiling Reactor Experiments [15]	BORAX-2, 3, 4.	NRTS, Idaho	ANL	Boiling water	2,400	15,500	1954	1958
Los Alamos Power Reactor Experiment No. 2.	LAPRE-2	Los Alamos, N. Mex.	LASL	Aqueous homogeneous (phosphoric acid).	No electricity.	1,000	1959	1959
Operable:								
Experimental Breeder Reactor No. 1 [16]	EBR-1	NRTS, Idaho	ANL	Fast breeder	150	1,400	1951	
Homogeneous Reactor Experiment No. 2.	HRE-2	Oak Ridge, Tenn.	ORNL	Aqueous homogeneous solution (UO_2SO_4).	300	5,220	1957	
Organic Moderated Reactor Experiment.	OMRE	NRTS, Idaho	AI	Organic cooled and moderated.	No electricity.	5,000 to 15,000	1957	
Plutonium Recycle Test Reactor	PRTR	Hanford, Wash.	GE	Heavy water moderated and cooled pressure tube.	No electricity.	70,000	1960	
Being built:								
Los Alamos Molten, Plutonium Reactor Experiment.	LAMPRE-1	Los Alamos, N. Mex.	LASL	Fast molten plutonium fueled, sodium cooled.	No electricity.	1,000	1961	
Heavy Water Components Test Reactor.	HWCTR	Savannah River, S.C. (TC-1 Area).	du Pont	Pressurized heavy water	No electricity.	61,000	1961	
Experimental Organic Cooled Reactor.	EOCR	NRTS, Idaho	AI-PPC	Organic cooled	No electricity.	40,000	1962	
Molten Salt Reactor Experiment	MSRE	Oak Ridge, Tenn.	ORNL	Single region graphite moderated.		5,000 to 10,000	1963	

See footnotes at end of table.

B. Propulsion

B.1. Maritime Experiments and Prototypes

Name and/or owner	Designation	Location	Contractor	Type	Power[1] Kw(t)	Startup
Planned:						
Beryllium Oxide Reactor Experiment	BORE			Gas cooled, BeO moderated	10,000	1962

B.2. Space Experiments and Prototypes (Rover)

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Startup	Dismantled
Operated, Later Dismantled:						
Low Power Nuclear Rocket Propulsion Experiment	KIWI-A	NTS, Nev	LASL	Open cycle hydrogen gas cooled.	1959	1959
Low Power Nuclear Rocket Propulsion Experiment	KIWI-A, prime	NTS, Nev	LASL	Open cycle, hydrogen gas cooled.	1960	1960
Low Power Nuclear Rocket Propulsion Experiment	KIWI-A3	NTS, Nev	LASL	Open cycle, liquid hydrogen gas cooled.	1960	1960
Planned:						
Intermediate Power Nuclear Rocket Propulsion Experiment	KIWI-B1	NTS, Nev	LASL	Open cycle, liquid hydrogen gas cooled.	1961	

C. Process Heat Experiments

Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] Kw(t)	Startup
Planned:						
Experimental Low Temperature Process Heat Reactor	ELPHR		AC	Pressurized water	40,000	
High Temperature Gas Cooled Reactor Experiment, II	TURRET	Los Alamos, N. Mex.	LASL	Gas cooled	3,000	1962

A.1. Government Facilities

Name and/or owner	Designation	Location	Principal nuclear contractor	Operator	Type	Power[1] kw(t)	Startup
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
Being built:							
Plum Brook Reactor Facility (NASA)	NASA-TR	Sandusky, Ohio	NASA		Tank	60,000	1962
Planned:							
Advanced Test Reactor	ATR	NRTS, Idaho	Ebasco-B&W	PPC	Tank	250,000	1964

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Name (all owned by AEC except as noted)	Designation	Location	Principal nuclear contractor	Type	Power[1] Kw(t)	Startup
Planned:						
Experimental Low Temperature Process Heat Reactor	ELPHR	[illegible]	AC	Pressurized water	40,000	
High Temperature Gas Cooled Reactor Experiment.[11]	TURRET	Los Alamos, N. Mex.	LASL	Gas cooled	3,000	1962

[illegible]

Name and/or owner	Designation	Location	Principal nuclear contractor	Operator	Type	Power[1] kw(t)	Startup
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
Being built:							
Plum Brook Reactor Facility (NASA)	NASA-TR	Sandusky, Ohio	NASA		Tank	60,000	1962
Planned:							
Advanced Test Reactor	ATR	NRTS, Idaho	Ebasco-B&W	PPC	Tank	250,000	1964

A.2. Private Facilities

Name and/or owner	Designation	Location	Principal nuclear contractor	Operator	Type	Power[1] kw(t)	Startup
Operable:							
General Electric Company Materials Testing Reactor	GETR	Pleasanton, Calif.	Owner	Owner	Tank	30,000	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 contractor	Type	Power kw(t)	Startup
Operable:						
Thermal Test Reactor	SP	Savannah River, S.C.	du Pont	Graphite	2 to 10	1953
Bulk Shielding Reactor No. 1	BSR-1	Oak Ridge, Tenn.	ORNL	Pool	1,000	1950
Bulk Shielding Reactor No. 2[18]	BSR-2	Oak Ridge, Tenn.	ORNL	Pool	1,000	1959
Special Power Excursion Reactor Test No. 1	SPERT-1	NRTS, Idaho	PPC	Open tank	Transient	1955
Special Power Excursion Reactor Test No. 2	SPERT-2	NRTS, Idaho	PPC	Pressurized water	Transient	1960
Special Power Excursion Reactor Test No. 3	SPERT-3	NRTS, Idaho	PPC	Pressurized water	Transient	1958
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
Being built:						
Special Power Excursion Reactor Test No. 4	SPERT-4	NRTS, Idaho	PPC	Pool	Transient	1961
Biological Research Reactor	JANUS	Argonne, Ill.	ANL	Tank	200	1961
Fast Burst Reactor	FBR	Oak Ridge, Tenn.	ORNL	Fast		1962

See footnotes at end of table.

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C. Research

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [19] 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).[20]	CP-1	Chicago, Ill.	Met. Lab.	Graphite	0.2	1942	1954
Argonne CP-3, rebuilt as CP-3, (Manhattan Engineering District-AEC).	CP-3,	Palos Park, Ill.	Met. Lab.	Heavy water	300	1944	1955
Los Alamos Fast Reactor (AEC)	Clementine	Los Alamos, N. Mex.	LASL	Fast, plutonium fuel, mercury cooled.	25	1946	1953
Operable:							
Oak Ridge Graphite Reactor	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)[21]	LITR	Oak Ridge, Tenn.	ORNL	Tank	3,000	1950	
North American Aviation Water Boiler Neutron Source (AEC).[22]	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	Argonne, Ill.	ANL	Heavy water	5,000	1954	
Pennsylvania State University		University Park, Pa.	Owner	Pool	200	1955	
Armour Research Foundation	ARR	Chicago, Ill.	AI	Homogeneous	50	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	
Curtiss-Wright Corporation [23]		Quehanna, Pa.	Owner	Pool	4,000	1958	
General Dynamics Corp.	TRIGA	San Diego, 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	1,000	1958	
Industrial Reactor Laboratories, Inc. (Operated by Columbia Univ.).		Plainsboro, N.J.	AMF	Pool	5,000	1958	
Babcock and Wilcox Lynchburg Pool Reactor.	LPR	Lynchburg, Va.	Owner	Pool	10	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	3,000	1959	
Omaha Veterans Administration Hospital	TRIGA	Omaha, Nebr.	GDC	U-Zr hydride, tank	10	1959	
General Dynamics Corp. TRIGA Pulsing Reactor.	TRIGA Mk F	San Diego, 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	
[illegible]	[illegible]	[illegible], N.Y.	AMF	Pool	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible], N.Y.	AMF	Pool	1,000	1961	
Walter Reed Army Institute of Research	[illegible]	Washington, D.C.	AI	Homogeneous	50	1961	
Brookhaven High Flux Beam Research Reactor (AEC)	HFBR	Upton, N.Y.	BNL	Heavy water	40,000	1962	
Ames Laboratory Research Reactor (AEC)	ALRR	Ames, Iowa	AMF	Heavy water	5,000	1962	
Washington State University		Pullman, Wash.	GE	Pool	100	1961	
Georgia Institute of Technology	GTRR	Atlanta, Ga.	GNE	Heavy water, tank	1,000	1962	
Nuclear Science Center Reactor, Texas A&M.	NSCR	College Station, Tex.	Convair	Pool	100	1961	
Biomedical Radiation Research Facility (DOD).	DASA-TRIGA	Bethesda, Md.	GDC	U-Zr, hydride	100	1961	
Planned:							
High Flux Isotope Reactor (AEC)	HFIR	Oak Ridge, Tenn.	ORNL	Pool, flux trap	100,000	1963	
University of Rhode Island		Saunderstown, R. I.	GE	Pool	1,000	1961	

D. Teaching

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Curtiss-Wright Corporation [illegible]							
General Dynamics Corp.	TRIGA	San Diego, Calif.	[illegible]	[illegible]			
Brookhaven Neutron Source Reactor (AEC)		Upton, N.Y.	BNL	Tank	1,000	1958	
Massachusetts Institute of Technology	MITR	Cambridge, Mass.	ACF	Heavy water	5,000	1958	
Industrial Reactor Laboratories, Inc. (Operated by Columbia Univ.).		Plainsboro, N.J.	AMF	Pool			
Babcock and Wilcox Lynchburg Pool Reactor.	LPR	Lynchburg, Va.	Owner	Pool	10	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	3,000	1959	
Omaha Veterans Administration Hospital	TRIGA	Omaha, Nebr.	GDC	U-Zr hydride, tank	10	1959	
General Dynamics Corp. TRIGA Pulsing Reactor.	TRIGA Mk F	San Diego, 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	
[illegible]	[illegible]	[illegible]	AMF	Tank	[illegible]	[illegible]	
[illegible]		Washington, D.C.	AI	Homogeneous	50	1961	
Brookhaven High Flux Beam Research Reactor (AEC)	HFBR	Upton, N.Y.	BNL	Heavy water	40,000	1962	
Ames Laboratory Research Reactor (AEC)	ALRR	Ames, Iowa	AMF	Heavy water	5,000	1962	
Washington State University		Pullman, Wash.	GE	Pool	100	1961	
Georgia Institute of Technology	GTRR	Atlanta, Ga.	GNE	Heavy water, tank	1,000	1962	
Nuclear Science Center Reactor, Texas A&M	NSCR	College Station, Tex.	Convair	Pool	100	1961	
Biomedical Radiation Research Facility (DOD).	DASA-TRIGA	Bethesda, Md.	GDC	U-Zr, hydride	100	1961	
Planned:							
High Flux Isotope Reactor (AEC)	HFIR	Oak Ridge, Tenn.	ORNL	Pool, flux trap	100,000	1963	
University of Rhode Island		Saunderstown, R. I.	GE	Pool	1,000	1961	

D. Teaching

Operated, later dismantled:							
Atomics International	L-47	Canoga Park, Calif.	AI	Homogeneous	Negligible	1957	1958
American Radiator & Standard Sanitary Corp.[24]	UTR-1	Mountain View, Calif.	ARRS	Graphite/water	Negligible	1958	1960
General Dynamics Corporation (World Agricultural Fair-U.S. Exhibit Reactor [25]		San Diego, Calif.	GDC	TRIGA-Mk II	50	1960	1960
Operable:							
North Carolina State College (Raleigh Research Reactor) [26]	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	
U.S. Naval Post Graduate School (USN)	AGN-201-100	Monterey, Calif.	AGN	Homogeneous solid	Negligible	1956	
Catholic University of America	AGN-201-101	Washington, D.C.	AGN	Homogeneous solid	Negligible	1957	
Oklahoma State University of Agriculture and Applied Science.	AGN-201-102	Stillwater, Okla.	AGN	Homogeneous solid	Negligible	1957	
Aerojet-General Nucleonics	AGN-201P-103	San Ramon, Calif.	AGN				
University of Akron	AGN-201-104	Akron, Ohio	AGN	Homogeneous solid	Negligible	1957	
National Naval Medical Center (USN)	AGN-201M-105	Bethesda, Md.	AGN	Homogeneous solid	Negligible	1957	
Texas Agricultural and Mechanical College	AGN-201-106	College Station, Tex.	AGN	Homogeneous solid	Negligible	1957	
University of Utah	AGN-201-107	Salt Lake City, Utah	AGN	Homogeneous solid	Negligible	1957	
Argonne National Laboratory (AEC)	AGN-201-108	Lemont, Ill.	AGN	Homogeneous solid	Negligible	1957	
Colorado State University	AGN-201-109	Ft. Collins, Colo.	AGN	Homogeneous solid	Negligible	1957	
University of California	AGN-201-112	Berkeley, Calif.	AGN	Homogeneous solid	Negligible	1957	
University of Delaware	AGN-201-113	Newark, Del.	AGN	Homogeneous solid	Negligible	1957	
Oregon State College	AGN-201-114	Corvallis, Oreg.	AGN	Homogeneous solid	Negligible	1958	
Atomics International	L-77	Canoga Park, Calif.	AI	Homogeneous	Negligible	1958	
American Radiator and Standard Sanitary Corp. Exhibition, UTR Model 2.[24]	UTR Mod. 2	Mountain View, Calif.	Owner	Graphite/water	Negligible	1960	
Pawling Research Reactor	PRR	Pawling, N.Y.	NDA	Heavy water	Negligible	1958	
William Marsh Rice University	AGN-211-101	Houston, Tex.	AGN	Homogeneous solid, pool	Negligible	1959	
University of Oklahoma	AGN-211-102	Norman, Okla.	AGN	Homogeneous solid, pool	Negligible	1958	

See footnotes at end of table.

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D. Teaching—Continued

Name and/or owner	Designation	Location	Principal nuclear contractor	Type	Power [19] kw(t)	Start-up	Dis-mantled
Operable—Continued.							
West Virginia University College of Engineering.	AGN-211-103	Morgantown, W. Va.	AGN	Homogeneous 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.	GNE	Graphite/water	10	1959	
Puerto Rico Nuclear Center (AEC)	L-77	Mayaguez, P.R.	AI	Homogeneous	Negligible	1959	
Iowa State University	UTR-10	Ames, Iowa	ARSS	Graphite/water	10	1959	
Leland Stanford University		Palo Alto, Calif.	GE	Pool	10	1959	
Worcester Polytechnic Institute		Worcester, Mass.	GE	Pool	Negligible	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	
University of Washington	Educator	Seattle, Wash.	AMF	Graphite/water	10	1960	
Being built:							
Aerojet-General Nucleonics (5 reactors)	AGN-201 (126-130)	San Ramon, Calif.	AGN	Homogeneous solid	Negligible	1961-62	
Aerojet-General Nucleonics (5 reactors)	AGN-211 (106-110)	San Ramon, Calif.	AGN	Homogeneous solid, pool	Negligible	1961-62	
Cornell University	TRIGA	Ithaca, N.Y.	GDC	U-Zr hydride, tank	10	1961	
University of Missouri, School of Mines and Metallurgy.		Rolla, Mo.	CW	Pool	10	1961	
Argonne National Laboratory (AEC) [27]	Juggernaut	Lemont, Ill.	ANL	Graphite/water	250	1961	
University of Kansas	Model 4180	Lawrence, Kans.	BAC	Pool	10	1961	
Ohio State University		Columbus, Ohio	Lockheed	Pool	10	1961	
Texas Technological College	CONVAIR	Lubbock, Tex.		Pool	10	1963	
Planned:							
University of Maine	AGN-201-132	Orno, Maine	AGN	Homogeneous solid	Negligible	1961	
Kansas State University	TRIGA-Mk II	Manhattan, Kans.	GDC	U-Zr hydride, tank	10	1961	

1. Defense Power Applications

A. Electrical Power Generation for Remote Installations

Name and/or owner	Designation [28]	Location	Principal nuclear contractor	Type	Power [1] net kw(e)	Start-up
Operable:						
Portable Medium Power Plant No. 2A (USA)[29]	PM-2A	Camp Century, Greenland	Alco	Pressurized water	1,500	1960
Being built:						
Stationary Medium Power Plant No. 1A (USA)[30]	SM-1A	Fort Greely, Alaska	Alco	Pressurized water	1,700	1960

Metallurgy.							
Argonne National Laboratory (AEC) [27]	Juggernaut	Lemont, Ill.	ANL	[illegible]	[illegible]	[illegible]	
University of Kansas	Model 4180	Lawrence, Kans.	BAC	Pool	10	1961	
Ohio State University		Columbus, Ohio	Lockheed	Pool	10	1961	
Texas Technological College	CONVAIR	Lubbock, Tex.		Pool	10	1963	
Planned:							
University of Maine	AGN-201-132	Orno, Maine	AGN	Homogeneous solid	Negligible	1961	
Kansas State University	TRIGA-Mk II	Manhattan, Kans.	GDC	U-Zr hydride, tank	10	1961	

[illegible] POWER APPLICATIONS

A. ELECTRICAL POWER GENERATION FOR REMOTE INSTALLATIONS

Name and/or owner	Designation [28]	Location	Principal nuclear contractor	Type	Power [1] net kw(e)	Start-up
Operable:						
Portable Medium Power Plant No. 2A (USA)[29]	PM-2A	Camp Century, Greenland	Alco	Pressurized water	1,500	1960
Being built:						
Stationary Medium Power Plant No. 1A (USA)[30]	SM-1A	Fort Greely, Alaska	Alco	Pressurized water	1,700	1960
Portable Medium Power Plant No. 3A	PM-3A	McMurdo Sound Antarctica	Martin	Pressurized water	1,500	1962

B. PROPULSION (Naval)

Name (all owned by U.S. Navy)	Designation	Nuclear designer	Shipbuilder	Type [31]	Start-up	Dis-man-tled
Operated, later dismantled:						
Seawolf S2G Sodium Reactor	S2G	GE		Sodium	1956	1959
Operable:						
USS Nautilus	SSN571	West	Electric Boat	S2W	1955	
USS Seawolf [32]	SSN575	West	Electric Boat	S2Wa	1960	
USS Skate	SSN578	West	Electric Boat	S3W	1957	
USS Swordfish	SSN579	West	Portsmouth	S4W	1958	
USS Sargo	SSN583	West	Mare Island	S3W	1958	
Operable:						
USS Seadragon	SSN584	West	Portsmouth	S4W	1959	
USS Skipjack	SSN585	West	Electric Boat	S5W	1958	
USS Triton (2 reactors)	SS(R)N586	GE	Electric Boat	S4G	1959	
USS Halibut	SS(G)N587	West	Mare Island	S3W	1959	
USS Scorpion	SSN589	West	Electric Boat	S5W	1960	
USS George Washington	SSB(N)598	West	Electric Boat	S5W	1959	
USS Patrick Henry	SSB(N)599	West	Electric Boat	S5W	1960	
USS Robert E. Lee	SSB(N)601	West	Newport News	S5W	1960	

See footnotes at end of table.

B. PROPULSION (Naval)—Continued

Name (all owned by U.S. Navy)	Designation	Nuclear designer	Shipbuilder	Type [31]	Start-up	Dis-man-tled
Being built:						
Submarine Scamp	SSN588	West	Mare Island	S5W		
Submarine Sculpin	SSN590	West	Ingalls	S5W		
Submarine Shark	SSN591	West	Newport News	S5W		
Submarine Snook	SSN592	West	Ingalls	S5W		
Submarine Thresher	SSN593	West	Portsmouth	S5W		
Submarine Permit	SSN594	West	Mare Island	S5W		
Submarine Plunger	SSN595	West	Mare Island	S5W		
Submarine Barb	SSN603	West	NYSC	S5W		
Submarine Tullibee	SSN597	CE	Electric Boat	S2C		
Submarine Theodore Roosevelt	SSB(N)600	West	Mare Island	S5W		
Submarine Abraham Lincoln	SSB(N)602	West	Portsmouth	S5W		
Submarine Pollack	SSN596	West	Ingalls	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 Ethan Allen	SSB(N)608	West	Electric Boat	S5W		
Submarine Sam Houston	SSB(N)609	West	Newport News	S5W		
Submarine Thomas A. Edison	SSB(N)610	West	Electric Boat	S5W		
Submarine John Marshall	SSB(N)611	West	Newport News	S5W		
Submarine Guardfish	SSN612	West	NYSC	S5W		
Submarine Flasher	SSN613	West	Electric Boat	S5W		
Submarine Greenling	SSN614	West	Electric Boat	S5W		
Submarine Gato	SSN615	West	Electric Boat	S5W		
Submarine Lafayette	SSB(N)616	West	Electric Boat	S5W		
Submarine	SSB(N)617	West	Electric Boat	S5W		
Submarine	SSB(N)618	West	Newport News	S5W		
Submarine	SSB(N)619	West	Mare Island	S5W		
Submarine	SSB(N)620	West	Portsmouth	S5W		
Submarine	SSN621	West	Ingalls	S5W		
Submarine	SSN622	West		S5W		
Submarine	SSN623	West		S5W		
Submarine	SSN624	West		S5W		
Guided Missile Cruiser Long Beach (2 reactors)	CG(N)9	West	Bethlehem	C1W		
Aircraft Carrier Enterprise (8 reactors)	CVA(N)65	West	Newport News	A2W		
Guided Missile Destroyer Bainbridge (2 reactors)	DLG(N)25	GE	Bethlehem	D2G		

[illegible]

A. ELECTRIC POWER EXPERIMENTS AND PROTOTYPES

A.1. Power for Remote Installations

Name (all owned by AEC except as noted)	Designation [28]	Location	Principal nuclear contractor	Type	Power,[1] net, kw(e), Kw(t)	Startup
Operable:						
Stationary Medium Power Plant No. 1 (formerly APPR-1) (USA).	SM-1	Ft. Belvoir, Va	Alco	Pressurized water	1,855	1957
Stationary Low Power Plant No. 1 (formerly ALPR) [33]	SL-1	NRTS, Idaho	ANL-CE	Boiling water	200	1958
Gas Cooled Reactor Experiment	GCRE-1	NRTS, Idaho	AG	Gas cooled	No electric	1960
Being built:						
Portable Medium Power [34] Plant No. 1 (USAF-AEC)	PM-1	Sundance, Wyo	[illegible]			
Mobile Low Power Plant No. 1						

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Submarine	SSN622	West		S5W		
Submarine	SSN623	West		S5W		
Submarine	SSN624	West	Bethlehem	S5W		
Submarine	CG(N)9	West	Newport News	C1W		
Guided Missile Cruiser Long Beach (2 reactors)	CVA(N)65	West	Bethlehem	A2W		
Aircraft Carrier Enterprise (8 reactors)	DLG(N)25	GE		D2G		
Guided Missile Destroyer Bainbridge (2 reactors)						

Electric Power Experiments and Prototypes

A.1. Power for Remote Installations

Name (all owned by AEC except as noted)	Designation [28]	Location	Principal nuclear contractor	Type	Power,[1] net, kw(e), Kw(t)	Startup
Operable:						
Stationary Medium Power Plant No. 1 (formerly APPR-1) (USA).	SM-1	Ft. Belvoir, Va	Alco	Pressurized water	1,855	1957
Stationary Low Power Plant No. 1 (formerly ALPR) [33]	SL-1	NRTS, Idaho	ANL-CE	Boiling water	200	1958
Gas Cooled Reactor Experiment	GCRE-1	NRTS, Idaho	AG	Gas cooled	No electric	1960
Being built:						
Portable Medium Power [34] Plant No. 1 (USAF-AEC)	PM-1	Sundance, Wyo	Martin	Pressurized water	1,000	1961
Mobile Low Power Plant No. 1	ML-1	NRTS, Idaho	AG	Gas cooled	300 to 500	1961
Planned:						
Military Compact Reactor Pilot Plant	MCRPP	NRTS, Idaho	NDA		Up to 3,000	

A.2. SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP)

Name (All owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Power		Startup
					KWE	KWT	
Operable:							
SNAP 2 Experimental Reactor	SER	Santa Susana, Calif	AI	NaK cooled		50	1959
Being built:							
SNAP 2 Developmental System #1	S-2-DS-1	Santa Susana, Calif	AI	NaK cooled	3	50	1961
SNAP 10 Developmental System	S-10-DS	Santa Susana, Calif	AI	Fuel plates, static	.3	12	1961
Planned:							
SNAP 2 Developmental System #2	S-2-DS-2	Santa Susana, Calif	AI	NaK cooled	3	50	1962
SNAP 2 Package System	S-2-PS	Santa Susana, Calif	AI	NaK cooled	3	50	1962
SNAP 8 Experimental Reactor	S-8-ER	Santa Susana, Calif	AI	NaK cooled		600	1962
SNAP 10 Package System	S-10-PS	Santa Susana, Calif	AI	Fuel plates, static	.3	12	1962

See footnotes at end of table.

B. Propulsion Experiments and Prototypes

B.1. Naval

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	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.	CE	Pressurized water	1959	
Being built:						
Destroyer Reactor Prototype	D1G	West Milton, N.Y.	GE	Pressurized water		
Planned:						
Natural Circulation Test Plant	S5G	NRTS, Idaho	GE	Pressurized water	1963	

B.2. Aircraft

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Thermal power Kw(t)	Start-up	Dis-man-tled
Operated, later dismantled:							
Aircraft Reactor Experiment	ARE	Oak Ridge, Tenn.	ORNL	Molten salt		1954	1954
Heat Transfer Reactor Experiment No. 1 [35]	HTRE-1	NRTS, Idaho	ANPD	Air cooled	20,000	1956	1957
Operable:							
Heat Transfer Reactor Experiment No. 2	HTRE-2	NRTS, Idaho	ANPD	Air cooled	14,000	1957	
Heat Transfer Reactor Experiment No. 3	HTRE-3	NRTS, Idaho	ANPD	Air cooled	32,000	1958	
Being built:							
Experimental Reactor	PWAC-IIC	NRTS, Idaho	P&W	Liquid metal cooled	10,000		
Planned:							
Advanced Core Test	ACT	NRTS, Idaho	ANPD	Air cooled			

Name (all owned by AEC)	Designation	Location	Principal nuclear contractor	Type	Start-up
Being built:					
Experimental Power Reactor Test	Tory-IIA-1	NTS, Nev	UCLRL	Air cooled	1960
Experimental Power Reactor	Tory-IIA-2	NTS, Nev	UCLRL	Air cooled	
Planned:					
Nuclear Ramjet Test Reactor	Tory-IIC	NTS, Nev	UCLRL	Air cooled	

3. Test and Research

Being built:							
Experimental Reactor	PWAC-IIC	NRTS, Idaho	P&W	Liquid metal cooled	10,000		
Planned:							
Advanced Core Test	ACT	NRTS, Idaho	ANPD	Air cooled			

	Designation	Location	Principal nuclear contractor	Type	Start-up
Being built:					
Experimental Power Reactor Test	Tory-IIA-1	NTS, Nev.	UCLRL	Air cooled	1960
Experimental Power Reactor	Tory-IIA-2	NTS, Nev.	UCLRL	Air cooled	
Planned:					
Nuclear Ramjet Test Reactor	Tory-IIC	NTS, Nev.	UCLRL	Air cooled	

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3. Test and Research

A. Test

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)	GTR	Ft. Worth, Tex.	Convair	Pool	3,000	1953	
Aircraft Shield Test Reactor	ASTR	Ft. Worth, Tex.	Convair	Light water	3,000	1954	
Radiation Effects Reactor (USAF)	RER	Dawsonville, Ga.	Lockheed	Tank	10,000	1958	
Shield Test Pool Facility	SUSIE	NRTS, Idaho	ANPD	Pool	10 to 100	1959	
Tower Shielding Reactor No. 2	TSR-2	Oak Ridge, Tenn.	ORNL	Light water	5,000	1960	
Being built:							
Nuclear Engineering Test Reactor (USAF)	NETR	Dayton, Ohio	Maxon-AC	Pool	10,000	1961	
Sandia Engineering Reactor Facility	SERF	Sandia Base, N. Mex.	Sandia	Tank	5,000	1961	
Sandia Pulsed Reactor Facility	SPRF	Sandia Base, N. Mex.	Sandia	Prompt burst		1961	

See footnotes at end of table.

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	100	1956	
Being built:							
Horace Hardy Lester Reactor for Materials Research (Watertown Arsenal, USA).		Watertown, Mass.	Owner	Pool	1,000	1961	
Diamond Ordnance Fuse Laboratory Radiation Facility (USA).	TRIGA (DORF)	Washington, D.C.	GDC	Zr hydride, tank	100	1961	
Planned:							
Ordnance Pulsed Experimental Research Assembly (USA).	OPERA	Aberdeen Proving Ground, Md.	AGN	Prompt burst	100	1962	
White Sands Missile Range Nuclear Effects Facility (USA).	WSMR	White Sands, N. Mex.		Prompt burst		1963	
Picatinny Arsenal (USA)		Dover, N.J.		Prompt burst	20,000		

Part III.—PRODUCTION REACTORS

1. Materials Production

Designation	Nuclear designer	Type	Location
Operable:			
B Reactor	du Pont	Graphite	Hanford, Wash.
D Reactor	du Pont	Graphite	Hanford, Wash.
F Reactor	du Pont	Graphite	Hanford, Wash.
C Reactor	GE	Graphite	Hanford, Wash.
DR Reactor	GE	Graphite	Hanford, Wash.
H Reactor	GE	Graphite	Hanford, Wash.
KE Reactor	GE	Graphite	Hanford, Wash.
KW Reactor	GE	Graphite	Hanford, Wash.
R Reactor	du Pont	Heavy water	Savannah River, S.C.
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 [3]	GE	Graphite	Hanford, Wash.

[illegible]

Name (all owned by AEC)	Designation	Location	Nuclear designer	Type	Power kw(t)	Startup
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

KE Reactor			
KW Reactor	GE	Graphite	Hanford, Wash.
R Reactor	du Pont	Heavy water	Savannah River, S.C.
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 [36]	GE	Graphite	*Hanford, Wash.*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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

Part IV.—REACTORS FOR EXPORT

1. Power Reactors

A. Central Station Electric Power

Name and/or owner	Location	Principal nuclear contractor	Type	Power [1]		Start-up
				Net kw(e)	Kw(t)	
Operable:						
Germany (Rhine-Westphalia Power Co., RWE)	Kahl-am-Main	GE	Boiling water	16,000	60,000	1960
Being built:						
Belgium (Center for the Study of Nuclear Energy CEN)	Mol	West	Pressurized water	11,500	43,000	1960
Italy (Project Enrico Fermi of SELNI, Edisonvolta)	Trino	West	Pressurized water	165,000	615,000	1964
Italy (Project ENSI of SENN)	Punta Fiume	GE	Boiling water	150,000	508,000	1963
Planned:						
Japan, Government of (JAERI)	Tokai-Mura	GE	Boiling water	10,000	40,000	1962
France (Franco-Belgium Society for Nuclear Energy of Ardennes—SENA).	Chooz	West	Pressurized water	150,000	----------	1964

See footnotes at end of table.

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B. Propulsion

Name	Owner	Designation	Designer	Type	Start-up
Being built: S5W for HMS Dreadnaught	Great Britain		West	S5W	

2. Test, Research, and Teaching

A. General Irradiation Test

Owner	Location	Principal nuclear contractor	Type	Power,[19] Kw(t)	Start-up
Operable:					
Sweden, Gov't of (Atomic Energy Company)	Studsvik	AC	Tank (MTR)	30,000	1960
Japan, Gov't of (Atomic Energy Research Inst.)	Tokai-Mura	AMF	Heavy water	10,000	1960
Being built:					
Netherlands, Gov't of (Reactor Center)	Petten	AC	Tank (MTR)	20,000	1962

B. Research

Owner	Location	Principal nuclear contractor	Type	Power, Kw(t)	Start-up
Operable:					
Austria, Gov't of (Seibersdorf Research Center)	Seibersdorf	AMF	Pool	5,000	1960
Brazil, Gov't of (University of Sao Paulo)	Sao Paulo	B&W	Pool	5,000	1957
Canada (McMaster University)	Hamilton, Ont	AMF	Pool	1,000	1959
Denmark, Gov't of (Atomic Energy Commission)	Riso	FW	Tank	5,000	1959
Germany, Federal Republic of (Technical Univ. 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
Israel, Gov't of (Atomic Energy Commission)	Nebi Rubin	AMF	Pool	1,000	1961
Italy, Gov't of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1959
Italy (SORIN Nuclear Center)	Saluggia	AMF	Pool	1,000	1959
Italy, Gov't of (National Committee for Nuclear Research)	Rome	GDC	TRIGA-MkII	100	1960
Spain, Government of (Nuclear Energy Board)	Moncloa	GE	Pool	3,000	1958
Switzerland, Gov't of (Reactor, Inc.)[17]	Wuerenlingen	ORNL	Pool	1,000	1955
Venezuela, Gov't of (Institute of Neurology and Brain Research)	Caracas	GE	Pool	3,000	1960
Being built:					
China, Republic of (National Tsing Hua University)	Hsinchu	GE	Pool	1,000	1961
Greece, Gov't of ([illegible])	Athens	AMF	Pool	1,000	1961
[illegible]	[illegible]	[illegible]	Pool	[illegible]	[illegible]
[illegible]	Lisbon	AMF	Pool	1,000	1960
Thailand (Chulalongkorn University)	Bangkhen	CW	Pool	1,000	1961
Turkey, Gov't of (Atomic Energy Commission)	Istanbul	AMF	Pool	1,000	1961
Planned:					
Pakistan, Gov't of (Atomic Energy Commission)	Taxila	AMF	Pool	1,000	
Union of South Africa (Atomic Energy Commission)		AC	Tank (OROO)	6,600	

C. Teaching

Owner	Location	Principal nuclear contractor	Type	Power, Kw(t)	Start-up
Operable:					
Brazil (University of Minas Gerias)	Belo Horizonte	GDC	TRIGA	30	1960
Congo, Gov't of (University of Lovanium)[38]	Leopoldville	GDC	TRIGA		
Denmark, Gov't of (Atomic Energy Commission)	Ris[illegible]				
Germany, Federal [illegible]					

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[illegible]					
Denmark, Gov't of (Atomic Energy Commission)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Germany, Federal Republic of (Technical Univ. of Munich)	Munich	AMF	[illegible]	[illegible]	[illegible]
Germany, Federal Republic of (Society for the Utilization of Nuclear Energy in Shipbuilding and Navigation, Inc.).	Geesthacht	B&W	Pool	5,000	1958
Israel, Gov't of (Atomic Energy Commission)	Nebi Rubin	AMF	Pool	1,000	1961
Italy, Gov't of (National Committee for Nuclear Research)	Ispra	AC	Heavy water, tank	5,000	1959
Italy (SORIN Nuclear Center)	Saluggia	AMF	Pool	1,000	1959
Italy, Gov't of (National Committee for Nuclear Research)	Rome	GDC	TRIGA-MkII	100	1960
Spain, Government of (Nuclear Energy Board)	Moncloa	GE	Pool	3,000	1958
Switzerland, Gov't of (Reactor, Inc.) [37]	Wuerenlingen	ORNL	Pool	1,000	1955
Venezuela, Gov't of (Institute of Neurology and Brain Research)	Caracas	GE	Pool	3,000	1960
Being built:					
China, Republic of (National Tsing Hua University)	Hsinchu	GE	Pool	1,000	1961
Greece, Gov't of (Atomic Energy Commission)	Athens	AMF	Pool	1,000	1961
Planned:					
[illegible] (Atomic Energy Commission)	Istanbul	AMF	Pool	[illegible]	1961
Pakistan, Gov't of (Atomic Energy Commission)	Taxila	AMF	Pool	1,000	-------
Union of South Africa (Atomic Energy Commission)		AC	Tank (OROO)	6,600	-------

C. Teaching

Operable:					
Brazil (University of Minas Gerias)	Belo Horizonte	GDC	TRIGA	30	1960
Congo, Gov't of (University of Lovanium) [38]	Leopoldville	GDC	TRIGA	10	1959
Denmark, Gov't of (Atomic Energy Commission)	Riso	AI	L-55	2	1957
Germany, Federal Republic of (Universities of Frankfurt and Darmstadt)	Frankfurt	AI	L-54	50	1958
Germany (Interatom, Inc.) [39]	Duisberg	AI	L-77	Neglig.	1958
Italy (University of Palermo)	Palermo	AGN	201-110	Neglig.	1960
Italy (University of Milan)	Milan	AI	L-54	50	1959
Japan, Gov't of (Atomic Energy Research Institute)	Mito	AI	L-54	50	1957
Netherlands, Gov't of (Delft Technical Univ.) [40]	Delft	AMF	Pool	100	1957
Switzerland (University of Geneva) [41]	Geneva	AGN	201-111	Neglig.	1958
Switzerland (University of Basel) [42]	Basel	AGN	211-100	Neglig.	1958
West Berlin, City of (Institute for Nuclear Research)	West Berlin	AI	L-54	50	1958
Being built:					
Australia (Atomic Energy Commission)	Lucas-Hights New South Wales.	ARSS	UTR-10	Neglig.	1961
Austria, Gov't of (Vienna Polytechnic Institute)	Vienna	GDC	TRIGA-Mk II	100	1961
Japan (Kinki University)	Osaka	ARSS	UTR-10	Neglig.	1961
Japan (Rikkyo University)	Yokosuka City	GDC	TRIGA-Mk II	100	1961
Japan (Musashi University)	Kawasaki City	GDC	TRIGA-Mk II	100	1961
Korea, Gov't of (Atomic Energy Commission)	Seoul	GDC	TRIGA-Mk II	100	1961
Vietnam, Government of	Dalat	GDC	TRIGA-Mk II	100	1961
Planned:					
Finland, Gov't of (Institute of Technology)	Helsinki	GDC	TRIGA-Mk II	100	1961
Germany (University of Mainz)	Mainz	GDC	TRIGA-Mk II	100	-------
Indonesia (Institute of Technology)	Bandung	GDC	TRIGA-Mk II	100	-------
Japan (Tokai University)		ARSS	UTR-10	Neglig.	-------
Yugoslavia, Federal Peoples Gov't of (Josef Stefan Nuclear Institute)	Ljubljana	GDC	TRIGA-Mk II	100	1962

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	Number of cells	Number 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	3	3
ANL-ID	Argonne National Laboratory, Idaho Division (AEC), NRTS, Idaho	ANL	1	1
ARMF	Advanced Reactivity Measurement Facility (AEC), NRTS, Idaho	PPC	1	1
Bettis	Bettis Plant (AEC), Pittsburgh, Pa.	West	9	9
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
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
GDC	General Dynamics Corp., San Diego, Calif.	Owner	3	3
HAN	Hanford Critical Facilities (AEC Hanford, Wash.)	GE	2	2
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		
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
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	Owner	1	1
NDA	Nuclear Development Corporation of America, Pawling, N.Y.	Owner	1	1
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn.	ORNL	3	5
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn.	ORNL	1	1
RMF	Reactivity Measurement Facility, MTR Canal (AEC), NRTS, Idaho	PPC	1	1
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev.	UCLRL	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

[illegible]

B.1. Civilian

Operator and location within facility	Subject of current experiment or study	Designation	Start-up
Operable:			
AC	Northern States Power Reactor critical experiment	CRBR-CX	1959
AI, Bldg 9	Nuclear properties of organic moderated systems	OCMA	1959
AI, Bldg 9	Nuclear properties of sodium graphite systems	SCGA	1959
AI, Bldg 100	Nuclear properties of epithermal reactor systems	AETR	1960
ANL-ID	Fast critical mass determinations	ZPR-3	1955
ANL, Bldg 316, Cell A [43]	Parameters of thermal reactor systems	ZPR-4	1957
ANL, Bldg 316, Cell B	Interactions between two basic systems	ZPR-5	1956
[illegible]	[illegible]	ZPR-7	1957

Livermore	University of California Lawrence Radiation Laboratory Critical Assembly Area (AEC), [illegible] Building, Livermore, Calif.	[illegible]		
LPTF	Low Power Test Facility (AEC), NRTS, Idaho	GE	2	2
Martin	Martin Co., Middle River, Md.	Owner	3	3
NASA	Lewis Flight Propulsion Laboratory, Sandusky, Ohio	Owner	1	1
NDA	Nuclear Development Corporation of America, Pawling, N.Y.	Owner	1	1
ORNL-CF	Oak Ridge National Laboratory Critical Facility (AEC), Oak Ridge, Tenn	ORNL	3	5
ORNL-PCA	Pool Critical Assembly, BSF Pool (AEC), Oak Ridge, Tenn	ORNL	1	1
RMF	Reactivity Measurement Facility, MTR Canal (AEC), NRTS, Idaho	PPC	1	1
UCLRL-NTS	University of California Lawrence Radiation Laboratory (AEC), NTS, Nev	UCLRL	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

[illegible] Civilian

Operator and location within facility	Subject of current experiment or study	Designation	Start-up
Operable:			
AC	Northern States Power Reactor critical experiment	CRBR-CX	1959
AI, Bldg 9	Nuclear properties of organic moderated systems	OCMA	1959
AI, Bldg 9	Nuclear properties of sodium graphite systems	SCGA	1959
AI, Bldg 100	Nuclear properties of epithermal reactor systems	AETR	1960
ANL-ID	Fast critical mass determinations	ZPR-3	1955
ANL, Bldg 316, Cell A [43]	Parameters of thermal reactor systems	ZPR-4	1957
ANL, Bldg 316, Cell B	Interactions between two basic systems	ZPR-5	1956
ANL, Bldg 316, Cell C	Physics experiments for AHFR	ZPR-7	1957
Bettis, Bldg CX, Cell 3	PWR core 1 physics	PWR-FA-1	1954
Bettis, Bldg CX, Cell 4	PWR core 2 physics	PWR-FA-2	1957
B&W, Cell 1	Consolidated Edison Reactor		1957
B&W, Cell 2	Critical experiments with Nuclear Ship *Savannah* Production Fuel		1958
B&W, Cell 3 [43]	LMFRE physics data		1958
BMI, Cell 1	Reflector control critical	BMI-CX	1957
BNL, Bldg T-526	Exponential and critical assembly		1956
CE, Bldg 1, Cell 1	Vacant		
CE, Bldg 2, Cell 1	Boiling Nuclear Superheat Critical Experiment	BONUS	
CE, Bldg 2, Cell 2	Integral nuclear superheat core configuration	NUSU	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
GDC	Maritime gas cooled reactor critical experiments		1960
GE, Cell 1	Commonwealth Edison reactor		1957
LASL, Kiva I	Cold criticals for ROVER reactors	Honeycomb	
LASL Kiva II	Physics measurements of thin enriched uranium foils in thick D_2O cold critical experiments	Cavity	1960
LASL	Kiva heated critical assembly		1960
LASL	Cold Criticals for ROVER reactors	ZEPO	
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	1960
NASA, Materials and Stresses Bldg	NASA Test Reactor critical experiments		1959
NDA, Cell 1 [45]	Development of research reactor	NDA-CX	1957
ORNL-CF, Bldg 9213, Cell E	Uranium-paraffin experiments related to physics and safety of homogeneous reactors	CA-28	1950
ORNL-CF, Bldg 9213, Cell W	Reactor physics and nuclear safety studies with homogeneous uranium solutions; lattices slightly enriched uranium in water; TSR-2 tests; investigations of neutron absorbers as poisons in chemical processing equipment.		1950
ORNL-PCA, Bldg 3010	Physics research on reactivity effects	PCA	1958
MTR canal (PPC)	Reactor physics constants and reactivity changes caused by test reactor irradiation	RMF	1954
ETR-MTR Area (PPC)	Reactor physics constants and reactivity changes caused by test reactor irradiation	AMRF	1960

See footnotes at end of table.

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B.1. Civilian—Continued

Operator and location within facility	Subject of current experiment or study	Designation	Start-up
Operable—Continued			
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-CRX	1960
West, YCF	Loose lattice critical experiments		
Being built:			
ANL, Bldg 315	Basic fast reactor theoretical studies	ZPR-6	1961
ANL, Bldg 315	Coupled fast core-thermal breeder blanket investigations	ZPR-9	1961
Cornell	Zero Power Reactor	ZEPR	1960
HAN-CML	Critical Mass Laboratory	CML	1960
HAN-PRCF	Plutonium Recycle Criticals	PRCF	1961

B.2. Military

Operator and location within facility	Subject of current experiment or study	Designation	Start-up
Operable:			
Alco	APPR-1A core design	APPR-s	1956
Bettis, Bldg C, Cell 1	Two region physics	TRX	1953
Bettis, Bldg CA, Cell 2	S5W	SPE-CX	1960
Bettis, Bldg CX, Cell 1	Surface ship physics [46]	SS-CFB	1957
Bettis, Bldg CX, Cell 2	Physics measurements	SPE-CBM	1960
Bettis, Bldg CY, Cell 1	High-temperature physics and mock-up	HTTF	1960
CANEL, Physics Bldg, Cell 1	Aircraft propulsion		1958
CANEL, Physics Bldg, Cell 2	Aircraft propulsion		1959
GEANP-1	Criticals for direct-cycle reactors	KEY	1960
GEANP-2	Criticals for direct-cycle reactors	SSR-RAG	1960
KAPL, Bldg F1, Cell 1	Physical data	PPA	1948
KAPL, Bldg F2, Cell 1	Reactor physics studies with plastic moderator and mock-up	PMA	1954
KAPL, Bldg F3, Cell 1	Submarine advanced reactor mock-up	ATR	1954
KAPL, Bldg F1, Cell 1	SAR physics and mock-up	FPR	1956
KAPL, Bldg E5, Cell 1	DIG cold-water mock-up	CWA	1958
KAPL	SAR high-temperature and -pressure physics and mock-up	PTR	1958
LAC	RER core configurations	CERF	1958
LASL	Enriched metal in 3-inch-thick uranium reflector	*Little Eva*	*1951*
LASL, Kiva I	Plated bare plutonium (*to be replaced by* U^{233}) sphere studies	*Jezebel*	*1954*
LASL, Kiva I	Critical configuration safety tests	*Comet*	
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 II	*Critical configuration safety tests*	*Planet*	[illegible]
[illegible]	[illegible] critical experiments	[illegible]	[illegible]
[illegible]	Hot critical experiments		1957
NAA-AI	Critical experiment tank for HTRE-2	HOTCE	1958
NTS, Nevada	Criticals for SNAP reactors	CET	1957
	Hot criticals for Tory-II (Project PLUTO)		
Being Built:			
KAPL	Water Reactor Test Cell	Hot Box	1960
Livermore, SAGA Bldg	Tory-II critical experiments		1960

B.3. Export

Operator and location within facility	Subject of current experiment or study	Designation	Start-up
Operable:			
Canada, Gov't of (AECL) Chalk River	Natural uranium, D_2O moderated power reactor lattice studies	ZED II	[illegible]

CANEL, Physics Bldg, Cell 1	Aircraft propulsion		
CANEL, Physics Bldg, Cell 2	Aircraft propulsion		1959
GEANP-1	Criticals for direct-cycle reactors	KEY	1960
GEANP-2	Criticals for direct-cycle reactors	SSR-RAG	1960
KAPL, Bldg F1, Cell 1	Physical data	PPA	1948
KAPL, Bldg F2, Cell 1	Reactor physics studies with plastic moderator and mock-up	PMA	1954
KAPL, Bldg F3, Cell 1	Submarine advanced reactor mock-up	ATR	1954
KAPL, Bldg F1, Cell 1	SAR physics and mock-up	FPR	1956
KAPL, Bldg E5, Cell 1	DIG cold-water mock-up	CWA	1958
KAPL	SAR high-temperature and -pressure physics and mock-up	PTR	1958
LAC	RER core configurations	CERF	1958
LASL	Enriched metal in 3-inch-thick uranium reflector	Little Eva	1951
LASL, Kiva I	Plated bare plutonium (to be replaced by U^{233}) sphere studies	Jezebel	1954
LASL, Kiva I	Critical configuration safety tests	Comet	
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 II	Critical configuration safety tests	Planet	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
NTS, Nevada	Hot criticals for Tory-II (Project PLUTO)	[illegible]	[illegible]
Being Built:			
KAPL	Water Reactor Test Cell	Hot Box	1960
Livermore, SAGA Bldg	Tory-II critical experiments		1960

B.3. Export

Operable:			
Canada, Gov't of (AECL) Chalk River	Natural uranium, D_2O moderated power reactor lattice studies	ZED-II	1960
Planned:			
Japan, Gov't of (JAERI) Tokai-MURA	Aqueous homogeneous		
Japan, Gov't of (JAERI) Tokai-MURA	Semi-homogeneous		

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.

[2] The Shippingport station is provided with a turbogenerator rated at 100,000 kw(e).

[3] Project under Power Demonstration Reactor Program.

[4] The net electrical kilowatt output for the Yankee's second core is expected to be 134,000.

[5] Of the total net output shown for the Consolidated Edison plant, 151,000 kw will be nuclear and 104,000 kw will be oil-fired superheat.

[6] 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.

[7] The capacity of the Northern States plant includes about 17,000 kw(e) nuclear superheat.

[8] Approved as basis for the AEC contract negotiations under the Power Demonstration Reactor Program.

[9] The net output of the Elk River plant includes about 15,000 kw conventional superheat.

[10] Capacity of CVNPA plant includes about 2,000 kwe from conventional superheat.

[11] Capacity of SSNPP includes about 5,500 kwe from conventional superheat.

[12] EBWR was successfully operated at a power level of 62,000 kw of heat in experiments on March 20, 1958. It is now being converted to a 100,000 kw thermal plant, but its electrical output is limited by turbogenerator capacity.

[13] The power output of EGCR will depend on the operation of experimental loops to be provided in the core.

[14] LAPRE-1 was designed as a small reactor experiment that was to produce 2,000 kw of heat power. It operated only very briefly and never succeeded in reaching full power.

[15] 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.

[16] 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.

[17] The purpose of this reactor is to investigate problems associated with high-temperature process heat reactors.

[18] BSR-2 is a stainless steel-UO_2 core that can be used alternately in the same facility with BSR-1 (aluminum alloy core).

[19] 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 201 M's, 5 watts; AGN 201 P'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.

[20] 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 2 kw.

[21] 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.

[22] AE-6 (also designated WBNS) was built and first operated at Downey, Calif. It was moved to Santa Susana in 1957.

FOOTNOTES—Continued

[23] Ownership of the Curtiss-Wright Research Reactor Facility has been transferred to Pennsylvania State University. The reactor is being maintained on a standby basis pending issuance of an operating license to the University.

[24] These reactors were shipped abroad for exhibition purposes in Pakistan and Egypt in 1960.

[25] This TRIGA–Mk II reactor was operated at the New Delhi World Agricultural Fair in 1960. It has been dismantled for storage in California by GDC.

[26] 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.

[27] After the assembly and operation of this reactor in the Government exhibit at Geneva in September 1958, it was dismantled and returned to ANL where it is being rebuilt as a 250-kw(t) Juggernaut.

[28] 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)—semi-mobile, 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: *V* (very low)—less than 100 kwe; *L* (low)—100 to 1,000 kwe; *M* (medium)—1,000 to 10,000 kwe; *H* (high)—10,000 kwe or more.

Arabic numerals indicate order in which plants having the same mobility and power characteristics are initiated. Where not followed by an additional letter, the designation indicates a prototype or pilot plant.

The last capital letter (when present) indicates alphabetical order in which field plants of a specific type are initiated.

[29] PM–2A will produce 1 million Btu per hour of space heat in addition to electrical output.

[30] SM–1A, formerly known as APPR–1A, will produce 38 million Btu per hour for space heat in addition to electrical output.

[31] 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 prime 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 prime-contractor designation letters are *W* for Westinghouse, *G* for General Electric, and *C* for Combustion Engineering.

[32] USS *Seawolf*, originally commissioned with a sodium-cooled reactor in March 1957 was recommissioned with a pressurized water reactor on September 30, 1960.

[33] SL–1 can produce 1.3 million Btu per hour of space heat in addition to electrical output; this additional output is now being dissipated through a heat dump. The plant is now being operated by Combustion Engineering.

[34] PM–1, formerly known as APPR–2, will produce 7 million Btu per hour of space heat in addition to electric output.

[35] This reactor (HTRE–1) was partially dismantled in 1957. It could be made operable again if desired, but there are no present plans to do so.

[36] The design of this reactor incorporates features making possible conversion to permit power take-off should this be desirable at a later date.

[37] This is the 1955 Geneva Conference reactor rebuilt with increased power and now operating at Wuerenlingen, Switzerland.

[38] 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.

[39] This L–77 reactor was operated in the commerical exhibit of the 1958 International Conference in Geneva. It is presently in storage at Interatom, Inc.

[40] The Netherlands research reactor was orginally operated at the Amsterdam International Exhibition in June 1957. It is now in storage at Delft Technical University.

[41] AGN201–111 was operated in the commercial exhibit of the 1958 International Conference in Geneva prior to transfer to the University of Geneva.

[42] 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.

[43] 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).

[44] B&W cells 2 and 3 share a control panel with only one cell capable of being operated at any one time.

[45] The NDA facility is designed to accommodate two experiments but has a present capability of one.

[46] The cell has one control panel but two pots. Experiments may be operated in either pot, but not simultaneously.

APPENDIX 13

... UNDER ACTIVE DESIGN OR CONSTRUCTION JUNE 30, 1959, AND JUNE 30, 1960

(Supplement to Tables 1, 2 and 3, Chapter 1)

CIVILIAN POWER PROTOTYPES AND EXPERIMENTS

... of Projects for ... Ended 6/30/60	
1	CVTR (Carolinas-Virginia Tube Reactor).
2	Florida West Coast Nuclear Group.
3	Enrico Fermi—Power Reactor Development Co.
4	Hallam—Consumers Public Power District of Nebraska.
5	Pathfinder—Northern States Power Co.
6	City of Piqua.
7	Elk River—Rural Cooperative Power Association.
8	Yankee Atomic Electric Co.
9	Humboldt Bay—Pacific Gas and Electric Co.
10	Dresden—Commonwealth Edison Co.
11	Indian Point—Consolidated Edison Co.
12	EBR–2.
13	EGCR (Experimental Gas Cooled Reactor).
14	Peach Bottom—Philadelphia Electric Co.
15	TURRET.
16	LAMPRE–1.
17	EBWR Modifications.
18	PWR Modifications.
19	Saxton Nuclear Reactor Project.
20	EOCR (Experimental Organic Cooled Reactor).
21	BONUS—Puerto Rico Water Resources Authority.
22	Big Rock Point—Consumers Power Co.
23	BORAX–5 (Modification of BORAX–4).

CIVILIAN TESTING

1	Plum Brook—National Aeronautics Space Agency.
2	WTR—Westinghouse Testing Reactor.
3	JANUS (Biological Research Reactor—ANL).
--	Argonne Fast Source Reactor (At NRTS).
4	HWCTR—Heavy Water Components Test Reactor.
5	PRTR—Plutonium Recycle Test Reactor.
6	SPERT–2.
7	SPERT–4.

CIVILIAN RESEARCH

1	Brookhaven High Flux Beam Research Reactor.
2	Juggernaut (ANL).
3	Puerto Rico Nuclear Center Research Reactor.

CIVILIAN RESEARCH—Continued

Number of Projects for Quarter Ended 6/30/59	6/30/60	
4	4	Texas A & M Research Reactor.
5	5	Ohio State University Research Reactor.
6	6	University of Virginia Research Reactor.
7	--	Worcester Polytechnic Institute Research Reactor.
8	--	North Carolina State College Research Reactor.
9	7	University of California at Los Angeles.
10	8	University of Kansas Research Reactor.
11	9	University of Washington Research Reactor.
12	10	Walter Reed Medical Center.
13	--	Virginia Polytechnic Institute Reactor.
14	11	Washington State University Research Reactor.
15	12	Georgia Tech Research Reactor.
16	13	Union Carbide Research Reactor (Sterling Forest, N.Y.).
17	14	Cornell TRIGA Reactor.
18	--	Stanford University Research Reactor.
19	--	Iowa State University Research Reactor.
--	15	University of Missouri (School of Mines).
--	16	University of Buffalo.
--	17	University of Illinois.
--	18	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	Ames Laboratory Research Reactor.

MERCHANT SHIP PROPULSION

1	1	N.S. Savannah.

MILITARY PROTOTYPES, EXPERIMENTS, & FIELD PLANTS

1	1	Destroyer Reactor Prototype (D1G).
2	2	Mobile Low Power Plant (ML-1) (NRTS).
3	3	Portable Medium Power Plant (PM-1) (S[illegible] Wyoming).
4	4	Portable Medium Power Plant (PM-2A) (Camp [illegible]tury, Greenland).
5	--	Small Submarine Reactor Prototype (S1C).
6	5	Stationary Medium Power Plant (SM-1A) (Fort [illegible] Alaska).
7	--	Gas Cooled Reactor Experiment (GCRE).

MILITARY TESTING

1	1	Nuclear Test Plant (Army-NRTS).
2	2	SERF—Sandia Engineering Reactor Facility ([illegible] DMA).
3	--	TSR-2—Tower Shielding Reactor No. 2 (ANP-[illegible] Ridge).

MILITARY TESTING—Continued

…of Projects for …ter Ended 6/30/60	
3	NETR—Nuclear Engineering Test Reactor (USAF–Dayton, Ohio).
4	Materials Research Reactor (USA–Watertown Arsenal).
5	Ordnance Pulsed Experimental Research Assembly (USA).
6	SPRF—Sandia Pulsed Reactor Facility (AEC).

MATERIALS PRODUCTION

1	NPR—New Production Reactor (Hanford).

…Projects are *added* to this tabulation:
…During the calendar quarter in which license applications are received,
…For projects under the cooperative demonstration program, during the quarter in which a basis for arrangements is submitted to the JCAE,
…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.)
…ts are *dropped* from this tabulation in the quarter following the calendar quarter …they first operate at design power.
…ations to existing projects are included only when a substantial increase in the …wer output will result.

APPENDIX 14

Status of Agreements for Cooperation in the Civil Uses of Atomic Energy and Special Agreements

Cumulative numbers countries	Agreements	Country	Scope of Exchange	Effective date of agreement
1	1	Argentina	**Research	[illegible]
2	2	*Australia	Research and power	[illegible]
3	3	Austria	Research	[illegible]
4	4	*Belgium	**Research and power	[illegible]
5	5	Brazil	**Research	[illegible]
6	6	*Canada	**Research and Power	[illegible]
7	7	China, Republic of	**Research	[illegible]
8	8	Cuba	Research	[illegible]
9	9	Denmark	**Research	[illegible]
10	10	Dominican Republic	Research	[illegible]
11	11	Ecuador	Research	[illegible]
12	12	France	**Research and power	[illegible]
13	13	Germany, Federal Republic of	**Research and power	[illegible]
	14	West Berlin, city of	Research	[illegible]
14	15	Greece	**Research	[illegible]
15	16	Guatemala	Research	[illegible]
16	17	Indonesia	Research	[illegible]
17	18	Iran	Research	[illegible]
18	19	Ireland	Research	[illegible]
19	20	Israel	**Research	[illegible]
20	21	Italy	Research and power	[illegible]
21	22	Japan	**Research and power	[illegible]
22	23	Korea, Republic of	**Research	[illegible]
23	24	*Netherlands	**Research and power	[illegible]
24	25	New zealand	**Research	[illegible]
25	26	Nicaragua	Research	[illegible]
26	27	Norway	Research and power	[illegible]
27	28	Peru	Research	[illegible]
28	29	Philippines	**Research	[illegible]
29	30	Portugal	**Research	[illegible]
30	31	South Africa	Research and power	[illegible]
31	32	Spain	Research and power	[illegible]
32	33	Sweden	**Research	[illegible]
33	34	Switzerland	Research	[illegible]
	35	*Switzerland	**Power	[illegible]
34	36	Thailand	**Research	[illegible]
35	37	Turkey	Research	[illegible]
36	38	*United Kingdom	**Research and power	[illegible]
37	39	Uruguay	Research	[illegible]
38	40	Venezuela	Research and power	[illegible]
39	41	Viet-Nam	Research	[illegible]

Special Agreements

1. European Atomic Energy Community (EURATOM).	Joint Nuclear Power Program.	Feb [illegible]
2. European Atomic Energy Community (EURATOM).	Additional Agreement	July [illegible]
3. International Atomic Energy Agency (IAEA)	Supply of Materials, etc	Aug. [illegible]

Mutual D

Australia
Canada*
France
Germany, Federal Republic
Greece
Netherlands*
Turkey*
United Kingdom*
(Amendment to U.K. Ag

In effect: 27 research and 1
8 Mutual Defense Pur
EURATOM).
Signed and awaiting comp
agreements with Brazil, Costa
Classified agreements.
*Denotes agreement has be

MUTUAL DEFENSE PURPOSES AGREEMENTS

Australia	Aug. 14, 1957
Canada*	July 27, 1959
France	July 20, 1959
Germany, Federal Republic of*	July 27, 1959
Greece	Aug. 11, 1959
Netherlands*	July 27, 1959
Turkey*	July 27, 1959
United Kingdom*	Aug. 4, 1958
(Amendment to U.K. Agreement)*	July 20, 1959

SUMMARY

In effect: 27 research and 14 power agreements with 39 countries and West Berlin, 8 Mutual Defense Purposes Agreements, and 3 special agreements (IAEA and EURATOM).

Signed and awaiting completion of ratification are research and/or power agreements with Brazil, Costa Rica, Cuba, Iraq, Peru, and Panama.

*Classified agreements.

*Denotes agreement has been amended.

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APPENDIX 15

Foreign Reactors and Critical Assemblies Subject to U.S. Safeguards Including Those Expected to Go Critical in 1961 as of September 30, 1960

(62 REACTORS AND CRITICAL ASSEMBLIES IN 23 COUNTRIES)

Country	Facility name	Facility type	Site	Kilograms of material: Total element	Kilograms of material: Isotope	Form	Percent enriched	Thermal	Reason for safeguards: U.S. fuel	Reason for safeguards: U.S. built	Reason for safeguards: U.S. heavy water
Argentina [1]	RA-1	Argonaut	Buenos Aires	30.4	6.0	U_3O_8	20	10 KW	x		
Australia	HIFAR	Tank	Lucas Heights	5.4	4.9	U-A1 Alloy [2]	90	10 MW			12 tons
Austria	ASTRA	Pool	Seibersdorf	6.4	5.7	Elements	90	5-12 MW	x	x	
(NC)		Triga MK II	Vienna	60.0	12.0	Elements (NS)	20	100 KW	x	x	
Belgium	BR-2	MTR	Mol	5.4	4.9	Elements	90	25 MW	x		
	BR-2-0	Core Mockup	Mol	4.9	4.4	Elements	90	50 KW	x		
	BR-3	PWR	Mol	2,277.0	91.0	Elements (NS)	4	40 MW	x	x	
Brazil		Pool	Sao Paulo	58.9	11.6	Elements	20	MW 5	x	x	
(NC)		Triga	Belo Horizonte	11.1	2.2	Elements (NS)	20	30 KW	x	x	
China, Republic of (NC)		Pool	Tsing Hua Univ.	20.0	4.0	Elements (NS)	20	1 MW	x	x	
Congo	TRICO	Triga	Leopoldville	10.0	2.0	Elements	20	10 KW	x	x	
Denmark [illegible]	DR-1	Homogeneous L-54	Riso	[illegible]	[illegible]	UO_2SO_4	20	[illegible] W	x	x	
	DR-2	Tank	Riso	[illegible]	[illegible]	Elements	[illegible]	5 MW	x	x	
	DR-3	[illegible]	Riso	[illegible]		Elements	[illegible]	10 MW	x	x	17 tons
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Germany [1]	[illegible]	[illegible]	Fontenay	[illegible]	[illegible]	Elements	[illegible]	1 MW	x		
			Fontenay	27.8	5.5	Elements	20	100 W	x		
	FRM	Pool	Munich	24.9	4.9	Elements	20	1 MW	x	x	
	FRM	Pool	Munich	6.6	6.0	Elements	90	1 MW	x	x	
(NC)	SAR	Argonaut	Munich	30.2	6.0	Elements	20	10 KW	x		
	FR-2	Research	Karlsruhe			German Elements	Natural	12 MW			35 tons
	FR-2-0	CA	Karlsruhe			German Elements	Natural	0			9 tons
	FRF	Homogeneous	Frankfurt	9.1	1.8	UO_2SO_4	20	50 KW	x	x	
(NC)	FRB	Homogeneous	West Berlin	9.1	1.8	UO_2SO_4	20	50 KW	x	x	
		Homogeneous L-77	Duisburg			Display-No Fuel	20	10 W	x	x	
	FRH	Pool	Geesthacht	28.8	5.7	Elements	20	5 MW	x	x	
	RWE	Power	Kahl am Main	6,325.6	155.0	UO_2	2.5	60 MW	x	x	
		Argonaut	Grosswelzheim	37.7	7.4	U_3O_8	20	10 KW		x	
Greece		Sub-Critical	Athens	2,493.6		Elements	Natural	0			
(NC)		Pool	Athens	25.0	5.0	[illegible]			x		

(NC)		Triga	Belo Horizonte	11.1	2.2	Elements (NS)					
China, Republic of (NC)		Pool	Tsing Hua Univ.	20.0	4.0	Elements (NS)	20	1 MW	x	x	
Congo	TRICO	Triga	Leopoldville	10.0	2.0	Elements	20	10 KW	x	x	
Denmark	DR 1	Homogeneous L 55	Riso	7.0	1.4	UO_2SO_4	20	500 W	x	x	
	DR 2	Tank	Riso	13.4	13.9	Elements	90	5 MW	x	x	
	DR 3	Plate	Riso	[illegible]		Elements	90	10 MW			[illegible] tons
Germany	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
	FRM	Pool	Munich	24.9	4.9	Elements	20	1 MW	x	x	
(NC)	FRM	Pool	Munich	6.6	6.0	Elements	90	1 MW	x	x	
	SAR	Argonaut	Munich	30.2	6.0	Elements	20	10 KW	x		
	FR-2	Research	Karlsruhe			German Elements	Natural	12 MW			35 tons
	FR-2-0	CA	Karlsruhe			German Elements	Natural	0			9 tons
	FRF	Homogeneous	Frankfurt	9.1	1.8	UO_2SO_4	20	50 KW	x	x	
(NC)	FRB	Homogeneous	West Berlin	9.1	1.8	UO_2SO_4	20	50 KW	x	x	
		Homogeneous L-77	Duisburg			Display-No Fuel	20	10 W	x	x	
	FRH	Pool	Geesthacht	28.8	5.7	Elements	20	5 MW	x	x	
	RWE	Power	Kahl am Main	6,325.6	155.0	UO_2	2.5	60 MW	x	x	
		Argonaut	Grosswelzheim	37.7	7.4	U_3O_8	20	10 KW		x	
Greece		Sub-Critical	Athens	2,493.6		Elements	Natural	0	x		
(NC)		Pool	Athens	25.0	5.0	Elements (NS)	20	1 KW	x	x	
India (NC)		Zero energy	Trombay			Indian Fuel	Natural	0			15 tons
Israel	IRR	Pool	Rehovoth	7.3	6.5	Elements	90	1-5 MW	x	x	
Italy	RS-1	Pool	Saluggia	33.1	6.6	Elements	20	5 MW	x	x	
	ISPRA-1	Pool-CP-5	Ispra	22.0	4.4	Elements	20	5 MW	x	x	10 tons
	ISPRA-1	Pool-CP-5	Ispra	6.8	6.1	Elements	90	5 MW	x	x	
		Homog. L-54	Milan	7.5	1.5	UO_2SO_4	20	50 KW	x	x	
(NC)	CAMEN	Pool	Livorno	6.0	5.4	Elements (NS)	90	3-5 MW	x	x	
	CNRN	Triga MK II	Rome	11.8	2.3	Elements	20	100 KW	x	x	
		AGN-201	Palermo	3.3	0.7	UO_3	20	20 W	x	x	
(NC)	AGIP	Argonaut	San Donato	44.0	8.8	Elements (NS)	20	10 KW	x		
		Sub-Critical	U-of-Cagliari	1,998.7		Elements	Natural	0	x		
Japan	JRR-1	Water Boiler	Tokai-Mura	10.0	2.0	UO_2SO_4	20	50 KW	x	x	
	JRR-2	CP-5	Tokai-Mura	17.1	3.4	Elements	20	10 MW	x	x	13 tons
(NC)		Semi Homog. CA	Tokai-Mura	75.0	15.0	UO_2 pellets (NS)	20	0	x		
(NC)		Aq. Homog. CA	Tokai-Mura	10.0	2.0	UO_2SO_4 (NS)	20	0	x		
(NC)		Fast Neutron Converter.	Tokai-Mura	15.0	3.0	Elements (NS)	20	0	x		
Korea (NC)	KRR	Triga MK II	Seoul	10.0	2.0	Elements (NS)	20	100 KW	x	x	
Netherlands	HOR	Pool	Delft	22.5	4.4	Elements	20	2 MW	x	x	
	HOR	Pool	Delft	2,499.0		Elements	Natural	2 MW	x	x	
(NC)	HFR	Tank	Petten	5.3	4.7	Elements	90	20 MW	x	x	
(NC)	SUSPOP	Homog	Arnhem	5.0	1.0	Pellets (NS)	20	250 KW	x		

See footnotes at end of table.

Foreign Reactors and Critical Assemblies Subject to U.S. Safeguards Including Those Expected to Go Critical in 1961 as of September 30, 1960—Continued

(62 REACTORS AND CRITICAL ASSEMBLIES IN 23 COUNTRIES)—Continued

Country	Facility name	Facility type	Site	Kilograms of material: Total element	Kilograms of material: Isotope	Form	Percent enriched	Thermal	Reason for safeguards: U.S. fuel	Reason for safeguards: U.S. built	Reason for safeguards: U.S. heavy water
Norway	HBWR	Boiling Water	Halden	149.1	2.3	UO_2	1.5	5–10 MW	x		18 tons
Portugal (NC)		Pool	Sacavem	19.0	3.8	Elements (NS)	20	1 MW	x	x	
Spain	JEN-1	Pool	Moncloa	23.8	4.7	Elements	20	3 MW	x	x	
Sweden (NC)	R-2	Tank	Studsvik	7.1	6.4	Elements	90	30 MW	x	x	
(NC)	R-2-0	Tank	Studsvik	5.2	4.7	Elements	90	100 KW	x	x	
(NC)	R-2	Tank	Studsvik	2,131.1	32.0	UO_2	1.5	30 MW	x	x	
	R-3/ADAM	N.U	Stockholm			Swedish Fuel	Natural	125 MW			28 tons
Switzerland	SAPHIRE	Pool	Wurenlingen	30.6	5.9	Elements	20	1 MW	x	x	
(NC)	DIORIT	N.U	Wurenlingen			Non U.S	Natural	12 MW			18 tons
		AGN-201	Geneva	3.4	0.7	UO_2	20	20 W	x	x	
		AGN-211	Basel	4.0	0.8	UO_2	20	1 KW	x	x	
Turkey (NC)	ATATURK	Pool	KUCUK Cekmece.	6.6	6.0	Elements (NS)	90	1	x	x	
Venezuela (NC)	RV-1	Pool	Caracas	24.7	4.9	Elements	20	3 MW	x	x	

[1] Has fuel fabrication facility which has processed or is processing U.S. supplied material.
[2] Material supplied for general research on fuel elements.
(NS) Not shipped.
(NC) Not critical.
CA Critical Assembly.

APPENDIX 16

FOREIGN RESEARCH REACTOR GRANTS

(May 30, 1956–December 31, 1960)

...GRANTS 22

Country	Type	Power (thermal)	Manufacturer	Estimated project cost (millions)
...Vienna [1]	Tank	5 MW [3]	American Machine and Foundry	$4.0
...Mol	Tank	25 MW [2]	Centre d'Etudes de l'Energie Nucleaire. Nuclear Development Associates.	10.01
...Paulo [1]	Pool	5 MW	Babcock and Wilcox	1.3
...chins	Pool	1 MW	International General Electric	1.0
...Risoe [1]	Tank	5 MW	Foster-Wheeler	1.4
...Aghia Paraskeri	Pool	1 MW	American Machine and Foundry	1.3
...roth	Pool	1 MW	American Machine and Foundry	1.4
...ars [1]	Tank	5 MW	American Car and Foundry	3.6
...kaimura [1]	Tank	10 MW	American Machine and Foundry	1.5
...rang	Tank	100 KW	General Atomic	1.1
..., Petten	Tank	20 MW	American Car and Foundry	3.9
...Kjeller	Pool	10 KW	Norstom	0.8
...Rawalpindi [4]	Pool	5 MW	American Machine and Foundry	3.5
...Lisbon	Pool	1 MW	American Machine and Foundry	1.0
...Madrid [1]	Pool	3 MW	International General Electric	1.0
...Studsvik	Tank	30 MW	American Car and Foundry	4.3
...Bangkok	Pool	1 MW	Curtiss-Wright	0.82
...Istabul [4]	Pool	1 MW	American Machine and Foundry	2.88
...Caracas [1]	Pool	3 MW	International General Electric	5.0
...Dalat	Tank	100 MW	General Atomic	0.75
...many, Munich [1]	Pool	1 MW	American Machine and Foundry	3.1
..., Ljubljana [4]	Tank	100 KW	General Dynamics	0.812

...paid.
...rtible to 50 MW.
...rtible to 12 MW.
...ssion approved grants during 1960.

[1] Has fuel fabrication facility which has processed or is processing U.S. supplied material.
[2] Material supplied for general research on fuel elements.
(NB) Not shipped.
(NC) Not critical.
CA Critical Assembly.

APPENDIX 17

Materials Shipments to Foreign Countries

January 1960–November 1960 [1]

Date	Country	Uranium		Other materials	Type of transaction	Purpose and remarks
		Kg U-235	Percent enrich. U-235			
Jan. 11, 1960	Sweden	0.072	90		Sale	Research
Jan. 11, 1960	Sweden			62 Gm Pu	Sale	Research
Jan. 12, 1960	Switzerland	0.059	20		Sale	Research
Jan. 21, 1960	Germany	(*)	20		Sale	Fiss. Cha
Jan. 22, 1960	Sweden	5.335	89.61		Lease	Fuel R-2
Feb. 9, 1960	Israel			160 Gm Pu	Sale	Nehi Rai
Feb. 11, 1960	Israel	(*)	90		Sale	Fiss. Co
Feb. 16, 1960	Sweden	0.746	89.61		Lease	Fuel R-2
Feb. 17, 1960	Israel	6.545	89.62		Lease	Fuel Rehov
Feb. 26, 1960	France	0.179	20		Lease	Fuel Me
Feb. 26, 1960	Italy	5.899	89.61		Lease	Fuel Ispra
Mar. 1, 1960	United Kingdom			*lbs D_2O	Sale	UK
Mar. 4, 1960	Brazil	67.0	Normal		Sale	Research
Mar. 7, 1960	Canada	(2.242)	90		Lease	Return for Reprocess
Mar. 7, 1960	Canada	(1.497)	90		Lease	Nuclear La
Mar. 8, 1960	Sweden	(*)	90		Lease	Fiss. Co
Mar. 14, 1960	Egypt	3.387	90			U.S. Exh
Mar. 18, 1960	Canada	4.490	90		Lease	NRX Reac
Mar. 21, 1960	Brazil	(*)	20		Lease	Fission Co for Sao P
Mar. 23, 1960	Belgium	0.736	90		Lease	Fuel BR-1
Mar. 25, 1960	Greece			2493 Kg Norm	Sale	Sub-critical
Mar. 28, 1960	Egypt	(*)	90			U.S. Exh
Mar. 28, 1960	Egypt			16 Gm Pu		U.S. Exh
Mar. 29, 1960	Spain	(*)	20		Sale	Fiss. Co
Mar. 29, 1960	Sweden	31.639	1.5		Sale	Research R-1
Mar. 30, 1960	Netherlands	(*)	90		Sale	Fiss. Co
Mar. 31, 1960	Israel	(*)	90		Sale	Fiss. Co
Apr. 1, 1960	France			8.5 Bm U-233	Sale	Research
Apr. 4, 1960	Italy			10 Gm Pu	Sale	Research
Apr. 5, 1960	Netherlands	(*)	90		Sale	Fiss. Co
Apr. 11, 1960	Japan			3.5 T D_2O	Sale	Research
Apr. 21, 1960	Germany			50 Mg Np 237	Sale	Research
Apr. 21, 1960	Germany			50 Mg Am 241	Sale	Research
Apr. 22, 1960	Netherlands			80 Gm Pu	Sale	Res. U. of
Apr. 26, 1960	Belgium	0.300	90		Sale	Research
Apr. 26, 1960	Belgium			10 Kg Depl. U	Sale	Research
May 6, 1960	United Kingdom			9.8 Kg Depl U	Sale	UK AEA
May 10, 1960	Denmark	0.014	90		Sale	Research
May 17, 1960	Sweden	0.291	89.63		Lease	Fuel R-2
June 2, 1960	Denmark	6.506	90		Lease	Fuel Riso
June 2, 1960	Italy	0.197	89.62		Lease	Fuel Ispra
June 6, 1960	France			18 T. D_2O	Lease	Aquilon II
June 8, 1960	Austria			998 lbs D_2O	Sale	Research
June 21, 1960	India			499 lbs D_2O	Lease	Trombay
June 21, 1960	Netherlands	4.724	89.74		Lease	Fuel Pet
June 23, 1960	Venezuela	4.914	19.92		Lease	Fuel Carac
June 23, 1960	Venezuela	(*)	90		Lease	Fiss. Co
June 23, 1960	Venezuela	(*)	90		Lease	Fiss. Co
July 1, 1960	Israel	(*)	89.61		Sale	Research
July 6, 1960	Sweden	2.337	89.66		Lease	Fuel R-2
July 8, 1960	Germany	83.874	2.33		Sale	Kahl
July 8, 1960	Germany	71.153	2.61		Sale	Kahl
July 11, 1960	Canada	0.004	90.0		Lease	U Al S
July 13, 1960	Sweden	2.323	89.69		Lease	Fuel R-2
July 15, 1960	Australia			20 Gm Pu	Sale	Research
July 25, 1960	Belgium			7 Kg Norm U	Sale	Research
July 27, 1960	France	0.046	20		Sale	Research
July 28, 1960	Canada	4.881	6.89		Sale	Research
July 28, 1960	Canada	(0.076)	90		Lease	Return
July 31, 1960	Germany	7.441	19.76		Lease	Argonaut RWE.
Aug. 9, 1960	France			50-Mg AM-241	Sale	Research

See footnotes at end of table.

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MATERIALS SHIPMENTS TO FOREIGN COUNTRIES—Continued

January 1960–November 1960 [1]—Continued

Country	Uranium		Other materials	Type of transaction	Purpose and remarks
	Kg U-235	Percent enrich. U-235			
Japan	3.405	19.89			Fuel JRR-2.
Austria			112 Gm Pu	Sale	Research.
Germany	5.954	89.94		Lease	Munich Reac.
Israel			5 Gm Pu	Sale	Research.
China	(*)	90		Sale	Fission Counter.
Australia			100 Mg NP-237	Sale	Research.
Austria	5.734	89.72		Lease	Res. Reactor.
Austria	(*)	90		Sale	Fission Counters.
France	1.047	20		Sale	Research.
Portugal	(*)	20		Sale	Fission Counter.
France	31.929	1.6		Lease	Fuel EL-3.
France			*Deplu	Sale	Research.
Belgium			42 Mg AM-241	Sale	Fission Counter.
United Kingdom	9.091	90		Sale	Fuel.
United Kingdom	(*)	90		Sale	Fission Counters.
Belgium			50 Mg AM-241	Sale	Research.
France			500 Mg AM-241	Sale	Research.
Germany			2T D_2O	Lease	Exp. Argonaut.
Netherlands			1300 Kg Norm	Lease	Sub Critical Assembly.
Spain	9.238	20		Lease	Fuel Argonaut.
Brazil			2494 Norm	Sale	Sub Critical Assembly.
Brazil			20 Mg NP-237	Sale	Research.
Brazil			1 Mg AM-241	Sale	Research.
Italy			1 Gm U-233	Sale	Research.
United Kingdom	(*)		0.8 Kg Norm. U	Sale	UO_2 Samples Harwell.
Brazil	2.197	19.81		Lease	Belo Horizonte.
Brazil	(*)	20		Lease	Fission Counter. Belo Horizonte.
Norway			0.5 T D_2O	Sale	Halden Reactor.
Italy			200 Mg. Np-237	Sale	Research.
United Kingdom			1.0 Kg Norm. U	Sale	UO_3 Harwell.
Australia			16 Gm Pu	Sale	Research.
Australia	0.002	90		Sale	Fiss. Counter.
Belgium			50 Mg Am-241	Sale	Research.
Norway			12,475 lbs D_2O	Sale	Physics Study.
Japan	15.145	20		Sale	Fuel Element.
Korea	2.500	20		Lease	Fuel Element.
Korea	0.003	90		Lease	Fiss. Counter.
Switzerland			10 Gm Pu	Sale	Research.
Australia			16 Gm Pu	Sale	Research.
Israel			16 Gm Pu	Sale	Research.
France			497 Gm Pu	Sale	Research. (Rapsody).
France			7 Gm U-233	Sale	Research.

... shipment data see p. 282, Twenty-fifth Semiannual Report (July–December 1958), pp. 44–45, ... Semiannual Report (January–June 1958, and pp. 576–578, Annual Report for 1959.
... less than reportable quantity of the reporting unit involved.

APPENDIX 18

Commission Communication on Commercial-Industrial Activities of the Government Providing Products or Services for Governmental Use

February 10, 19…

Chamber of Commerce of the United States
Committee on Commercial Uses of Atomic Energy
Attention: Jack H. Abernathy, Chairman

National Association of Manufacturers
Nuclear Energy Committee
Attention: J. F. Fairman, Chairman

Manufacturing Chemists' Association, Inc.
Attention: R. C. Johnson

Gentlemen:

Your letters which submitted examples of Commission activities which you believe may constitute competition with industry within the meaning of Budget Bulletin 60–2 cover to a great extent the same activities. For this reason, a single reply seems appropriate.

In carrying out its statutory responsibility to encourage widespread use of atomic energy in such a manner as to strengthen free competition in private enterprise, the Commission has maintained a firm policy to procure goods and services from private industry wherever practical. From inception the Commission has turned to private industry to construct for the Government the major facilities required for the production of fissionable materials and for the comprehensive research and development program contemplated by the Atomic Energy Act. Government ownership of such facilities was found to be essential, since no reasonable way could be found to provide adequate incentive for private ownership of such specialized and costly facilities.

Further, as a means of utilizing and expanding the skills of the entire national economy and to take advantage of "knowhow" and proven business experience, the Commission engaged industrial companies and educational institutions to operate and manage these facilities.

The continued use of existing Government facilities is clearly necessary in the public interest for the production of fissionable materials, the assembly of weapons, and the conduct of most advanced research and development. 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. It should be emphasized, however, that the Commission must exercise care in discontinuing a specific activity to assure that related activities which are closely integrated do not unduly suffer in development, cost or efficiency by reason of the divorcement.

this new industry, the tempo of technological developments in many in- does not permit establishing precise specifications or assure a volume of orders necessary to attract the investment of private capital in the facilities, equipment, and personnel required. Consequently, there remain areas of the Commission's work where it is premature to expect such work can be procured from private industry on a competitive basis. more, we have a responsibility to avoid the concentration of services a single source of supply, particularly under circumstances where such tration might constitute a preemption of the market which would dis- widespread participation in the uses of atomic energy.

recognize that as the atomic energy industry grows there will be areas appropriate for transfer from Government to private operation. products and services formerly provided exclusively in Government are now procured commercially, major examples being fabricated shapes, hafnium and zirconium products, uranium hexafluoride, and ments for many non-production reactors. It is Commission policy to con- with private firms for the performance of Title I and Title II engineering of nuclear and non-nuclear portions of the plant unless the nature of the work circumstances clearly dictate otherwise. Also, it is Commission policy, in 1956, that the Commission will cease to provide any service or to the public whenever such service or product can be provided under terms by private industry.

examples presented in your letters are concerned, in large measure, with activities within a production or research and development complex. these activities have been carefully studied over a period of years for of separate contracting. A major reason for contracting with in- concerns was to have our facilities operated in accordance with sound proven business practices. Such business practices include procuring and services from specialized concerns wherever such concerns can satis- furnish the product required and when to do so is sensible, economical, consistent with the efficiency of integrated operations.

example of the practices applied is contained in the following state- policy of one of our major industrial contractors:

determination of the method by which these services will be performed in accordance with normal private industrial criteria, modified to the necessary to comply with existing AEC directives and applicable law.

criteria include, but are not necessarily limited to, the following:

Costs: By what method and by whom can the service be performed at the least possible cost?

Relationship to the Manufacturing Process: How dependent is the process on the service being studied? Would an interruption in the service have a serious detrimental effect on the process?

Availability from Commercial Sources: Is the service available commercially at a competitive price? Is there sufficient productive capacity in commercial sources to assure delivery of needed quantities? Is the geographical location of the source or sources an advantage or disadvantage?

Volume of Work: Is the volume sufficient to make it feasible for contract ing?

DUSTRIAL ACTIVITIES
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February 10, 19

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"5. *Security Requirements:* What effect do the related security requirements, if any, have on the method of performing the service?

"6. *Developmental Aspects:* Is the design of the material or service sufficiently clear so that it is possible to contract without excessive cost?

"7. *Contamination:* Is the material contaminated above limits which can be released to commercial sources?"

As applied to the Commission's operations, such typical business criteria are supplemented as applicable by other Government criteria such as those contained in the recent Budget Bulletin 60–2. Such supplementation provides, for example, that the elements of cost as provided for in Budget Bulletin 60-2 be considered in making comparisons between the cost of providing services in the Government-owned plant and the cost of procurement from commercial sources. Furthermore, our contractors are specifically advised of activities where it is Commission policy to subcontract to private industry. It is our practice to make surveys and appraisals of operations at Government-owned installations to review the continued application of these criteria. By effective application of such criteria, evidenced by thousands of contract actions annually for research, engineering, construction, equipment, and supplies, a wide range of enterprise in the atomic energy industry is being developed.

For each of the activities cited as examples in your letters, we have prepared comments which are attached. Many of the examples are in areas of future activities in which we look forward to either initial or increasingly greater industrial participation on a commercial basis, while others generally fall into the following categories:

1. Activities where industry is already engaged in the normal conduct of their work.
2. Activities which are closely integrated with plant operation and in accordance with accepted industry practice should remain integrated.
3. Activities which are in such a fundamental stage of development that the coordinated use of the skill and facilities at Government-owned installations is still required.
4. Activities where large volume is dependent upon military requirements and where extremely large plant investments have already been made by the Government, or where the volume of activity is so small, sporadic, and non-standardized as to make it impractical or uneconomical to contract for separately.
5. Activities for which there is no known competitive commercial capacity.

We trust that this letter and our attached comments on the examples you have cited will provide a better understanding of the Commission's policy and practice regarding the utilization of private enterprise in fulfilling its responsibilities under the Atomic Energy Act. We will continue to examine commercial industrial activities of the Commission in the light of the growing capability in the private atomic energy industry. For this purpose we will welcome at any time expressions from industry of their capability to provide additional services and products through ordinary business channels.

Attachment:
(As stated)

Sincerely yours,
JOHN F. FLOBERG
Acting Chairman

5007062

ATTACHMENT TO THE COMMISSION'S REPLY TO THE CHAMBER OF COMMERCE OF THE UNITED STATES (C OF C), THE MANUFACTURING CHEMISTS' ASSOCIATION (MCA), AND THE NATIONAL ASSOCIATION OF MANUFACTURERS (NAM)

Comments on AEC activities cited as examples of competition with industry within the scope of Bureau of the Budget Bulletin No. 60–2

FUEL ELEMENT DEVELOPMENT AND FABRICATION

A vital part of any reactor is the fuel element with which it operates; the success or failure of a particular reactor experiment, prototype, or power reactor depends strongly upon whether a suitable fuel is available. Just what constitutes a suitable fuel depends upon the purpose of the experiment. Thus, for a zero power reactor the composition, weight, dimensions, and uniformity of the fuel are of controlling importance; resistance to irradiation damage is of little interest. On the other hand, fuel for a high temperature, high power reactor must have a high degree of irradiation stability. Thus, the fuel must be tailored to fit the experiment. The fuel itself is experimental in nature. In the continuing effort to improve the fuel, successive loadings of the same experimental reactor are usually different, each type of loading being used only once. The Commission carries on an extensive program in the development of suitable fuel elements; this work included the development of fuel and cladding materials, the determination of their physical, mechanical and thermal properties, and their behavior under irradiation and thermal cycling, and development of methods of melting, casting, fabrication and testing.

The program is so broad that it involves not only most of the Commission's laboratories and operating contractors but also a very large portion of the program is being conducted by commercial firms. In an action announced ... 13, 1959, contracts with contemplated expenditures totaling over $25 million were awarded to 18 firms.

Outside of purely experimental tasks which must be closely coordinated with other development work, it is the Commission's general policy to obtain fuel element manufacturing services, other than for the production reactors at Hanford and Savannah River, from commercial sources. Our general policy is to procure reactor materials from commercial suppliers whenever adequate facilities, skills and experience exist in commercial laboratories and the time schedules can be met. In addition, whenever it is feasible, we are now procuring end-items containing nuclear materials rather than separately procuring materials and fabrication. The ability of industry to produce according to requirements has increased very appreciably in the last 5 years or so and more and more of the requirements are being met from industrial sources.

To illustrate the extent to which procurement from commercial sources has increased, there follows a tabulation of the enriched uranium which has been furnished to all sources outside the weapon's production chain, showing the portion furnished in the form of UF_6 compared to that furnished in a form requiring additional processing in AEC facilities:

Fiscal year	Total (kg)	Furnished in form other than UF_6		Furnished as UF_6	
		kg	Percent of total	kg	Percent of total
1958	45,000	21,000	47	24,000	[illegible]
1959	116,500	6,500	6	110,000	[illegible]
1960 (5 months through Nov. 30, 1959)	42,500	1,500	4	41,000	[illegible]

Comments on specific cases mentioned in the letters follow:

Experimental Gas Cooled Reactor

CofC VI—1—"Enriched uranium and/or pellets for the Gas Cooled Reactor Project at the Oak Ridge National Laboratory."

MCA–5—"Enriched uranium oxide and/or pellets for the Gas Cooled Reactor Project at O.R.N.L."

NAM–A1b—"Supply of enriched uranium oxide, pellets, or metal for Gas Cooled Reactor Project; . . ."

Oak Ridge National Laboratory (ORNL) is currently preparing the design and specifications for the fuel element and materials so that the core loading can be procured from industrial sources following normal procurement practices. In the development of this element, ORNL has attempted to procure from industrial sources enriched UO_2 and/or UO_2 pellets which meet its specifications. Experience to date has been disappointing in that ORNL has been unable to obtain the necessary quantities of acceptable materials. The yields have been disappointingly low, the schedules have had to be changed at the convenience of suppliers, and in all cases ORNL has obtained the pellets it required only by relaxing the specification.

Process Heat Reactor

CofC I–2—"The conversion and fabrication of fuel elements for the Process Heat Reactor project to be built at Point Lomas, San Diego, California."

MCA–4—"Conversion and fabrication of fuel elements for the Process Heat Reactor project to be built at Point Lomas, San Diego, California."

NAM–A1a—"Conversion from UF_6 . . . for Process Heat Reactor to be built at Point Lomas, California."

The invitation to reactor manufacturers to supply the reactor and certain primary system components included all of the internals and the reactor core with 14 percent spares. This invitation was issued in October 1959, and a number of proposals from manufacturers had been received and were being evaluated when the letters to which this reply is addressed were received. All of the fixed price proposals received contemplate commercial supply of these fuel elements by the selected proposer. The Commission is supplying UF_6; all other services will be obtained commercially.

Bulk Shielding Reactor and Low Intensity Test Reactor

CofC I–1—"The Oak Ridge National Laboratory makes the fuel elements for most of its reactors. Examples include the bulk shielding reactor and the LITR."

Private sources of supply for procurement of replacement fuel elements for LITR and BSR are not used for the following reasons: The demand for [illegible] elements, based on data accumulated during the past 5 years, indicates the following average yearly requirements: LITR, 15 elements; BSR, 5 elements. The number of replacement elements is low because of the low power at which these reactors operate. (The BSR operates from zero to 100 kilowatts and the LITR at 3 megawatts). Since the BSR and LITR are used to test experimental assemblies, about 25 percent of the replacement fuel elements are not standard. Dies and fixtures are available for these specific elements so that the small number required can be produced by laboratory staff as "fill-in" [illegible].

Materials Testing Reactor and Engineering Test Reactor

[illegible]-7—"Supply of enriched uranium for ETR and MTR fuel elements."

[illegible]-41b—"Supply of enriched uranium . . . metal for . . . ETR and MTR at [illegible], Idaho. . . ."

The original MTR fuel elements were fabricated at Oak Ridge prior to availability of commercial sources. The first MTR replacement also was the first core for an AEC reactor to be obtained from a commercial fabricator. Since then all cores have been fabricated commercially:

MTR

Replacement quantity 1*, Babcock and Wilcox.
Replacement quantity 2*, Clevite.
Replacement quantity 3*, General Electric.

ETR

Original quantity, Babcock and Wilcox.
Replacement quantity 1*, General Electric.

[illegible] the Government furnished metal in each of these cases, the statistics previously cited indicate the effectiveness of AEC'S efforts to obtain the processing services from commercial sources. In the most recent case (MTR replacement No. 3) the invitation requested proposals on both bases (i.e., use of commercially procured metal or use of Government-furnished metal). The decision to use Government metal was based on the price differential analyzed in accordance with BOB Circular 57-7 (the predecessor to BOB Circular 60-2).

Nuclear Rocket Program—Project Rover

[illegible]-4—"The conversion and fabrication of the fuel elements for the nuclear-rocket program (Project Rover)."

[illegible]-4—"Conversion and fabrication of fuel elements for the AEC's nuclear rocket program at Livermore."

[illegible]-41a—"Conversion from UF_6 and fabrication of fuel elements for AEC nuclear rocket program at Livermore; . . ."

Responsibility for all research and development for the nuclear propulsion of rockets (Project Rover) is assigned to the Los Alamos Scientific Laboratory. The uranium metal for Rover fuel elements is drawn from the inventory maintained at Los Alamos for the weapons program, and fuel element fabrication is performed in the same facility in which development of uranium fabrication techniques is carried on for the weapons program. The material for Rover is a relatively small proportion of the amount fabricated in that facility.

* [illegible]r's supply.

At present, every Rover reactor is different. Fuel elements requirements and technology are still in development, and cannot yet be described by definite and inclusive specifications. In view of the frequent and last-minute changes in design details and characteristics to be sought, fuel element fabrication for the current, research-type Rover systems must continue as an activity performed directly by the Los Alamos Scientific Laboratory.

At later stages when there are repetitive tests of a single design, the degree of standardization may permit commercial procurement of both the conversion and fabrication of uranium for Rover fuel elements.

Naval Reactors

CofC III-1—"Conversion of enriched . . . uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys or uranium compounds."

MCA-1—"Conversion of all enriched uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys or uranium compounds."

NAM-A1b—"Supply of . . . all uranium alloys or compounds for the 'Nuclear Navy'."

Practically all of the highly enriched uranium utilized in these cores is obtained from scrap metal in the form of trimmings left from material utilized in the weapons program. These trimmings are chopped into small pieces and shipped to the core manufacturer who performs all further processing and fabrication operations involved in the manufacture of the fuel elements.

There are now five private companies supplying reactor cores for the Naval Reactors program on a fixed price, competitive basis.

Through calendar year 1959, contracts totalling approximately $200,000,000 have been awarded to private industry for fuel fabrication.

These companies now manufacture all reactor cores for the Naval Reactors program with the exception of some first reactor cores of a type which are of a highly developmental nature. However, many of the parts, even for these first developmental cores, are manufactured by private industry rather than in the Commission's Bettis and Knolls Atomic Power Laboratories. In this connection, it is also significant that a substantial portion of these parts for developmental cores which are subcontracted to private industry are in themselves of a developmental nature. This type of subcontracting from the Bettis and Knolls Atomic Power Laboratories to private industry has been increasing, commensurate with industry's capability to handle such work. Thus, the fuel fabrication work that remains in these Laboratories is only that which is of a highly developmental nature and pertains specifically to the first core of a new design being developed at the Laboratory.

Subcritical Training Reactors

MCA-12—"Conversion and fabrication of uranium elements required for subcritical training reactors for educational institutions."

NAM-A1a—"Conversion from UF_6 and fabrication of fuel elements . . . for subcritical training reactors. . ."

Educational institutions, as of January 1960, possess or are planning to acquire 2 enriched uranium and 84 natural uranium subcritical training reactors. The fuel is furnished by the AEC without charge to the institutions. The enriched fuel is fabricated commercially and the natural uranium fuel is furnished by the AEC from its supply of reject slugs at Savannah River. It is anticipated that

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the next several years
new subcriticals per year.
Since these are vital to
government must rely fo
able to provide the facili
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stations is a suitable and
training program.

Nuclear Ramjet Project

CofC VI-2—"Enriched u
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for this job on the basis o
unique and stringent chem
source other than the
expected to perform this
acceptable cost. It is an
TP, and the fabrication i
ading that commercial ca
cost and upon the required

Piqua and Hallam Reactor

MCA-13—"Production of
reactors."

Present plans for both
and conversion will be don
Atomics International, the
In both cases arrangement

Heavy Water Components T

MCA 11—"Production of u
built at Savannah River."
CofC I.4—"Savannah Rive
includes the conversion a
heavy water test reactor
NAM-A1a—"Conversion fr
water components test re
The driver and fuel ele
at the Savannah River pl
facilities, Nuclear Metals,
The contract for this work
facturing concerns which
ing tubular metallic f
small number required res
was indicated, however
required, industry woul
HWCTR fuel elements
development work

...the next several years educational institutions will require approximately 25 ...subcriticals per year.

Since these are vital to the educational programs on which both industry and ...rnment must rely for new trainees for this expanding industry, it is desir... to provide the facilities so that the greatest number of training programs ...benefit. Use of material which does not meet the production reactor speci...tions is a suitable and economical means of increasing the effectiveness of the ...ining program.

...lear Ramjet Project

...VI-2—"Enriched uranium for the Nuclear Ramjet Project."

...the original order for fuel for the Tory II A, the conversion from UF_6 to ...was performed by the Commission's Oak Ridge Y–12 plant. Y–12 was used ...this job on the basis of a technical evaluation of capability. Because of the ...and stringent chemical specifications for the U_3O_8 it was determined that ...source other than the highly experienced Y–12 plant could be reasonably ...cted to perform this conversion job on the required schedule and at an ...ptable cost. It is anticipated that future requirements for conversion of ..., and the fabrication into fuel materials will be obtained commercially, pro...ing that commercial capability exists to provide these services at reasonable ...and upon the required schedules.

... and Hallam Reactors

...A-13—"Production of enriched uranium metal for the Piqua and Hallam ...actors."

...resent plans for both the Piqua and Hallam reactor projects are that the ...conversion will be done commercially. Fabrication in both cases will be by ...ics International, the AEC prime contractor for construction of the reactor. ...th cases arrangements have not yet been completed.

...y Water Components Test Reactor

...11—"Production of uranium for heavy water component test reactor being ...t at Savannah River."

...14—"Savannah River is also doing fuel element development work. This ...des the conversion and fabrication of fuel elements for the fuel element ...y water test reactor being built at Savannah River."

...41a—"Conversion from the UF_6 and fabrication of fuel elements for heavy ...er components test reactor at Savannah River."

...e driver and fuel elements for the HWCTR are not being manufactured ...e Savannah River plant. This work is being carried out in commercial ...ies, Nuclear Metals, Inc., Concord, Mass., under a du Pont subcontract. ...ntract for this work was awarded after a survey of 6 fuel element man...ring concerns which appeared to have the experience and facilities for ...g tubular metallic fuel elements. In the case of the driver tubes, the ...number required resulted in little interest by industry in this operation. ...s indicated, however, that should significantly larger numbers of tubes ...uired, industry would be interested in submitting bids. In the case of ...HWCTR fuel elements, these are still in the development stage. Consid... development work and testing are required before establishing a firm design for this element. Nuclear Metals has been engaged to do much of the development work and to supply the necessary test elements during the devel-opment period.

Savannah River and Hanford Production Reactors

CofC I-4—"The Savannah River site makes some fuel elements for its reactors. Savannah River is also doing fuel element development work."

CofC I-5—"Fuel elements for the Hanford site are fabricated in Government facilities."

The manufacture of fuel elements for production reactors has been accomp-lished in Government-owned facilities operated by industrial contractors since the intiation of production activities during World War II. As the AEC pro-gram expanded, additional capability was provided to meet the increased re-quirements. The current operating facilities at Fernald and Weldon Spring represent a Government investment of about $165 million. These facilities are operated by industrial companies under cost type contracts.

There is no privately owned industrial facility in being which can meet the requirements of the production program. It is not considered feasible to contract for production reactor fuel element fabrication in privately owned facilities at fixed prices, chiefly because of the frequent and substantial changes which are required in fuel element types, specifications, and quantities resulting from new conditions in the production reactors. The operation of fuel fab-rication plants must be closely integrated with production reactor operations and thereby with weapons production schedules. In order to accommodate new operating requirements without delay any fixed price arrangement with a private supplier would necessarily involve price renegotiation to offset changes in costs as requirements change. Such an arrangement would approach closely a cost type contract similar to those which now exist between the companies operating AEC's fuel fabrication facilities and the AEC.

Because the level of production is directly related to weapons requirements and reactor performance both of which are subject to substantial change on short notice, because it is difficult to set firm specifications, because civilian re-quirements are so low that this capacity could not be fully utilized for peace-ful purposes for many years, and because of the large investment already made in AEC plants, the establishment of duplicate fabrication facilities in industry would not be in the best interests of either the Government or industry.

New Production Reactor

CofC VI-3—"Enriched uranium metal and/or fabrication for the new Hanford Production Reactor."

MCA-8—"Enriched uranium metal and fabrication of fuel for the NPR at Hanford."

NAM-A1b—"Supply of enriched uranium . . . metal for . . . NPR at Han-ford . . ."

The new Hanford production reactor, which is being built on an accelerated time schedule, will use metallic uranium fuel elements under temperature con-ditions similar to those which are found in current power reactors. This op-erating condition, representing a substantial departure from other AEC pro-duction reactors, requires that an extensive fuel element process development

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equipment required to
fuel elements, the inc
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facilities. Their repo
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II. REACTOR DESIGN AN

General

NAM-C1d—"Design, c
and reactor experim

Research, developme
reactor development
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type reactor itself.

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the desired techni
of a particular reactor
prototype plants under
it is highly desirable
systems to secure info
nance and operation.
its own sites only if
acceptable. All power re
a utility or Commi
by private companies
after conceptual desig
such specific paramete
which the reactor is int
With respect to exp
for the most part de
of the design which is
being furnished by ar
by assigning to the la
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program and as such.

program be conducted to develop specifications and fabrication and testing techniques. This work is being performed concurrently with the design and construction of the reactor. To avoid delay in startup of the new reactor, installation of the fabrication facilities must also proceed concurrently with the construction of the reactor, even though firm specifications are not available. Since even process specifications are not firm and would not be subject to change as operating experience is gained, contracting with industry for these fuel elements at this time could only result in the AEC's entering into a cost type contract for the operation, similar to those now in effect between AEC and the contractors operating plants. Since the AEC already has in existence or will install for the development program much of the equipment required to process the uranium and fabricate the proposed type of fuel elements, the incremental AEC investment required will not be major. However, since industry has indicated possible interest and capability for performing these operations, arrangements have been made for an industrial group to review the question of production of NPR fuel elements in private facilities. Their report has now been received but the Commission has not had an opportunity to evaluate its recommendations.

Reactor Design and Development

General

III-C1d—"Design, construction and testing of reactors, reactor prototypes, and reactor experiments for which industrial capacity and capital exists."

Research, development, and experimentation in the general field of advanced reactor development by AEC laboratories is a prime responsibility of such installations. The Chamber of Commerce itself recognizes this role of the AEC in section VIII of its letter. The design of an advanced reactor cannot in reality be divorced from the development effort leading up to the actual prototype reactor itself.

To the maximum extent consistent with the paramount objective of obtaining the desired technical data for which it is necessary to build a prototype of a particular reactor type, it is the intention of the Commission to construct prototype plants under cooperative arrangements with utilities, public or private. It is highly desirable to have power reactor prototypes integrated into power systems to secure information on compatibility and performance and on maintenance and operation. The Commission plans to construct such facilities on its own sites only if responses to invitations are not received or are not acceptable. All power reactor prototypes constructed by the Commission, whether on a utility or Commission site, are designed and constructed under contract with private companies with the Commission generally specifying only the reactor conceptual design, approximate power size, and general objectives, plus such specific parameters as are necessary to assure obtaining the information which the reactor is intended to provide.

With respect to experimental reactors and reactor experiments, these are for the most part designed by Commission laboratories, with that portion of the design which is not a direct outgrowth of the experimental program furnished by architect-engineers. Among the more important reasons for assigning to the laboratories the primary responsibility for such projects are (1) they are generally merely an extension of a planned laboratory program and as such, are of more benefit when designed, operated, and altered, as needed to accomplish the project objective, by the laboratory personnel; (2) due to the experimental nature of the project, specifications are developed as the work proceeds and a complete set of specifications is not available for the solicitation of bids from industry; (3) in many cases, the experiments are merely modifications of previous experiments; and (4) ancillary equipment already existing at Commission sites can be used which reduces the cost of the project and the time and effort required for setting up the experiment.

Detailed comments are given below and, in general, these comments are applicable to the general design, construction, and testing of AEC reactors. Current policy is that conceptual design will be made by the best qualified organization. However, Title I and Title II type work is normally contracted for with engineering firms.

Oak Ridge Research Reactor

CofC II-3—"Oak Ridge National Laboratory's Title 1 and Title 2 design of ORR."

The Oak Ridge National Laboratory had responsibility for the design of the ORR. However, Titles I and II design services required for this facility were by no means accomplished exclusively by members of the ORNL engineering staff. A private organization—the McPherson Company of Greenville, S.C.—performed a significant amount of the Title II design work. The McPherson Company participation in the design of the ORR included the design and preparation of working drawings and specifications for the complete reactor building, building services, utilities, reactor shield, reactor pool, and reactor cooling system. Oak Ridge National Laboratory, as the Commission's operating contractor, had direct responsibility for initiating and developing the over-all concept for the facility, for the preparation of design criteria for all phases of the project, and for the definitive design of the reactor proper including instrumentation and controls.

The latest figures on total cost of the ORR show that less than 6 percent was expended by Oak Ridge National Laboratory engineering forces on design which could be considered as Title I or Title II engineering. Approximately one-third of the 6 percent was expended in preliminary work required to develop design criteria and specifications necessary for the design work to proceed. The remaining 4 percent was expended in coordination of the work with the architect-engineer and in design of the reactor proper and the reactor control system.

High Flux Isotope Reactor

CofC II-1—"Oak Ridge National Laboratory's design of a high-flux isotope producing reactor."

It is anticipated that all Title I and Title II design of all portions of the job will be performed by an architect-engineer except for the design of the [illegible] and control systems. The control system components will be purchased from industry. Those portions of the job to be designed by an architect-engineer are a major fraction of the project.

The performance of this reactor will exceed by a large factor the performance of any existing reactor and is higher by a factor of nearly 2 than any other proposed high-flux reactor. It represents a sizeable extrapolation of

existing technology.
necessary to advanc
purpose of our nati

Beam Research Reactor

CofC II-2—"Brookhave
research reactor."

The high-flux beam
that require external
energies. The concept
reactor was largely an
the experimentors, the
array as determined b
of cost, safety, and gen
haven was assisted by
interest concerning all
management of constru
companies. Nine propo
negotiating with one of

Sandia Test Reactor

CofC II-5—"Sandia and

As of December 31,
expected to go critical in
All design aspects of
the reactor and associa
outside concerns. The
based almost entirely
existence and involved
effort for the reactor an
$5,000 in outside desig
need Sandia and Los
Alamos effort in this a
personnel sufficiently knowl
to do its job and to pr

Process Heat Reactor

CofC II-7—"Argonne N
heat reactor."

The ANL made an e
given to see if any suc
The AEC also requested
design for the selected
development program fo
Heat Reactor was not p

Natural Circulation Rea

CofC II-8—"Knolls Atom
Reactor for the Navy."

existing technology. In order to accomplish the research aims of the reactor it is necessary to advance the limits of current technology. We believe it to be the purpose of our national laboratories to perform this type of development.

Beam Research Reactor

AEC II-2—"Brookhaven National Laboratory's preliminary design of the beam research reactor."

The high-flux beam reactor will be used principally for research projects that require external beams of neutrons at both thermal and epithermal energies. The conceptual design study of a new and advanced research reactor was largely an effort to develop the best compromise of the needs of the experimentors, the actual performance of a chosen fuel and moderator as determined by critical experiments, and engineering considerations of cost, safety, and general feasibility. Even on this conceptual study Brookhaven was assisted by an industrial company, and in July 1959, statements of interest concerning all phases of the design, equipment procurement, and management of construction of the reactor were solicited from 12 industrial companies. Nine proposals were subsequently received and we are currently negotiating with one of the companies for this work.

Sandia Test Reactor

AEC II-5—"Sandia and Los Alamos design work for the Sandia Test Reactor."

As of December 31, 1959, this facility was 31 percent complete and is expected to go critical in late 1960.

All design aspects of the building and practically all design aspects of the reactor and associated equipment were handled through contracts with outside concerns. The designs of the reactor and associated equipment were based almost entirely on other components and fuel elements already in existence and involved only minor design modifications. The total design cost for the reactor and associated equipment was covered by approximately $... in outside design contracts plus approximately 4 man-years of combined Sandia and Los Alamos time over a 3-year period. The Sandia-Los Alamos effort in this area was the minimum necessary to keep Sandia personnel sufficiently knowledgeable to insure that it would get what it needed to do its job and to provide a background for the operation of the reactor.

Process Heat Reactor

AEC II-7—"Argonne National Laboratory's Title I design of the process heat reactor."

The ANL made an evaluation study of those reactor concepts which are known to see if any such concept is particularly suitable for this application. The AEC also requested the Laboratory to provide a report on the conceptual design for the selected reactor concept and an outline for the research and development program for such a reactor. The Title I design of the Process Heat Reactor was not performed by Argonne but by Sargent and Lundy.

Natural Circulation Reactor

AEC II-8—"Knolls Atomic Power Laboratory's work on a Natural Circulation Reactor for the Navy."

The development of a reactor plant for naval operation is quite different in many respects from the development of a stationary reactor plant. The compactness of the reactor system, the high power density, the shock and vibration requirements, the maneuvering capabilities, and the operation of the plant under varying conditions of inclination give rise to problems not encountered in a land plant. The natural circulation reactor plant is a new concept for naval application and its successful and timely completion as well as its further advancement requires full exploitation of pertinent naval reactor technology. The Commission laboratories which have specialized in naval research and development work for about 10 years are, to our knowledge, the only organizations having the necessary technical talent, experience, and special facilities for undertaking this project in the most expeditious manner.

Army Low Power Reactor

CofC–II–11—"Argonne National Laboratory's development of the Army Low Power Reactor."

NAM–C1e—"The first reactor in the Army Low Power Reactor program was fabricated by an industrial concern at its own facilities, but the second will be fabricated in a Government-owned facility."

We assume that the SM–1 plant at Ft. Belvoir is the "first reactor" and the SL–1 (formerly ALPR) at the National Reactor Test-Station is the "second."

In the light of a known interest of the Department of Defense in a nuclear power plant of approximately 1/10 the capacity of the SM–1 at Ft. Belvoir, six separate reactor concepts were investigated to determine which could best meet the requirements of the Department of Defense. These studies were made between January and June 1955. Of the various systems investigated, the boiling water system study by the Argonne National Laboratory appeared to be most suitable for this purpose.

Inasmuch as there was no industrial experience with power reactor systems developed at that time, Argonne was requested to undertake development and construction of the prototype 200–300 KWe plant which the Department of Defense requested in September 1955. In the course of constructing this plant, Argonne used subcontracts with many industrial firms. An industrial firm was awarded a contract to fabricate the fuel elements but defaulted because it was unable to fabricate elements meeting the prescribed standards. In order that the project completion date would not be jeopardized, the fabrication of the core was undertaken by Argonne Laboratory. Since completion the plant has been operated by Combustion Engineering.

III. Thorium

CofC VI–8—"Supplying A.E.C.'s needs for thorium alloy, thorium oxide, thorium carbide. . . ."

MCA–14—"Supply of thorium oxide for the homogeneous development program at ORNL."

MCA–15—"Supply of thorium metal for special projects at Los Alamos, Sandia and Lawrence Radiation Laboratory at Livermore."

NAM–C1a—"Supply of thorium oxide for homogeneous reactor development at ORNL."

NAM–C1b—"Supply of thorium metal for special projects at Los Alamos, Sandia, Lawrence Radiation Laboratory at Livermore."

The AEC presently has no production capacity either operating or available for the processing of thorium to metal. A small pilot plant for preparation of special types of thorium oxide powders is in operation at ORNL. Several years ago a thorium metal pilot plant was built at Fernald site and operated for a short period. Since the anticipated requirements for thorium which were the basis for the Fernald pilot plant effort did not materialize, the facility was shut down in 1955 and has been dismantled. During its period of operation, this plant produced a small inventory of thorium metal and compounds from which the small needs which have developed since 1955 have been supplied. It is intended that future requirements of comparable size would continue to be supplied from this inventory as long as available. The ORNL pilot plant, on the other hand, is preparing thorium oxide powders in an effort to produce oxide having desirable slurry properties for use in the homogeneous reactor program. Oak Ridge has also procured sample quantities of oxide from industry for testing. Development work on preparation of acceptable powders supported by AEC funds has been carried out by ORNL and several private companies. The development program at ORNL is still under way. At such time as oxide has been developed having the desired slurry properties for which specification can be set, we would seek to obtain thorium oxide for use in homogeneous reactors from commercial sources.

Current thorium operations are limited to development efforts on the utilization of this element in AEC programs. There are some indications that there may be a continuing requirement for modest quantities of thorium metal which would exceed the current inventory. Should such develop, AEC will obtain the metal by procurement from commercial sources.

DESIGN OF FACILITIES AND EQUIPMENT

Hot Cells at Argonne National Laboratory

Item II-4—"Argonne National Laboratory's Title 1 and Title 2 design of hot cells for its new research laboratory."

It is assumed that reference is made to the hot cell area in Wing F of the Technology Center, now under construction. The Title I and Title II designs of the building were carried out completely by a private architect-engineer (Singmaster and Breyer) on the basis of preliminary designs prepared by Argonne. The design of the manipulator, windows, and internal cave hardware is being carried out by Argonne because of the experimental nature of the design concept. In this particular case the cave equipment is being designed so that the operations can be carried out for extended periods of time without the need for access by personnel. The design concept represents a complete departure from present operating techniques and requires a large advancement in all aspects of remote handling equipment. This new research laboratory facility must be gastight to contain an inert atmosphere. No existing type of master slave manipulator is designed to operate under these conditions. Although the need for this new approach to remote handling has been discussed in many forums, no commercial company is working on this problem to the best of our knowledge.

It was also felt that the design of these features should be carried out by scientists and engineers who have already used such facilities and are acquainted with their problems in the design of remote handling and viewing systems.

Nuclear Ramjet Engines

CofC II–6—"The Government's University of California Radiation Laboratory, design, test and fabrication of nuclear ramjet engines."

The function of this program is to determine the feasibility of and construct a nuclear reactor as a ramjet engine and does not include design, test, and fabrication of nuclear ramjet engines on a production basis. The Laboratory is subcontracting as much of this project as is feasible, considering the technical requirements and schedules involved. Subcontracts with industry currently amount to about 45 percent of the laboratory's budget for the project.

Thermionic Cells

CofC II–9—"Los Alamos' experimental work on thermionic cells to convert fission energy directly to electricity."

This item refers to the "plasma thermocouple", a present research project at the Los Alamos Scientific Laboratory. As far as we are aware, the basic idea originated at LASL where technology in the exotic materials involved, (uranium and zirconium carbide), scientific competence, and adequate laboratory facilities required are available.

This field of research is unclassified and completely open to industry. The AEC welcomes parallel research by industry and the publication of the results of such research. LASL has published numerous documents in this area and has briefed many industrial organizations upon their work. We encourage our laboratories to undertake frontier research of this nature.

V. Depleted Uranium

CofC III–1—"Conversion of depleted uranium from UF_6 as required in the 'Nuclear Navy' for metal, alloys or uranium compounds."

CofC III–2—"Depleted uranium metal for an AEC shielding cask project at Schenectady."

MCA–2—"Depleted uranium for all activities at the national laboratories with specific attention directed to the conversion of depleted uranium from UF_6 and the fabrication of blanket fuel elements for the Zero Power Reactor at Argonne National Laboratory."

MCA–3—"Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field representing approximately 40 tons of cylindrical casting."

MCA–9—"Depleted uranium metal for AEC shielding cask at General Electric, Schenectady."

NAM–A2a—"Supply of blanket fuel elements for Zero Power Reactor at Argonne National Laboratory."

NAM–A2b—"Conversion from UF_6 of depleted uranium required for shielding cask at Bettis Field."

NAM–A2c—"Supply of depleted metal for shielding cask project at Schenectady."

Depleted uranium metal is used to a very limited extent in the Naval Reactors program as a shielding material in certain refueling equipment where compactness is required. Specifically, it has been used in the refueling equipment for the S3G and A1W type reactor plants. The depleted uranium for this equipment was fabricated into the desired shapes at Oak Ridge. The events leading to the decision to do the work at an AEC facility can be summarized as follows: In 1957, representatives from eleven private industrial concerns were invited to a pre-bid conference called to determine whether commercial vendors were tech-generally capable of fabricating the depleted uranium shielding components for the SSG refueling machine developed and being manufactured by the United Shoe Machinery Corporation. Three companies responded. As a result of this conference, the decision was made to perform the fabrication work at Oak Ridge because the capability of the three interested commercial vendors was uncertain, whereas it was evident that Oak Ridge had an established capability to perform this work. All three of the interested vendors lacked experience in casting the required depleted uranium alloy, and it was questionable whether their facilities could handle the size of the castings required. Similarly, starting in 1956, United Shoe Machinery Corporation designed and developed for the Bettis Laboratory a maintenance and refueling machine for use with the A1W type 1 and 2 reactor cores. Depleted uranium for this machine was also procured from Oak Ridge.

It is probable that the questions concerning the ZPR refer to the ZPR–VI and IX blanket for which procurement was initiated in November 1959. (The procurement for ZPR–III was in 1957-58.) Bids were requested for conversion of UF_6 to metal and commercial suppliers have been selected for both conversion and fabrication steps.

In another case, that of the EBR II blanket material, an exception was made to the general policy of using commercially available facilities, based on the apparent price differential that existed.

Irradiation Services

V—"Preference should be accorded private irradiation facilities in place of the current preference for loading Government facilities first. This is the best way of encouraging more private capacity. Underloaded commercial facilities exist whereas it is our impression that the Government owned facilities are heavily loaded. AEC's practice of offering space in the Government owned MTR and ETR should be limited to only those specific cases where private facilities are unavailable."

V-8—"The AEC should announce a policy to utilize privately-owned reactors for materials testing to the extent that industry is able to provide space. This use of private reactors should be in preference to the use of a similar Government-owned facility. The current use of MTR and ETR for Government-sponsored research, which constitutes the great majority of the materials testing business, results in severe competition for the private test reactors."

Negotiations currently are underway to determine the extent to which irradiation services required for Commission programs can be obtained from either Westinghouse or General Electric test reactors. As announced last summer, negotiations are also being conducted with the Babcock and Wilcox Company for the construction of an additional test reactor. Irradiations will be continued in Commission test reactors depending upon the type of irradiation required and the cost of outside service.

Chemical Processing

Uranium Scrap

VI-7—"Chemical processing of cold industrial scrap."

VI-8—"Recovery of cold fabrication scrap, both high and low enriched, from the above projects."

In early 1959, AEC took the initial steps to acquire more scrap recovery services from industry. In March 1959, AEC began to send bid invitations to commercial scrap recovery firms to provide this service. On November 4, 1959, AEC assigned the responsibility for developing the domestic unirradiated uranium scrap industry to New York Operations Office. That Office is acting as a central point for the AEC and its contractors for the placement and administration of contracts for commercial recovery of uranium scrap generated under the reactor development program. From March through November 1959, approximately 11 awards were made aggregating 344 kilograms of uranium with a total of $180,200 for recovery charges.

The New York Operations Office is currently establishing a system whereby the scrap available for commercial recovery will be reported by other offices and invitations for bids will be solicited from private firms. As a result of these steps it is expected that the commercial recovery of cold scrap will grow substantially in the future.

Irradiated Fuel Elements

CofC VII—"It is recognized that the reprocessing of irradiated fuel elements represents an area that is difficult to assess commercially. However, there is no reason to believe that many chemical firms could not handle the job if pricing, regulatory and load problems could be successfully met. While the Government is spending large sums on developing new processes which inhibit industrial investment in known processes it can speed the transition toward a desirable commercial mode of operation by making maximum use of industrial firms in research and development and possibly the construction and operation of reprocessing plants."

NAM-A-3—"In the area of reprocessing of irradiated fuel elements, the Government can and should greatly aid in the transition to a commercial mode of operation by making maximum use of industrial groups in process research and development and in construction of, and operations related to, reprocessing plants. To promote the growth of a healthy industry in this area, Government funds should be used to finance research and development programs in privately-owned facilities in preference to Government-owned facilities."

The Commission has made a continuing effort to bring private industry into the field of chemical reprocessing of irradiated fuel elements. At the present time, a group of five electric utilities and a chemical company are studying the technical and economic feasibility of the design, construction, and operation of a privately owned facility for the processing of spent nuclear fuels. This study will take approximately 6 months, at the end of which time it is expected the industry will have a much clearer view as to the potential in this field. The study has the full support of the AEC. Other groups making similar studies would have the same AEC support.

Since there are a number of approaches to the problems of private operation in this field, and technology must be developed in order to find a satisfactory solution to the general problem, development programs must proceed concurrently with the objective of obtaining economic nuclear power. AEC believes that the absence of adequate technology necessitates the constinuation of its programs.

Although to our knowledge there are no facilities outside of AEC capable of undertaking major development programs on recovery of spent fuel elements, AEC is prepared to receive proposals for research and development to improve fuel recovery technology.

VII. INSTRUMENT DEVELOPMENT AND MANUFACTURING

AEC II-10—"Oak Ridge National Laboratory's Instrument Development Section which in some instances is working on the development of instruments in competition with commercially available equipment."

AEC II-12—"Each of the major Government projects have developed their own, and different: hand and foot monitors, scalers, survey meters and multi-channel radiation analyzers in competition with commercially available equipment."

AEC VI-6—"Instrument production work at Los Alamos, Oak Ridge and the University of California (Berkeley)."

SAM C1g—"Personnel radiation monitors are developed and produced in instrument production sections at Government-owned laboratories. There is an instrument industry capable of furnishing such monitors and it should be used."

SAM C1h—"Government construction of radiation measuring equipment is also in direct competition with the private instrument industry."

It is the express policy of all of the laboratories to procure instruments which are available commercially rather than to fabricate them. A survey of all laboratories and industrial establishments made in 1954 showed that over 80 percent of radiation instruments of all types were procured from private industry. A more recent survey indicates this percentage ranges from 90 percent to 100 percent depending upon the mission of the facility.

It is true that some instrument development work is continuing at major laboratories. Such work is necessary for the following reasons:

a. To modify or create instruments to meet the specific requirements of a research project where the time and engineering effort necessary to prepare specifications, issue bids, instruct outside personnel, inspect for precision, and return for corrections, make outside procurement impractical.

b. To develop designs in instances where commercially available instruments have proven unsatisfactory in performance and private companies have not improved their products on their own initiative but will adopt laboratory-developed designs.

While it may appear that each loboratory develops its own instruments, our survey indicates that such development is undertaken only when necessary to meet a particular condition for which a commercially available instrument is not adaptable. The facts in respect to specific instruments are:

a. *Hand and Foot Monitors.* Obtained commercially. Developed initially by the laboratories. One laboratory has recently developed an improved design for greater reliability.

b. *Scalers.* Such instruments typically must be modified to meet specific needs. The laboratories use commercial sub-assemblies.

c. *Survey meters.* While these meters are purchased from private industry, the laboratories have had to undertake development of more reliable designs in the absence of such development by industry.

d. *Multi-channel analyzers.* To our knowledge, the only development work on these devices is that necessary to achieve devices for special applications. As an example, one laboratory assembled one such device in calendar year 1959 at a cost of $12,000, while in the same year it procured $192,000 worth of such devices commercially.

IX. Production of Radioisotopes

Cobalt 60 for the High Intensity Radiation Development Laboratory

CofC VI-4—"Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

MCA-10—"Supply and/or fabrication of high purity cobalt for the High Intensity Radiation Development Laboratory at the Brookhaven National Laboratory."

NAM Clc—"Supply of high purity cobalt for High Intensity Radiation Development Laboratory, Brookhaven."

The high purity cobalt in the form of nickel plated targets for the Brookhaven radiation development facility was furnished commercially. All such cobalt is and has been supplied by commerical vendors to AEC. The canning of the cobalt for use in a reactor is controlled by the reactor operator to insure the safety and integrity of all material inserted into the reactor. Approximately 500,000 curies of cobalt 60 are needed for the Brookhaven National Laboratory program and are being produced in the Engineering Test Reactor. At the time the radiation was begun no commercial sources of cobalt 60 existed.

Production of Certain Radioisotpes

CofC IV—"The Government is currently producing certain radioactive isotopes in a commercial way (e.g. Cobalt 60, Iodine 131, Carbon 14, Sulfur 35, Phosphorus 32). The demand for these radioactive isotopes is now at a level which makes commercial production feasible and commercial facilities exist which should be utilized."

CofC VI-8—"Supplying A.E.C.'s needs for . . . high purity cobalt and radioisotopes."

AEC's needs for radioisotopes are small in relation to AEC sales to others, representing 14 percent of the dollar sales. Until such time as commercial producers can supply the requirements, AEC production of radioisotopes will be necessary to meet all or part of its own needs. Commercial production of radioisotopes is small at the present time except for cobalt 60.

The Government is producing some, but not all, radioisotopes in a commercial way. In 1955, AEC discontinued the production of cyclotron produced radioisotopes because commercial sources were in a position to produce and market these products at reasonable prices. Also, many of the radioisotopes currently distributed by AEC are produced on a laboratory or semi-works scale because of the small demand, principally for research and developmental uses.

The AEC has never competed with the pharmaceutical industry in the manufacture and distribution of pharmaceuticals containing radioisotopes. The AEC has also turned over to private industry the following related services:

a. synthesis and marketing of C-14 labeled organics.
b. cobalt-60 encapsulation services.
c. cobalt-60 gamma irradiation services.

The foregoing demonstrates the way AEC policy has been carried out when private industry is ready to produce or perform services at reasonable prices.

The statement is made that the demand for certain radioisotopes is now at a level which makes commercial production feasible. The five leading revenue producers are:

	FY 1959 Sales [1] (in thousands)
Cobalt 60	$659
Iodine 131	325
Phosphorus 32	171
Polonium 210	208
Carbon 14	263
Total	1,626

[1] Includes research discounts of about $207,000 granted to users under the AEC radioisotope research support program.

These five radioisotopes represented 65 percent of AEC's dollar sales. All except cobalt 60 require radiochemical processing with attendant high investment in plant facilities. Indications until recently have been that the volume of sales is not sufficient to attract private capital. In fact, the Commission has cooperated with a number of private companies who have made very detailed examinations of AEC isotope production activities and the commercial opportunities for undertaking the total isotope program. These private groups did not find the market to be sufficiently attractive for a commercial venture involving the total program. It has only been within the last few months that the Commission has received concrete evidence of private interest and intention to produce isotopes. We understand that two existing commercial test reactors are irradiating cobalt, and that one commercial company is considering production and distribution of iodine 131 to be produced in another company's irradiation facilities. Power reactor operators have thus far indicated no interest in producing radioisotopes.

The nature and extent of private interest in the production of cobalt 60 is being explored. Industry plans will be taken into consideration in determining the Commission's future plans to meet requirements, particularly for megacurie sources. One of the objectives of AEC is to develop large scale uses for radioisotopes. Success in this objective is dependent on solving technical problems, achieving large-scale availability, and lowering prices. When this objective is reached, the demand for radioisotopes should be at a high enough level to attract private capital and make commercial production of a wider variety of radioisotopes economically feasible.

MISCELLANEOUS SERVICES

Film Badge Processing

II-5—"Servicing of film badges by AEC contractors."

II-f—"Furnishing of film badge service for personnel monitoring. Although a number of industrial firms offer this sevice, competing services are performed at Oak Ridge, Brookhaven, Savannah River, Sandia, etc."

Servicing of film badges at most AEC installations is regarded as an integral part of the operating procedures established to protect the health and safety of employees. The processing and reading of film badges is intimately related to interpretation and other steps in a monitoring system. Wherever radiation levels could reach dangerous levels or where personnel must work in radiation zones, quick detection and rapid estimation of exposure are needed for personnel protection and control of perations; any time delay involved in relying on a commercial contractor to provide these services is unacceptable.

One AEC contractor engaged in the processing of unirradiated source materials is understood to be considering the use of commercial film badge service. Another, responsible for operation of an AEC laboratory, is giving serious consideration to cancelling its commercial contract in favor of a return to its own film badge work because of several years of unsatisfactory experience with inaccuracies and errors on the part of two commercial contractors.

Printing

CofC VI-9—"Printing facilities at Government facilities."

Except for the printing establishment maintained for the production and dissemination of scientific and technical reports by the Technical Information Services Extension at Oak Ridge, AEC printing facilities are an integral part of the administrative support for routine management and operation at each AEC installation. Day-to-day operational needs are characterized by large numbers of short production runs with short lead time.

Provision of printing equipment for an AEC installation requires prior authorization by the Congressional Joint Committee on Printing, which periodically reviews production reports to assure that equipment continues to be needed. Typically, AEC installations procure from commercial sources a large volume of unclassified printing when large production runs are involved and lead time permits.

Transportation

CofC VI-10—"Operation and maintenance of automotive equipment and transportation facilities (bus and rail) at Government installations."

In the provision of automobile service at AEC installations, our contractors operate fleets of Government-owned vehicles of varied types. Where available, vehicles are obtained from Government motor pools. Peak loads are also met by renting equipment. Automobile service at most AEC installations is an integral supporting activity which can be provided most efficiently by the operating contractor rather than an outside commercial source.

At AEC installations which are in relatively isolated or rural locations, servicing and maintenance of motor vehicles are generally performed in AEC shops. There are, however, many locations where reliance on commercial shops and facilities is the practice because it has been found to be practical and more economical.

Bus transportation is provided by our operating contractors at some major AEC installations. Because of the isolation of these facilities, experience demonstrates that commercial bus service cannot be provided on a paying basis and operating conditions make it impractical to contract for such services at reasonable cost.

Intraplant railroad service is performed at several installations by the operating contractor. At Oak Ridge prior to 1956, the plant railroad was operated under contract by one of the major railroad companies. Cost studies prompted the AEC to transfer responsibility for maintenance and operation of the railroad to its operating contractor. Since 1956 the estimated cost has been less than one-third of the minimum amount payable under the earlier contract with the railroad company.

In general, intermittent low-volume operations within our plant sites, often involving special equipment and handling, are best performed as a part of the integrated responsibility of the plant operating contractor.

Power Distribution

Item VI-11—"Power distribution in connection with Government installations."

Electric power distribution systems at AEC installations are operated in accordance with the normal industrial practice under which the consumer owns and operates the distribution system beyond the point of delivery, usually the high side of the initial step-down transformer.

Generally, responsibility for the distribution of electric power within an AEC installation is such an integral part of the over-all responsibility of the operating contractor for carrying out the principal mission of the installation that a separate contract for power distribution services could not be tolerated.

A special situation exists at Los Alamos, where many private residences are served from the distribution system. The feasibility of eventually disposing of that part of the distribution system which serves the town facilities is now being studied.

Communication

Item VI-12—"Communications systems at Government installations."

Telephone, teletype, and radio communication equipment is regularly used by AEC installations. Only recently has it become possible to obtain radio equipment on a lease-maintenance basis from commercial sources, and substantial quantities of radio equipment are being secured under such arrangements.

Substantially all teletype facilities used by the AEC are leased from public utilities such as American Telephone and Telegraph Co., Western Union Co., and Radio Corporation of America. Teletype traffic of AEC is processed over networks and tie lines provided by public utilities as well as over the military and other Government networks.

Nearly all AEC telephone service is provided by public utilities such as the American Telephone and Telegraph Co., Bell Telephone companies, and independent telephone companies.

One notable exception is at Hanford, where during World War II a Government-owned telephone system was built because the local telephone company could not undertake to serve so large a site. Major portions of the Hanford system, serving the business and residential areas, were sold to a public utility. The portions directly and exclusively serving the Hanford plant areas are still owned by AEC and operated by the AEC prime contractor.

Previous analyses have indicated that the present arrangement is more economical than would be the purchase of the service from a telephone company under the rates established for that geographical area. Further studies will be made.

Machine Shop Facilities

Item VI-13—"Machine Shop Facilities at the Argonne National Laboratory."

Machine shop jobs are performed in the Argonne National Laboratory's own machine shops when (1) there is urgency to complete the job, (2) private companies are not able to perform the work, and (3) shop fabrication must be carried on coincident with design, development, and proof testing of the apparatus being built. When these factors are not present, it is the policy of the Laboratory to procure the work from private enterprise.

In recent years steps have been taken to develop commercial sources for shop fabrication having the qualifications and experience to perform the type of work generated by the Laboratory. A large number of qualified companies is now available.

APPENDIX 19

Principal Terms of Uranium Concentrate Purchase Contracts

(As released to the press November 18, 1960 [1])

The Atomic Energy Commission has contracts for the purchase of uranium concentrate (U_3O_8) from 26 domestic processing mills, one of which is under construction. Under one additional contract, the company may, at its option, build its own mill or arrange for treatment of its ore at some existing plant.

The Government buys uranium concentrates from privately owned and operated mills under the terms of individually negotiated contracts. During the period ending March 31, 1962, the price per pound paid for concentrates varies from mill to mill, depending principally upon the size and location of the mill, the grade and character of ore processed and the type of treatment process used. During the pre-1962 period (prior to April 1, 1962) these prices are subject to escalation based on Bureau of Labor Statistics indices.

For concentrates purchased subsequent to March 31, 1962, the price paid by the AEC will be at the established price of \$8.00 per pound of U_3O_8 with a few minor exceptions. These exceptions include final deliveries under contracts terminating March 31, 1962, and some deferred deliveries as a result of stretch-out provisions in some contracts extending beyond that date.

Fifteen uranium concentrate procurement contracts with milling companies have been extended in accordance with the Commission's announcement of November 24, 1958, which provides for the purchase of uranium concentrates (U_3O_8) in the 1962–1966 period.

The remaining 12 contracts provide essentially for purchase of concentrates in the pre-1962 period although in a few instances their terms extend into the post-1962 period. These contracts are being reviewed with the intent to bring them into accord with the November 24, 1958 announcement. These reviews include studies of ore reserves, the establishment of annual quotas, and related matters.

Upon executing additional milling contracts and contract extensions, the AEC will make public a summary of each contract's major provisions.

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[1] Since issuance of this statement the contracts with Kermac Nuclear Fuels Corp., Grants, N. Mex., and Susquehanna Western, Inc., Riverton, Wyo., have been modified in accordance with the November 24, 1958, announcement. Following is a summary of the approximate quantities and prices involved in the current contracts:

Kermac Nuclear Fuels Corp. The amended contract, effective as of November 1, 1960, provides for the purchase through December 31, 1966, of approximately 31,027,000 pounds of U_3O_8 in concentrate having a total value of \$237,000,000 at an average price of [illegible] per pound.

The price will average \$7.18 per pound for approximately 13,877,000 pounds which it is estimated will be produced by June 1, 1963. The remaining 17,150,000 pounds will be deliverable at \$8.00 per pound. Variation from the \$8.00 price early in the post-1962 period is due chiefly to stretch-out or deferral of pre-1962 production into the post-1962 period.

Susquehanna Western, Inc. The extended contract, effective as of June 1, 1960, provides for the purchase through December 31, 1966, of 5,775,000 pounds of U_3O_8 valued at approximately \$47,000,000.

Under the terms of the new contract, approximately 1,503,000 pounds of U_3O_8 are to be delivered between June 1, 1960, and April 1, 1962, at a unit price of \$8.635 per pound, and 4,272,000 pounds are deliverable after that date at \$8.00 per pound.

The 15 contracts completed in accordance with the November 24, 1958 announcement have several provisions in common applicable to the post-1962 period (April 1, 1962 through December 31, 1966). The ores to be treated will come only from properties designated in the contracts, including both company-owned and independent ores. The contracts give the Commission the option of taking at any time specified quantities of U_3O_8 produced by independent mine operators from eligible properties. Subject to suitable license arrangements, there are no restrictions on commercial sales by the milling companies above the amount to be sold to the Commission.

Beginning with July 1, 1960, the aggregate quantity of U_3O_8 in concentrates which has been contracted for under all outstanding contracts is approximately [illegible]74,000 pounds of U_3O_8, of which 74,307,000 pounds are scheduled for delivery in the pre-1962 period and 116,367,000 pounds in the post-1962 period. Estimated cost to the Government is $1,552,800,000 of which $621,300,000 will fall in the pre-1962 period and $931,500,000 in the post-1962 period. The foregoing figures do not include additional purchases which will result from contract extensions yet to be negotiated.

The following is a summary of the approximate quantities and prices involved in outstanding contracts. The quantities indicated and total costs may be affected by failure of mining properties to produce the requisite amount of ore to fulfill the contract.

Contracts Extended in Accordance With November 24, 1958 Announcement

[illegible]conda Co., operates a 3,000 ton-a-day processing mill in the Grants, N. [illegible] area. The current contract extends through December 31, 1966. There remained approximately 5,250,000 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.79 per pound. Post-1962 quantity contracted for is 10,708,500 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $[illegible]0,000.

[illegible] Uranium Co., operates a 330 ton-a-day processing mill at Grand Junction, Colo. This contract was effective August 1, 1960 and extends through December 31, 1966. There remained approximately 1,036,700 pounds of U_3O_8 to be delivered between August 1, 1960 and April 1, 1962, at a unit price of $8.00 per pound. Post-1962 quantity contracted for is 1,560,800 pounds of U_3O_8 at a unit price of $8.00 per pound.

Total cost of remaining contract quantity from August 1, 1960 is approximately $21,000,000.

[illegible] Corp. operates a 200-ton-a-day processing mill at Canon City, Colo. The contract runs from March 1, 1960 through February 28, 1965. There remained approximately 898,000 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.62 per pound. Post-1962 quantity contracted for is 1,503,100 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960, is approximately $[illegible]00.

[illegible] Mining Co., operates a 400-ton-a-day processing mill at Ford, Wash. The current contract extends through December 31, 1966. There remained approximately 999,200 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $9.27 per pound. The post-1962 quantity contracted for is 2,610,400 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960, is approximately $[illegible]00.

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Federal-Radorock-Gas Hills Partners, operates a 520-ton-a-day processing mill at Fremont County, Wyo., with a contract extending through December 31, 1966. There remained approximately 1,363,200 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.15 per pound. Post-1962 quantity contracted for is 3,700,200 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1960 is approximately $41,000,000.

Globe Mining Co., operates a 490-ton-a-day processing mill in Natrona County, Wyo., with a contract extending through December 31, 1966. There remained approximately 1,138,800 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.30 per pound. Post-1962 quantity contracted for is 3,091,000 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $34,000,000.

Gunnison Mining Co., operates a 200-ton-a-day processing mill at Gunnison, Colo. This contract extends through December 31, 1962. There remained approximately 823,200 pounds of U_3O_8 to be delivered between July 1, 1960 and July 1, 1962, at a unit price of $9.19 per pound. The pre-1962 price continues to July 1, 1962 due to stretch-out. The quantity contracted for between July 1, 1962 and December 31, 1962, is 205,800 pounds at a price of $8.00 per pound. Total cost of remaining contract quantity is approximately $9,200,000.

Homestake-Sapin Partners, operate a 1,500-ton-a-day processing mill at Grants, N. Mex., with a contract extending through December 31, 1966. There remained approximately 4,020,600 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.00 per pound. Post-1962 quantity contracted for is 10,680,000 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960, is approximately $118,000,000.

Kerr-McGee Oil Industries, Inc., operates a 300-ton-a-day processing mill at Shiprock, N. Mex. The current contract runs from November 1, 1959 through June 30, 1965. There remained approximately 942,200 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.00 per pound. Post-1962 quantity contracted for is 872,700 pounds at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $14,500,000.

Petrotomics Co., operates in the Shirley Basin Area of Wyoming. This contract, signed on August 12, 1960 extends through December 31, 1966. It provides for the purchase of 1,024,000 pounds of U_3O_8 contained in eligible ores in the pre-1962 period, and for the purchase of U_3O_8 in concentrate in the post-1962 period. The Petrotomics Co. may, at its option in the post-1962 period, build a mill for the production of uranium concentrates or make arrangements with existing mills for the treatment of its ore. In the post-1962 period AEC has contracted to buy a total of 3,158,800 pounds of U_3O_8 in concentrates at a unit price of $8.00 per pound . Total cost of the contract quantity of U_3O_8 in concentrate is approximately $25,000,000.

Phillips Petroleum Co., operates a 1,725 ton-a-day processing mill at Grants, N. Mex., and with a contract extending through December 31, 1966. There remained approximately 5,861,700 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $7.75 per pound. Post-1962 quantity contracted for is 13,345,500 pounds of U_3O_8, including the quantity deferred from the pre-1962 period. The average unit price will be $7.96 per pound due to stretch-out. Total cost of remaining contract quantity from July 1, 1960 is approximately $152,000,000.

...ehanna-Western, Inc.*, now building a new 200 ton-a-day processing mill ... Falls City, Tex. This contract was executed July 25, 1960, and runs through ...ember 31, 1966. Starting with the opening of the mill, pre-1962 contract ...tity is 337,500 pounds of U_3O_8 at a unit price of $9.90 per pound. Post-1962 ...tity contracted for is 1,247,400 pounds of U_3O_8 at a unit price of $8.00 per ... Total cost of entire contract quantity is approximately $13,300,000.

...anium Reduction Co.*, operates a 1,500 ton-a-day processing mill at Moab, ... and with a contract extending through December 31, 1966. There remained ...imately 6,175,500 pounds of U_3O_8 to be delivered between July 1, 1960 and ...1, 1962, at a unit price subject to upward or downward changes in accord... with an incentive-type formula. The current price is $8.15 per pound. ...962 quantity contracted for is 14,773,000 pounds of U_3O_8 at a unit price of ... per pound. Total cost of remaining contract quantity from July 1, 1960, is ...imately $169,000,000.

...*Construction and Mining Co.* (formerly Lucky Mc Uranium Corp.), ... a 980 ton-a-day processing mill in Fremont County, Wyo. This contract ... through December 31, 1966. There remained approximately 2,961,400 ... of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit ... $7.90 per pound. Post-1962 quantity contracted for is 8,432,700 pounds ... at a unit price of $8.00 per pound. Total cost of remaining contract ... from July 1, 1960 is approximately $91,000,000.

...*Nuclear Corp.*, operates an 845 ton-a-day processing mill at Jeffrey ... Wyo., and with a contract running through December 31, 1966. There ... approximately 2,828,600 pounds of U_3O_8 to be delivered between July ... and April 1, 1962, at a unit price of $7.72 per pound. Post-1962 quantity ...ted for is 8,526,900 pounds of U_3O_8, at a unit price of $8.00 per pound. ... cost of remaining contract quantity from July 1, 1960, is approximately ...000.

REMAINING CONTRACTS

...imate quantities and prices are given in the following summaries of ... mill contracts for the twelve contracts under review. Except as ... noted, the prices stated in the following contracts are base prices ... are subject to escalation up or down depending on the grade of ore fed ... All of these contracts require the milling companies to accept certain ... of amenable ore from independent producers.

...*take-New Mexico Partners*, operates a 750 ton-a-day processing mill in ...ts, N. Mex., area. The current contract extends through March 31, ... There remained approximately 3,459,600 pounds of U_3O_8 to be delivered ... July 1, 1960 and April 1, 1962 at a unit price of $8.31 per pound. Total ... remaining contract quantity from July 1, 1960, is approximately ...400.

...*Nuclear Fuels Corp.*,[1] a combine of four companies (Kerr-McGee Oil ..., Inc., Pacific Uranium Mines Co., Anderson Development Corp., and ... Lake Uranium Corp.), operates a 3,300 ton-a-day processing mill in the ... area of New Mexico with a contract extending through December 31, 1966. ...mained approximately 16,269,000 pounds of U_3O_8 to be delivered between ... 1960 and April 1, 1962 at a unit price of $7.46 per pound. Post-1962 ... contracted for is approximately 21,375,000 pounds of U_3O_8 at a unit ... $8.00 per pound. Total cost of remaining contract quantity from July ... approximately $292,000,000.

...note on page 494.

Lakeview Mining Co., operates a 210 ton-a-day processing mill at Lakeview, Oreg., with a contract extending through November 30, 1963. There remained approximately 805,000 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962 at a fixed unit price of $9.27 per pound for company-controlled ores. Post-1962 quantity contracted for is 766,600 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $13,600,000.

Mines Development, Inc., operates a 400 ton-a-day processing mill at Edgemont, S. Dak., with a contract extending through March 31, 1962. There remained approximately 938,600 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962 at a unit price of $9.87 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $9,300,000.

Rare Metals Corp. of America, operates a 300 ton-a-day processing mill at Tuba City, Ariz. This contract extends through March 31, 1962. There remained approximately 1,096,000 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962 at a unit price subject to upward or downward change in accordance with an incentive-type formula. The current price is $10.70 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $11,700,000.

Susquehanna-Western, Inc.,[1] operates a 500 ton-a-day processing mill at Riverton, Wyo., with a contract extending through October 31, 1963. There remained approximately 1,435,000 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.74 per pound. Post-1962 quantity contracted for is 1,298,300 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $22,900,000.

Texas-Zinc Minerals Corp., operates a 1,000 ton-a-day processing mill at Mexican Hat, Utah. This contract extends through December 31, 1966. There remained approximately 3,097,500 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $8.95 per pound. Post-1962 quantity contracted for is 8,407,500 pounds of U_3O_8 at a unit price of $8.00 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $95,000,000.

Trace Elements Corp., operates a 300 ton-a-day processing mill at Maybell, Colo., with a contract extending through March 31, 1962. There remained approximately 1,255,500 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $9.29 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $11,700,000.

Union Carbide Nuclear Co., operates a 1,000 ton-a-day processing mill at Rifle, Colo., with a contract extending through March 31, 1962. There remained approximately 5,772,800 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $9.65 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $56,000,000.

Union Carbide Nuclear Co., operates a 1,000 ton-a-day processing mill at Uravan, Colo., with a contract extending through March 31, 1962. There remained approximately 2,490,500 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962, at a unit price of $9.65 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately $24,000,000.

Vanadium Corp. of America, operates a 750-ton-a-day processing mill at Durango, Colo. This contract extends through March 31, 1962. There remained approximately 1,750,000 pounds of U_3O_8 to be delivered between July 1, 1960 and

[1] See footnote on page 494.

April 1, 1962 at a fixed unit price of \$8.02 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately \$14,000,000.

Vitro Chemical Co., operates a 600 ton-a-day processing mill at Salt Lake City, Utah, with a contract extending through March 31, 1962. There remained approximately 1,403,100 pounds of U_3O_8 to be delivered between July 1, 1960 and April 1, 1962 at a unit price of \$9.69 per pound. Total cost of remaining contract quantity from July 1, 1960 is approximately \$13,600,000.

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APPENDIX 20

Status and Prospects of Gas Centrifuge Technology

Statement by John A. McCone, Chairman

After careful study and discussions with many qualified scientists about gas centrifuge process, it is my conclusion that practical use of this method any nation for producing weapons material is several years away. There is enormous amount of development work still to be done. We foresee that the centrifuge ultimately can be used to separate uranium 235 from uranium 238 produce weapons-grade materials. But this cannot be done satisfactorily present technology. We do not think that the problems that remain are ins but they certainly will take time to solve.

This process will not be simple nor cheap. Apparently, as we see the of future development it will take thousands of gas centrifuge machines to duce material for weapons. With auxiliaries, these machines might cost thousand dollars each.

A country that is advanced scientifically and industrially would require a ber of years—perhaps as many as eight—to perfect the gas centrifuge to the where it could produce enough material for a nuclear weapon. Less indus ized countries will take much longer; the period of time depends upon how outside assistance they receive.

We do not minimize the potential importance of this process, however. though the gas centrifuge does not pose an immediate prospect for production weapons material, there is no doubt in my mind it will introduce an addi complicating factor in the problems of nuclear arms among nations and our for controlled disarmament. If successfully developed, a production plant the gas centrifuge method could be simply housed. Its power requirements be relatively small, and there would be no effects of the operation which easily disclose the plant. Therefore, a clandestine plant would not be as easy detect as a gaseous diffusion plant.

The attached comprehensive report by the Commission on the gas centri process has been prepared to elaborate further on this matter and to place better perspective.

AEC Report on Status of Gas Centrifuge Technology

The following report on the status of technology on the gas centrifuge for the separation of isotopes discusses the principle of the gas centri the possible advantages of this process and its possible use in the produ of weapons material. The report also outlines the development work by the United States and other countries and lists some of the problems still must be solved.

I. Principle of the Gas Centrifuge

The theory of the gas centrifuge process is to pass uranium in gaseous (uranium hexafluoride) through a centrifuge which spins at very high

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one can separate c
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of industrial centrifuges
the uranium 235 p
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SSIBLE ADVANTAGES

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capacity installations.
centrifuge process has
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being equal. This me
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possible improvement in

FOR WEAPONS MATERI

view by the Commission
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crude weapon per yea
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United States, the time
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LOPMENT PROBLEMS

al areas in which probl
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service with uranium he
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be developed.

is a slight difference in the weight of the uranium 238 and uranium 235 ... Consequently, it is theoretically possible to separate these isotopes as one can separate cream from milk by centrifugation. It must be ...ized, however, that although the same principle is involved, the gas ...ifuge is a good deal more complex than the "cream separator" or other ...of industrial centrifuges.

...the uranium 235 portion of natural uranium (U^{238}) is fissionable ...can be used for weapons purposes. Uranium 235 constitutes only 0.7 of ...vantage point of natural uranium. The other 99.3 percent of uranium is of no use for weapons. Therefore, it is necessary to separate the uranium ...from uranium 238.

...SIBLE ADVANTAGES

...possible advantages of the gas centrifuge method, as compared with ...eous diffusion process we now use for uranium isotope separation, are ...ential lower requirement of a centrifuge plant for electric power and its ...al requirement for fewer units in series in order to produce the desired ...ment of uranium 235. Further, it appears to be particularly well suited ...capacity installations.

...centrifuge process has the interesting theoretical property that the ...ive work performed varies with the fourth power of the speed, all other ...being equal. This means that doubling the speed would, in theory, ...the separative work performed by the unit by a factor of 16. ...this potential, as progress is made in materials of construction and equip-...design, enthusiasm rises for the application of this process to the separation ...isotopes. In at least one respect this is a desirable situation since ...processes should be developed for uranium 235 separation as a step ...possible improvement in the economics of nuclear power.

...FOR WEAPONS MATERIAL

...by the Commission of available information on the gas centrifuge ...built both here and abroad indicates that these machines cannot now ...in a production plant without further development work. So far, ...units have been operated only as single laboratory models for isotope .... These machines are complex and expensive.

...after substantial improvements have been made, thousands of gas ...probably would be required to produce enough enriched uranium ...crude weapon per year. Including auxiliaries, a plant of this type ...several thousand dollars per centrifuge. Compared with development ...United States, the time period would be much longer for a country not ...engaged in centrifuge research and development and not having ...advanced technical and industrial capability.

...OPMENT PROBLEMS

...areas in which problems still must be solved before a satisfactory ...possible with the current centrifuges include:

...ability of the present experimental machines for continuous, long ...service with uranium hexafluoride must be proved out.

...model of the machine satisfactory for mass production of identical units ...be developed.

(3) A method must be developed to provide for the introduction and removal of gas when the machines are grouped as would be necessary in a production plant.

(4) The auxiliary processes, services and instrumentation necessary for the operations have to be determined.

None of these problems is simple to solve. Excellent technical and industrial talent are required.

V. Development Work by United States

The United States has followed development of this process for some time. The gas centrifuge was one of the methods investigated during World War II. Development work on the centrifuge method had not progressed so far as other methods when it became necessary to select the processes to be used in production plants. The United States temporarily discontinued work on the centrifuge and went ahead with gaseous diffusion, thermal diffusion and the electromagnetic methods for production of uranium 235.

Although the United States ultimately continued to employ the gaseous diffusion method as the most economical process available, the Commission has not lost sight of the gas centrifuge's possibilities. The AEC resumed research on the centrifuge method in 1953 and expanded this work gradually as the technology advanced. Most of the Commission's research work has been carried out at the University of Virginia.

As the technology advances, it will be possible to make more realistic appraisals of the economic attractiveness of this method for the separation of uranium 235. The Commission has recently increased the United States effort on the development of the centrifuge program. It is now expected that the total effort will be at a level of roughly $2 to $3 millions per year. Because of its potential significance to production of weapons materials, however, the program is classified.

The technology of centrifuge separation is not now developed to a point where this process can produce uranium 235 at a cost competitive with the product from AEC's current gaseous diffusion plants. On the other hand, projections of possible gains in the gas centrifuge process indicate the possibility that the process may become attractive from the economic standpoint in the future. However, this would require very substantial further advances in the technology. In this country, the gaseous diffusion method remains the most economical process for large-scale production of uranium 235 at this time.

Since there has been considerable commercial interest expressed in possible industrial application of the gas centrifuge process to the development of economic nuclear power, the Commission has approved a program under which private industry in the United States will be permitted to work on the centrifuge process with private funds, under appropriate conditions of security.

VI. Work in Other Countries

Scientists in West Germany and the Netherlands also have worked to develop the potential of the gas centrifuge process for its inter-scientific and commercial possibilities. They have been particularly interested in the potential of the centrifuge for the production of low enriched uranium for civilian research and power reactors.

In July of 1960 representatives of the Department of State and of the Atomic Energy Commission discussed centrifuge technology with the West German and Netherlands Governments and the United States asked that Germany and the Netherlands give consideration to the control of gas centrifuge technology. The two countries shared the concern of the United States over the possible application of the centrifuge process for weapons production.

The West German Government recently announced that it has taken steps to control the dissemination of information on the gas centrifuge process. The United States understands that the Netherlands Government is actively studying the question of applying controls to its work.

The United States also discussed the gas centrifuge question with the United Kingdom. The United Kingdom follows classification criteria similar to those of the United States on the gas centrifuge process.

Other Methods for Producing Fissionable Material

There are already two methods—available today—to produce weapons material. These proven methods are (1) the gaseous diffusion method of producing enriched uranium and (2) the use of reactors, which produce plutonium. The three nuclear powers, the United States, the United Kingdom and the Soviet Union, have built gaseous diffusion plants to produce uranium 235 for weapons purposes. In each case this has been a very costly undertaking and in each case the technology has been held very secret. Gaseous diffusion plants are inherently of substantial capacity and require very large amounts of electrical power. For various reasons, it is unattractive for many countries to proceed with the necessary effort to build even a small gaseous diffusion plant.

France, for example, while planning to build a gaseous diffusion plant, exploded its first nuclear device from plutonium produced in reactors fueled with natural uranium.

Technology applicable to the production of plutonium in reactors has been widely disseminated in the course of the program for the development of the peaceful uses of the atom, and this technology could be used to assist any country in attaining a weapons capability.

For example, it is possible for a country to develop a plutonium production capability to produce one crude weapon per year with an investment on the order of $50 million.

With application of plutonium technology, the additional development work and construction of a small plutonium production complex would not be a major task. In order to accomplish this within a period of four to five years, a country must have a substantial technical and industrial capability of its own, or it must receive assistance from a country that has such a capability.

The Control Problem

The United States has supported broad international safeguards to insure that uranium, as well as any other nuclear material used or produced in peaceful programs, are not diverted to weapons uses.

The General Conference of the International Atomic Energy Agency, which met in Vienna in September, endorsed proposed safeguards to apply to reactors and special nuclear materials that will be subjected to IAEA control. The principle of these safeguards can be extended to apply to the gas centrifuge.

The United States also has sought agreement among supplier nations of natural uranium to control international traffic in this material to assure that it will be used only for peaceful purposes. In over forty bilateral agreements for cooperation in civil uses of atomic energy, the United States has obtained guarantees from its cooperating partners that any materials or equipment received or produced as a result of such cooperation will not be used for military purposes. The United States has been given rights of inspection in order to assure that these guarantees are met.

APPENDIX 21

COMMISSION'S FINANCIAL REPORT FOR FISCAL YEAR 1960

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

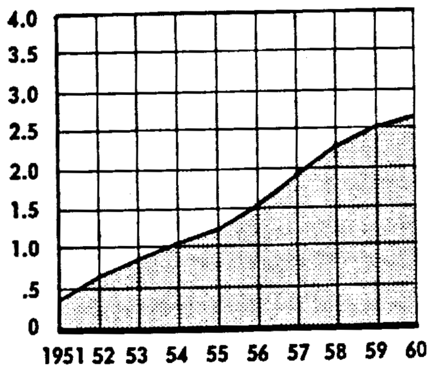
September 30, 1960

MEMORANDUM FOR CHAIRMAN McCONE
COMMISSIONER GRAHAM
COMMISSIONER WILSON
COMMISSIONER OLSON

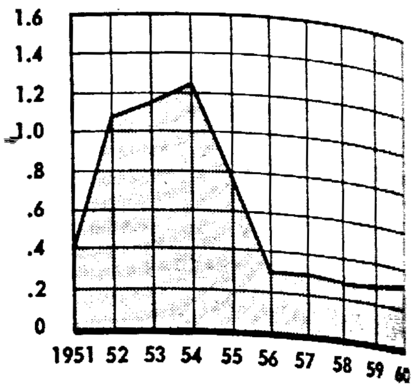
The Annual Financial Report of the Atomic Energy Commission for fiscal year 1960 is transmitted herewith. The report contains financial statements setting forth the financial position of AEC at June 30, 1960, the results of operations for fiscal year 1960 and other unclassified financial information. These financial statements have been independently examined and certified by the AEC internal audit staff.

DON S. BURROWS
Controller

COST OF OPERATIONS

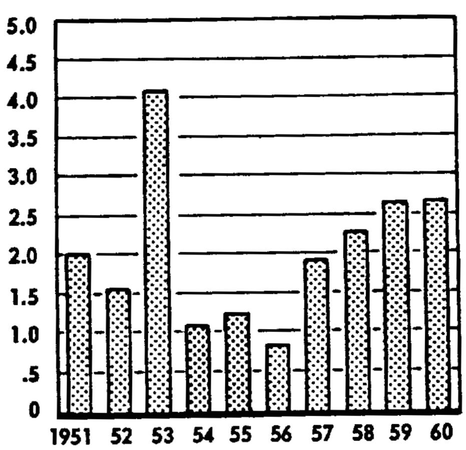


PLANT & EQUIPMENT EXPENDITURES

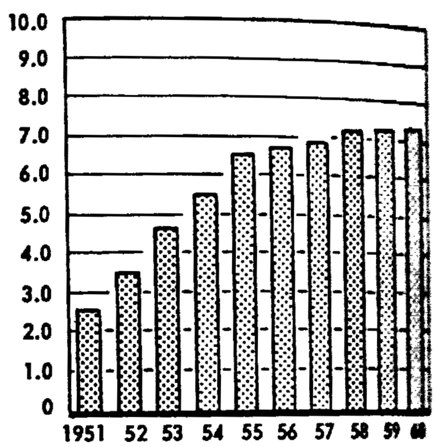


FINANCIAL TRENDS
FISCAL YEARS 1951 - 1960
(BILLIONS OF DOLLARS)

FUNDS APPROPRIATED - NET



PLANT INVESTMENT AT JUNE 30



Highlights

- Procurement and productio
of AEC costs. In 1960 these
operating costs.

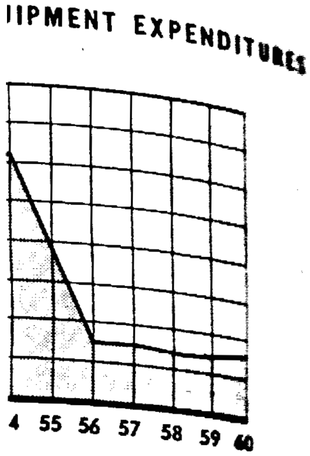
- Development of power and
million in 1960. Costs in 19

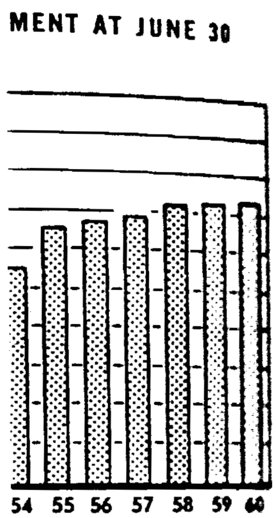
- A measure of AEC's efforts
the growth in the value of n
In 1960 this totaled $99 mill

- The cost of physical resear
million was for controlled th
physics.

- The effects of radiation in th
continued to be studied. In
1959 were $43 million.

- Additional plant now under c





Highlights

- Procurement and production of nuclear materials continue to provide the major portion of AEC costs. In 1960 these activities cost $1.4 billion or 55 per cent of AEC's total operating costs.

- Development of power and propulsion reactors and other reactor research cost $399 million in 1960. Costs in 1959 were $356 million.

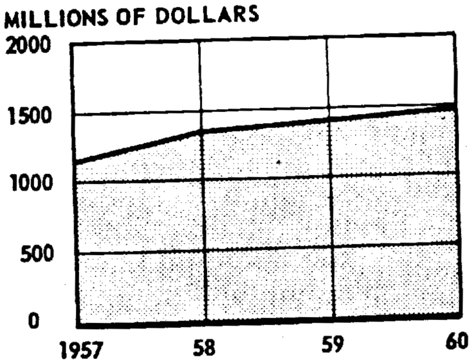
- A measure of AEC's efforts to develop peaceful uses of atomic energy is indicated by the growth in the value of materials leased domestically and to foreign organizations. In 1960 this totaled $99 million compared to $72 million in 1959.

- The cost of physical research amounted to $133 million in 1960. Of this amount $32 million was for controlled thermonuclear research, and $32 million was for high energy physics.

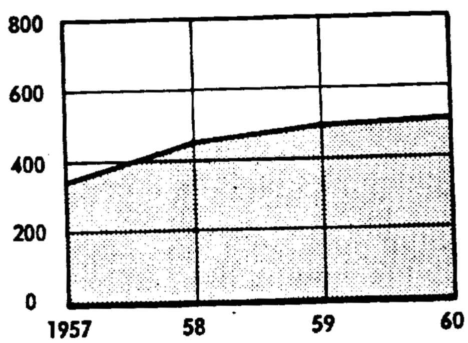
- The effects of radiation in the environment—air, land, and water—on living organisms continued to be studied. In 1960 costs for this research totaled $49 million. Costs in 1959 were $43 million.

- Additional plant now under construction or authorized totaled $1.2 billion.

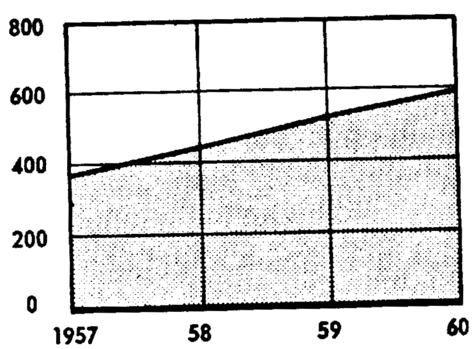
COST TRENDS



PROCUREMENT & PRODUCTION OF NUCLEAR MATERIALS



WEAPONS DEVELOPMENT & FABRICATION



REACTOR DEVELOPMENT & OTHER RESEARCH

Fin

ASSE

FUNDS IN U. S. TREASURY
ALLOCATIONS FROM OTHER
CASH ON HAND AND WITH CO
ACCOUNTS RECEIVABLE (les accounts of $80 thousand in 1959)
DUE FROM OTHER FEDERAL
INVENTORIES
Source and nuclear materials installations
Special reactor material
Stores (less allowance for los 1960 and $11 million in 195
Isotopes
Other special materials

PLANT
Completed plant and equipmen
Less-Accumulated depreciati

Construction work in progress

PREPAYMENTS AND SPECIAL I

TOTAL ASSETS

Financial Statements

UNITED STATES ATOMIC
COMPARATIVE

ASSETS	June 30, 1960	June 30, 1959
	(in thousands)	
...S IN U. S. TREASURY	$1,510,056	$1,483,389
...CATIONS FROM OTHER FEDERAL AGENCIES	105,129	166,196
... ON HAND AND WITH CONTRACTORS	27,812	29,958
...NTS RECEIVABLE (less allowance for uncollectible ...s of $80 thousand in 1960 and $183 thousand in ...)	16,906	12,246
... FROM OTHER FEDERAL AGENCIES	10,491	4,821
...TORIES		
...e and nuclear materials leased and at research ...allations	459,326	402,390
...al reactor material	102,940	111,934
... (less allowance for loss of $12 million in ... and $11 million in 1959)	93,953	91,346
...	9,864	8,634
...r special materials	19,910	18,050
	685,993	632,354
...		
...pleted plant and equipment	7,018,062	7,043,027
...-Accumulated depreciation	2,005,589	1,900,265
	5,012,473	5,142,762
...ruction work in progress	326,689	249,757
	5,339,162	5,392,519
...MENTS AND SPECIAL DEPOSITS	45,080	43,287
...TAL ASSETS	$7,740,629	$7,764,770

ENERGY COMMISSION
BALANCE SHEET

LIABILITIES AND AEC EQUITY	June 30, 1960	June 30, 1959
	(in thousands)	
LIABILITIES		
Accounts payable and accrued expenses	$ 262,975	$ [illegible]
Advances from other Federal agencies	91,547	[illegible]
Funds held for others	9,747	[illegible]
Deferred credits	1,784	[illegible]
TOTAL LIABILITIES	366,053	[illegible]
AEC EQUITY, JULY 1	7,363,566	[illegible]
Additions		
Funds appropriated – net	2,649,614	[illegible]
Nonreimbursable transfers from other Federal agencies	3,187	[illegible]
	2,652,801	[illegible]
Deductions		
Net cost of operations	2,665,654	[illegible]
Less – Costs charged to inventories of source and nuclear materials leased and at research installations	84,384	[illegible]
	2,581,270	[illegible]
Nonreimbursable transfers to other Federal agencies	60,448	[illegible]
Funds returned to U. S. Treasury	73	[illegible]
	2,641,791	[illegible]
AEC EQUITY, JUNE 30	7,374,576	[illegible]
TOTAL LIABILITIES AND AEC EQUITY	$7,740,629	[illegible]

The notes on the following page are an integral part of this statement.

The balance sheet does not i
Certain inventories for s
64,751,316 troy ounces o
use as electrical conduct
silver had a value of $59.
Plant and equipment on
$100 million.
Contested claims against
The balance sheet does not i
Contingent liabilities rel
Ridge, Paducah, and Po
given at June 30, 1960, th
Contingent liabilities as g
Contingent liabilities for
approximately $13.2 milli
Commitments for accrued
Commitments for payme
Atomic Bomb Casualty
liability would have amoun
Under provisions of Secti
the delivery of domestic u
minimum prices for urani
April 1, 1962 to Decemb
$8 per pound has been
1962 and before Decembe
through 1966 for the purc
and overseas sources. Th
at June 30, 1960.
Commitments under Secti
special nuclear material
amount of the commitmen
price established for the
delivered by domestic lice
Outstanding contracts, pur
obligations of $944 million

NOTES TO THE BALANCE SHEET

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. Based on market quotations at June 30, 1960, this silver had a value of $59.2 million.

c. Plant and equipment on loan from other Federal agencies at June 30, 1960 amounting to $100 million.

d. Contested claims against others of $1.1 million.

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, 1960, the estimated liabilities would have amounted to $316 million.

b. Contingent liabilities as guarantor of loans to the extent of $65 million.

c. Contingent liabilities for claims against the Federal government or AEC contractors of approximately $13.2 million.

d. Commitments for accrued annual leave of AEC employees of $6.6 million.

e. Commitments for payment of involuntary termination allowances to employees of the Atomic Bomb Casualty Commission. If terminated at June 30, 1960, the estimated liability would have amounted to $652 thousand.

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 $2.9 billion at June 30, 1960.

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 $8 million at June 30, 1960, 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.

Outstanding contracts, purchase orders, and other commitments represented by unpaid obligations of $944 million.

UNITED STATES ATOMIC ENERGY COMMISSION
COMPARATIVE STATEMENT OF OPERATIONS

(includes depreciation)

	Fiscal Year Ended June 30, 1960	Fiscal Year Ended June 30, 19[illegible]
	(in thousands)	
Production		
Procurement of raw materials	$ 716,507	$ [illegible]
Production of nuclear materials	731,348	713,247
Weapons development and fabrication	505,448	[illegible]
	1,953,303	1,905,234
Development of nuclear reactors		
Civilian nuclear power development	117,786	[illegible]
Naval propulsion	88,799	[illegible]
Aircraft propulsion	69,687	[illegible]
Missile propulsion	31,777	[illegible]
Auxiliary power sources	11,480	[illegible]
Army reactors	11,965	[illegible]
Merchant ships	7,424	[illegible]
General research and development	60,334	[illegible]
	399,252	[illegible]
Research		
Physical research	132,845	[illegible]
Biology and medicine research	48,878	[illegible]
Peaceful application of nuclear explosives	6,392	[illegible]
Isotope development	3,808	[illegible]
	191,923	[illegible]
Community Operations		
Expenses	17,582	[illegible]
Revenues	(10,492)	[illegible]
	7,090	[illegible]
Sales of materials and services		
Cost	12,192	[illegible]
Revenue	(14,726)	[illegible]
	(2,534)	[illegible]
Education and training	7,675	[illegible]
AEC administrative expenses	51,197	[illegible]
Security investigations	7,057	[illegible]
Other expenses—net	4,180	[illegible]
Net cost of operations*	2,619,143	[illegible]
Special Items		
Transfer of community property	43,958	[illegible]
Adjustments to costs of prior year—net	2,553	[illegible]
Net cost of operations—after special items	$2,665,654	[illegible]

* Includes depreciation of $284 million in 1960 and $285 million in 1959.

5007100

U. S. GOVERNMENT INVESTMENT IN THE ATOMIC ENERGY PROGRAM

From June 1940 through June 1960

	Amount (in millions)	
Appropriation payments—net		
National Defense Research Council	$ .5	
Office of Scientific Research and Development	14.6	
War Department (including Manhattan Engineer District)		
Fiscal year 1943	77.1	
Fiscal year 1944	730.3	
Fiscal year 1945	858.6	
Fiscal year 1946	366.3	
Fiscal year 1947—part	186.0	
		$ 2,233.4
Atomic Energy Commission		
Fiscal year 1947—part	146.1	
Fiscal year 1948	477.6	
Fiscal year 1949	627.3	
Fiscal year 1950	534.3	
Fiscal year 1951	920.5	
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	1,633.4	
Fiscal year 1957	1,931.3	
Fiscal year 1958	2,267.9	
Fiscal year 1959	2,541.1	
Fiscal year 1960	2,622.8	
		20,976.7
Total payments—net		23,210.1
Unexpended balance of funds in U. S. Treasury June 30, 1960*		1,510.1
Total funds appropriated		24,720.2†
Less		
Collections paid to U. S. Treasury	54.1	
Property and services transferred to other Federal agencies without reimbursement, net of such transfers received from other Federal agencies	145.0	
Cost of operations including depreciation and obsolescence from June 1940 through June 30, 1960	17,146.5	
		17,345.6
Equity at June 30, 1960 as shown on Balance Sheet		$ 7,374.6

*Appropriations of $2,664 million for fiscal year 1961 were approved September 2, 1960.
†Includes $7.2 million net transfers from AEC appropriations to other Federal agencies.

5001401

Operations

PROCUREMENT OF RAW MATERIALS

Uranium and other raw materials procured in fiscal year 1960 cost $717 million as compared with $700 million in 1959.

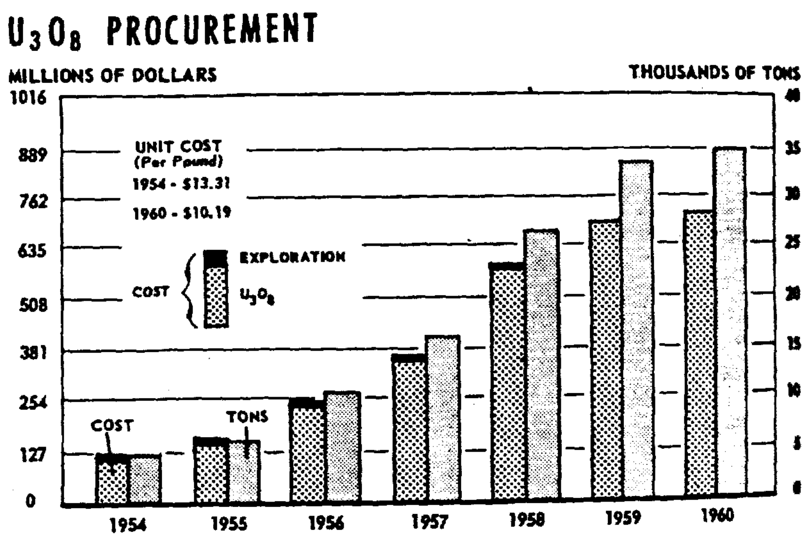
URANIUM CONCENTRATES (U_3O_8)

The total quantity of uranium concentrates purchased in fiscal year 1960 increased 4 per cent over 1959. Foreign purchases remained at the 1959 level but domestic purchases increased 9 per cent. The average cost of U_3O_8 decreased 15 cents to $10.19 per pound.

	Total Cost		Quantity		Average Cost	
	1960	1959	1960	1959	1960	1959
	(in thousands)		*(tons U_3O_8)*		*(dollars per lb.)*	
Domestic	$297,800	$285,168	16,567	15,162	$ 8.99	$ 9.40
Canadian	296,796	293,618	13,443	13,506	11.04	10.87
Overseas	109,852	110,294	4,572	4,658	12.01	11.84
Total	$704,448	$689,080	34,582	33,326	$10.19	$10.34

The costs shown above represent all costs incurred by the Commission in connection with procurement of uranium concentrates, including bonus payments to miners for the initial production of ore. The prices paid to suppliers for U_3O_8 produced in privately owned domestic mills averaged $8.78 per pound in fiscal year 1960 as compared with $9.18 in fiscal year 1959.

The chart below shows the cost and quantities of U_3O_8 procured in fiscal years 1954 through 1960.



PRODUCTION OF SPECIAL NUCLEAR MATERIALS

...al cost of production of special nuclear materials including uranium-235, plutonium, and ... materials to meet the weapons production schedule, other military needs, and the re... ...ments for peaceful uses of atomic energy increased in 1960 to $731 million compared ... $713 million in 1959, an increase of 2.5 per cent. Although the total cost increased, the ... cost of production continued to decrease in 1960.

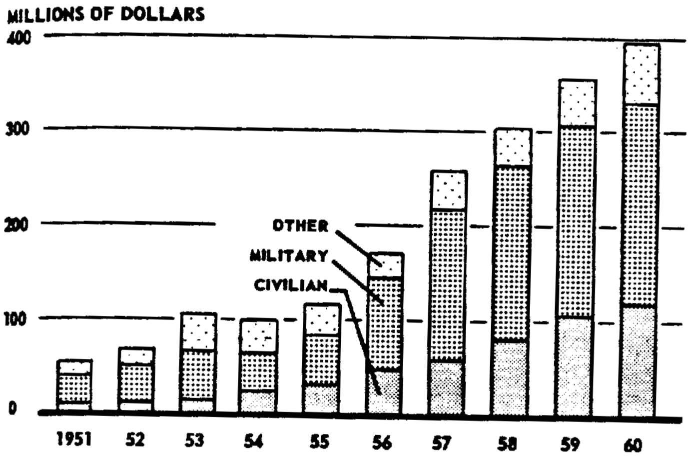
WEAPONS DEVELOPMENT AND FABRICATION

...cost of development and fabrication of weapons, weapons parts, weapons storage, surveil... ...and directly related activities, was $505 million in fiscal year 1960 as compared with ... million in fiscal year 1959. These amounts exclude the cost of source and special nuclear ...als contained in weapons or used in weapons research. The investment in completed ... and equipment for weapons production, research, and storage at June 30, 1960 was $803 ...

REACTOR DEVELOPMENT

...omic Energy Commission continued to develop nuclear reactors for both military and ... uses. The total cost in 1960 amounted to $399 million compared with $356 million in ... The following chart shows the growth in reactor development from 1951 through 1960.

DEVELOPMENT OF NUCLEAR REACTORS



...below compares the cost of reactor development in 1951 with 1960.

	1960	1951
	(in millions)	
Civilian	$118	$ 3
Military	213	30
Other	68	11
	$399	$44

REACTOR DEVELOPMENT COST SUMMARY

	Research and Development Costs*			Capital Costs†	
	Cumulative through June 30, 1960	Fiscal Year 1960	Fiscal Year 1959	Cumulative through June 30, 1960	Additional Construction Authorized
	(in millions)				
CIVILIAN NUCLEAR POWER REACTORS					
Pressurized light water	$ 125.0	$ 22.1	$ 26.1	$ 50.0	$ 25.0
Boiling light water	39.8	10.5	5.9	9.4	27.1
Heavy water	36.4	17.9	10.8	23.3	7.1
Organic moderated	23.9	8.4	6.1	3.4	11.6
Gas cooled	32.3	19.0	9.5	5.2	24.8
Sodium cooled	111.1	27.5	24.3	35.3	26.9
Fluid fuel	102.9	10.0	21.6	4.1	.1
Other studies & development	4.3	2.4	1.0	2.6	3.9
Total	475.7	117.8	105.3	133.3	126.5
ARMY REACTORS					
Pressurized water	7.0	2.6	1.7	3.1	6.5
Boiling water	3.4	1.0	.8	1.7	.3
Gas cooled	19.0	6.8	6.4	1.7	.8
Other studies & development	2.9	1.6	.5	.8	.2
Total	32.3	12.0	9.4	7.3	7.8
MERCHANT SHIP REACTORS	14.6	7.4	4.7	14.7	11.6
AIRCRAFT REACTORS					
Manned Aircraft					
Direct cycle	220.4	42.6	50.3	31.6	17.9
Indirect cycle	156.7	22.8	17.0	.9	
Other studies & development	24.2	4.3	4.5	5.5	
Total	401.3	69.7	71.8	38.0	17.9

REACTOR [

MISSILE PROPULSION
Rocket (Project Rover) $
Ramjet (Project Pluto)
Total

AUXILIARY POWER SOURCES

NAVAL REACTORS
Submarines
Large ship prototype
Guided missile cruiser
Destroyer prototype
Other studies & development
Total

GENERAL

Total reactor development costs $2,

*Includes AEC depreciatior
† Equipment has not been al

REACTOR DEVELOPMENT COST SUMMARY (CONTINUED)

	Research and Development Costs*			Capital Costs†		
	Cumulative through June 30, 1960	Fiscal Year 1960	Fiscal Year 1959	Cumulative through June 30, 1960	Additional Construction Authorized	Total
	(in millions)					
MISSILE PROPULSION						
Rocket (Project Rover)	$ 49.0	$ 15.4	$ 14.0	$ 18.3	$ 32.5	$ 50.8
Ramjet (Project Pluto)	34.9	16.3	8.8	9.7	17.8	27.5
Total	83.9	31.7	22.8	28.0	50.3	78.3
AUXILIARY POWER SOURCES	24.4	11.5	7.7	2.3	1.2	3.5
NAVAL REACTORS						
Submarines	327.1	31.1	35.6	129.3	19.4	148.7
Large ship prototype	117.6	21.0	25.9	33.3	1.7	35.0
Guided missile cruiser	11.4	2.3	3.0			
Destroyer prototype	42.8	20.0	13.4	23.6	12.1	35.7
Other studies & development	57.9	14.4	12.7	7.6	.2	7.8
Total	556.8	88.8	90.6	193.8	33.4	227.2
GENERAL	437.3	60.4	43.3	318.2†	45.2	363.4
Total reactor development costs	$2,026.3	$399.3	$355.6	$735.6	$293.9	$1,029.5

*Includes AEC depreciation but does not include funding by other Federal agencies.
†Equipment has not been allocated but is included in the general category.

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. On August 19, 1960, the reactor constructed by the Yankee Atomic Electric Company became critical and was thus the first nuclear power plant under the cooperative program to achieve criticality.

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 / Plant Capacity ekw (net)	Cumulative Costs Through June 30, 1960: AEC Assistance	Cumulative Costs Through June 30, 1960: Participant's Costs	Total Estimated Costs: AEC Assistance*	Total Estimated Costs: Participant's Costs
		(in millions)			
Yankee Atomic Electric Company, Rowe, Mass.	August 1960 / 136,000 ekw				
Research and development		$ 4.8	$ .2	$ 5.0	$ .3
Plant, equipment and land			35.9		52.5
Waiver of use charges		.5		3.7	
Total		5.3	36.1	8.7	52.8
Power Reactor Development Company, Lagoona Beach, Michigan	December 1960 / 94,000 ekw				
Research and development			14.4		20.2
Plant, equipment and land			42.0		56.1
Waiver of use charges		1.0		3.7	
Total		1.0	56.4	3.7	76.3
Rural Cooperative Power Association, Elk River, Minnesota	November 1960 / 22,000 ekw				
Research and development		.2		2.2	
Plant, equipment and land		5.8	3.4	8.8	3.4
Fuel fabrication				.7	
Total		6.0	3.4	11.7	3.4
City of Piqua, Piqua, Ohio	May 1961 / 11,400 ekw				
Research and development		3.5		4.7	
Plant, equipment and land		1.7	3.7	8.3	3.7
Fuel fabrication				1.2	
Total		5.2	3.7	14.2	3.7
Consumers Public Power District, Hallam, Nebr.	March 1962 / 75,000 ekw				
Research and development		12.9		21.1	
Plant, equipment and land		9.7	11.1	26.7	18.2
Fuel fabrication		.1		2.9	
Total		22.7	11.1	50.7	18.2

Northern States Power Co.
Sioux Falls, S. D.
Research and development
Plant, equipment and land
Waiver of use charges
Total

Carolinas-Virginia Nuclear
Power Assoc., Inc.
Parr, South Carolina
Research and development
Plant, equipment and land
Waiver of use charge
Total

East Central Nuclear Group, I
Florida West Coast Nucle
Group, Western Fla.
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
Total

Puerto Rico Water Resources
Authority, Punta Higuera,
Puerto Rico
Research and development
Plant, equipment and land
Fuel fabrication
Total

Fast breeder technology

Summary
Research and development
Plant, equipment and land
Fuel fabrication
Waiver of use charges
Total

*Includes estimated costs for

	Date of Criticality / Plant Capacity ekw (net)	Cumulative Costs through June 30, 1960: AEC Assistance	Cumulative Costs through June 30, 1960: Participant's Costs	Total Estimated Costs: AEC Assistance*	Total Estimated Costs: Participant's Costs
		(in millions)			
Northern States Power Co. Sioux Falls, S. D.	June 1962 62,000 ekw				
Research and development		$ 4.3		$ 8.5	$ 1.2
Plant, equipment and land			$ 5.3		22.6
Waiver of use charges		.2		1.8	
Total		4.5	5.3	10.3	23.8
Carolinas-Virginia Nuclear Power Assoc., Inc. Parr, South Carolina	July 1962 16,950 ekw				
Research and development		3.9	1.2	13.9	7.5
Plant, equipment and land			.2		17.7
Waiver of use charge				1.2	
Total		3.9	1.4	15.1	25.2
East Central Nuclear Group, Inc.-Florida West Coast Nuclear Group, Western Fla.	50,300 ekw				
Research and development		.9	1.3	11.7	18.0
Plant, equipment and land					28.9
Waiver of use charges				1.5	
Total		.9	1.3	13.2	46.9
Philadelphia Electric Co. York County, Pa.	December 1963 40,000 ekw				
Research and development		5.5	1.5	14.5	5.6
Plant, equipment and land			.7		29.2
Waiver of use charges				2.5	
Total		5.5	2.2	17.0	34.8
Puerto Rico Water Resources Authority, Punta Higuera, Puerto Rico	December 1962 16,300 ekw				
Research and development		.1		.8	.3
Plant, equipment and land		.1		9.6	3.6
Fuel fabrication				.6	
Total		.2		11.0	3.9
Fast breeder technology		1.8		4.5	
Summary	523,950 ekw				
Research and development		37.9	18.6	86.9	53.1
Plant, equipment and land		17.3	102.3	53.4	236.1
Fuel fabrication		.1		5.4	
Waiver of use charges		1.7		14.4	
Total		$57.0	$120.9	$160.1	$289.2

*Includes estimated costs for five years after operations commence.

Army Reactors

AEC costs of research, development, fuel fabrication, test operations, and other costs necessary in developing compact, lightweight, economical power plants for military bases amounted to $12 million in 1960 compared to $9 million in 1959.

The following table shows a comparison of costs for 1960 and 1959 by reactor concept:

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Gas-cooled	$6,811	$6,344
Pressurized water	2,531	1,706
Boiling water	1,009	791
General support and advanced studies	1,614	535
	$11,965	$9,376

Naval Propulsion Reactors

The development of nuclear propulsion plants and long-life reactor cores to meet naval requirements cost $89 million in 1960. The cost in 1959 was $91 million.

The chart below shows the change in total cost of research and development for naval propulsion reactors from 1951 to 1960.

NAVAL PROPULSION REACTORS
RESEARCH AND DEVELOPMENT

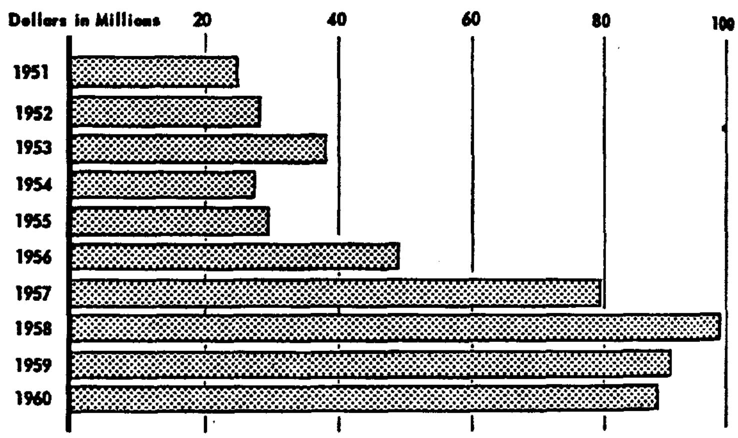


table below shows costs for fiscal year 1960 and 1959 for research, development and op- of test facilities:

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Submarines	$31,114	$35,601
Large ship prototype	20,951	25,826
Guided missile cruiser	2,332	3,011
Destroyer prototype	19,977	13,439
Operation of test facilities and other costs	14,425	12,737
	$88,799	$90,614

...ft Propulsion Reactors

...of research, test operations and experiments of aircraft propulsion reactors was ...in 1960 compared with $72 million in 1959.

...wing table compares costs of the direct cycle, indirect cycle and general research for ...and 1959:

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Direct cycle reactor	$42,566	$50,361
Indirect cycle reactor	22,797	16,975
General research and development	4,324	4,486
Total	$69,687	$71,822

...Propulsion Reactors

...of research and development of missile propulsion systems increased to $32 million ...from $23 million in 1959, an increase of $9 million. As shown in the table below this ...is largely due to cost of research and development of the ramjet approach.

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Rocket (Project Rover)	$15,462	$14,010
Ramjet (Project Pluto)	16,315	8,810
Total	$31,777	$22,820

...Rover, the test operation of the first experimental reactor (Kiwi-A) was successfully ...at the Nevada Test Site. Research and development effort on nuclear rocket propul- ...directed toward the fabrication, assembly and initial testing of the second and third ...al reactors.

Auxiliary Power Sources

The cost of research and development of long-term, light-weight sources of auxiliary power in space vehicles and for other applications amounted to $11 million in 1960 compared with $8 million in 1959.

The table below shows a comparison of 1960 and 1959 research and development costs for radio-isotope and reactor space power systems:

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Radioisotope power systems	$ 3,100	$3,568
Reactor space power systems	8,380	4,128
Total	$11,480	$7,696

The radioisotope-fueled thermoelectric generator demonstrated in FY 1959 culminated in the receipt of requirements from the Coast Guard for prototype units for use in light buoys and from the Navy for prototype units for use at remote weather stations and navigational satellites.

In 1960 an experimental lightweight (250 lb.) reactor (SER) was successfully operated for an accumulated 2900 hours, 100 hours of which were continuous.

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 $60 million in fiscal year 1960, an increase of $17 million over 1959.

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Reactor fuels and materials development	$17,359	$10,379
Engineering physics and advanced reactor development	16,158	9,431
Reactor components development	2,624	1,903
Fuel element separations systems development	7,218	6,037
Waste storage and disposal systems	4,700	3,620
Reactor safety	10,205	8,427
Operations of service facilities and miscellaneous	2,070	3,505
Total	$60,334	$43,302

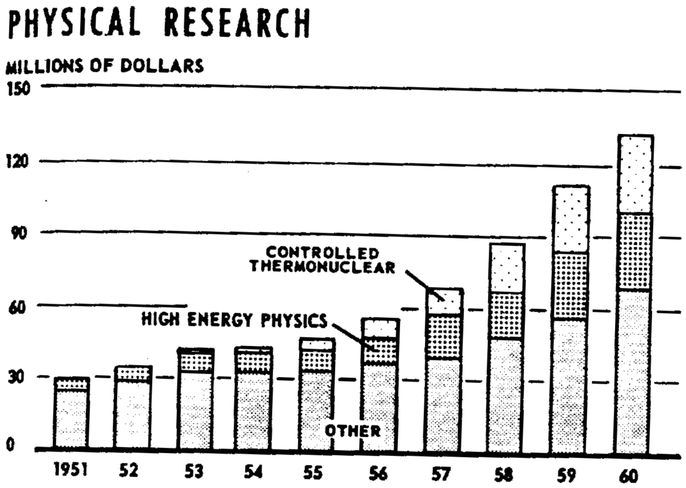
PHYSICAL RESEARCH

Investigations of the laws of nature, including nuclear interactions at high energies, the effects of irradiations on the behavior and properties of materials, and research effort to harness thermonuclear energy are the major areas under study in physical research.

The following table shows a comparison of costs in major scientific areas for fiscal years 1960 and 1959.

	Fiscal Year 1960 (in thousands)	Fiscal Year 1959 (in thousands)
Controlled thermonuclear research	$ 32,148	$ 27,685
High energy physics	32,263	27,517
Chemical properties and reactions	23,116	19,356
Nuclear structure and neutron physics	17,894	14,518
Metallurgy and materials research	12,672	9,348
Chemical process research	5,811	5,712
Physical and chemical methods of isotope separation	2,405	2,733
Computer research and development	2,856	2,191
Other physical research	3,680	3,258
Total	$132,845	$112,318

The chart below shows the growth in the total cost of physical research in the last ten years and the increasing emphasis on research in high energy physics and controlled thermonuclear research.



Controlled Thermonuclear Research

In fiscal year 1960 the cost of the program leading to the future development of thermonuclear energy for the production of power was $32 million. The cost in 1959 was $28 million.

Laboratory	Fiscal Year 1960: Scientific Effort (man-years)	Fiscal Year 1960: Research and Development Costs	Fiscal Year 1960: Construction Costs	Cumulative Costs through June 30, 1960
		(dollar amounts in thousands)		
Lawrence Radiation Laboratory Pinch and collapse, magnetic mirror and astron	91	$ 5,657	$ 443	[illegible]
Los Alamos Scientific Laboratory Pinch and collapse	36	2,302	87	[illegible]
Oak Ridge National Laboratory Hot ion trapping	91	5,575	1,058	[illegible]
Princeton University Stellarator	248	14,483	3,149	[illegible]
Other sites General research	49	4,131		[illegible]
Total	515	$32,148	$4,737	[illegible]

High Energy Physics

Fiscal year 1960 costs of high energy physics were $32.3 million, an increase of $4.7 million or 17 per cent over fiscal year 1959. The major effort in high energy physics centers around attempts to learn as much as possible about the fundamental properties of nuclear matter through research with high energy particle accelerators. In addition to the major accelerators in operation or under construction shown below, costs of $2.7 million were incurred during fiscal year 1960 by Midwestern Universities Research Association and Stanford University for research studies directed toward the design of accelerators on which construction has not yet been authorized.

HIGH ENERGY ACCELERATORS
(One billion electron volts or greater)

(dollar amounts are in millions)

In Operation

	Lawrence Radiation Laboratory (Bevatron)	Brookhaven National Laboratory (Cosmotron)	California Institute of Technology (CIT)
Particle	Proton	Proton	Electron
Energy	6.2 BEV	3.2 BEV	1.2 BEV
Start-up	FY 1953	FY 1952	FY 1953
Plant at June 30, 1960:			
Original	$ 9.7	$9.3	$1.3
Modifications:			
Completed	4.2	3.5	.3
Not completed*	9.6		
Fiscal year 1960 operating costs	10.0	4.6	.3

Under Construction

	Brookhaven Nat'l Lab. (AGS)	Argonne Nat'l Lab. (ZGS)	Harvard U. and MIT (CEA)	Princeton U. and U. of Pa. (PPA)
Particle	Proton	Proton	Electron	Proton
Energy	25-30 BEV	12.5 BEV	6 BEV	3 BEV
Start-up	FY 1961	FY 1963	FY 1962	FY 1962
Estimated cost of construction*	$31.0	$42.0	$11.5	$22.0

*Includes 1961 authorization.

BIOLOGY AND MEDICINE RESEARCH

The cost of AEC research in the life sciences amounted to $49 million in 1960. The cost in [illegible] was $43 million. Increased efforts were made in environmental research required to [illegible] the public safety from radiation hazards. Research activities have continued in the [illegible] of atomic energy including its tools and by-products in the biomedical and agricultural [illegible]

The following table shows a comparison of costs and scientific effort in fields of [illegible] biology and medicine:

	Research Costs		Scientific Effort	
	FY 1960	FY 1959	FY 1960	FY [illegible]
	(in thousands)		(man-years)	
Fields of research				
Cancer	$ 4,753	$ 4,294	226	[illegible]
Medical	14,572	12,828	690	[illegible]
Biological	17,123	15,309	811	[illegible]
Radiological physics, dosimetry & instrumentation	4,574	4,047	171	[illegible]
Radiation ecology and marine sciences	3,344	2,237	136	[illegible]
Fallout studies	2,897	2,474	135	[illegible]
Nuclear energy civil effects and other costs	1,615	1,592	6	[illegible]
Total	$48,878	$42,781	2,175	[illegible]

RESEARCH LABORATORIES

A major portion of AEC research and development is conducted in government-owned laboratories operated by educational institutions and industrial concerns. The investment in completed AEC-owned research facilities at June 30, 1960 was $1.3 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 twelve 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 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.

	Investment in Completed Plant June 30, 1960	Operating Costs 1960	Operating Costs 1959
	(in thousands)		
Los Alamos Scientific Laboratory, Los Alamos, New Mexico	$145,505	$ 64,660	$ 61,657
Argonne National Laboratory, Argonne, Illinois	117,248	44,295	38,797
Oak Ridge National Laboratory, Oak Ridge, Tennessee	144,726	66,201	56,559
Brookhaven National Laboratory, Upton, Long Island, New York	87,069	23,451	20,634
Lawrence Radiation Laboratory, Livermore & Berkeley, California	107,964	90,465	74,258
Bettis Field (including Naval Reactor Facility at NRTS, Idaho) Westinghouse, Pittsburgh, Pennsylvania	102,558	57,074	59,779
Knolls Atomic Power Laboratory, Schenectady, New York	72,897	41,388	34,389
Ames Research Laboratory, Ames, Iowa	7,897	4,136	3,749
Aircraft Nuclear Propulsion Facilities (including facilities at NRTS, Idaho) General Electric–Lockland, Ohio	46,981	39,023	49,424
Connecticut Aircraft Nuclear Engineering Laboratory–Pratt-Whitney, Middletown, Connecticut	4,618*	20,414	16,278
Hanford Laboratory, Richland, Washington	56,375	27,428	24,056
Savannah River Laboratory, Aiken, South Carolina	46,335	13,842	13,648

*Equipment only.

EDUCATION AND TRAINING

The continuation of financial assistance to colleges, universities, teachers and students, for the purpose of encouraging more interest in the curriculum and courses offered in the field of atomic energy, amounted to $8 million in 1960. In addition, the AEC has source and special nuclear materials on loan to educational institutions valued at $8 million on which use charges are waived.

	Fiscal Year 1960 (in thousands)
Grants for the purchase of equipment	$3,076
Operation of schools and courses	1,826
Training institutes – 651 teachers	1,116
Fellowships – 300 fellows	919
Other costs	738
	7,675
Waiver of use charges	263
Security clearances	37
Total	$7,975

Grants for the purchase of equipment. Financial assistance in the form of grants for the purchase of training equipment was made to 167 American colleges and universities. The cost was $3 million in fiscal year 1960.

Operation of schools and courses. The following table shows the number of students in attendance and the cost of operating two schools and seven courses in the field of nuclear technology.

	Number of Students: Foreign	Number of Students: Domestic	Net Operating Cost (in thousands)
Schools			
International Institute of Nuclear Science & Engineering – ANL	134	12	$ 565
Puerto Rico Nuclear Center	26	52	554
Courses			
Industrial Radioisotope Training Course – ORINS	25	104	102
Reactor Supervisors Training Course – Shippingport	11	19	8
Nuclear Reactor Operations Supervision Course – ORNL	12	1	69
Nuclear Reactor Hazards Evaluation Course – ORNL	10	2	69
Radioisotopes Special Training Course – ORINS	71	283	178
Traveling Science Teachers Course – ORINS	2	76	15
Mobile Isotope Training Course – ORINS		104	32
TOTAL	291	653	$1,592*

*After deducting revenue of $234 thousand.

SALE OF MATERIAL AND SERVICES

... from sales of materials and services for fiscal year 1960 amounted to $15 million as ...ared with $9 million for fiscal year 1959. The table below shows the major sources of ...come:

	Fiscal Year 1960	Fiscal Year 1959
	(in thousands)	
Source and special nuclear materials	$ 4,061	$1,353
Heavy water	4,867	3,327
Radioisotopes	2,426	2,498
Vanadium Pentoxide	1,581	
Other materials	279	396
Services	1,512	1,032
Total	$14,726	$8,606

...ce and special nuclear materials and heavy water with licensees and foreign governments ...ased to $99 million at June 30, 1960 from $72 million at June 30, 1959. These amounts ...sent the established value of the material. The following table shows the value of material ...pe of licensee and the amount of material subject to use charges versus that on which use ...ges were waived at June 30, 1960 as compared to June 30, 1959. Use charges waived during ...l year 1960 were $1.5 million.

SOURCE AND SPECIAL NUCLEAR MATERIALS AND HEAVY WATER LEASED

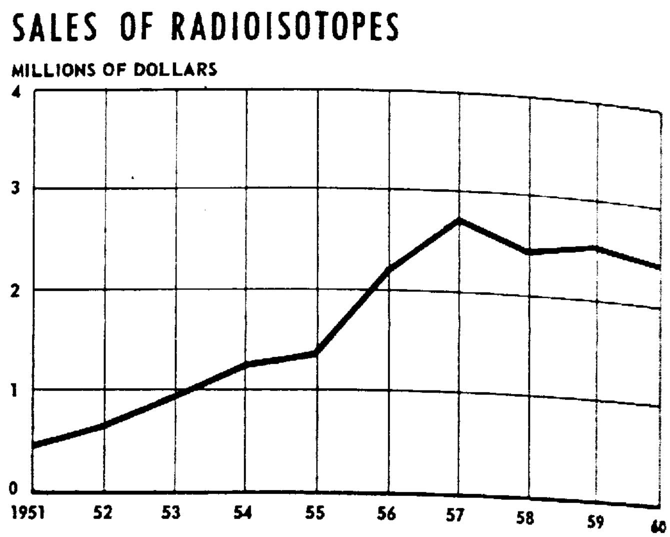
	Total Inventory*		Subject to 4% Use Charge		Not Subject to Use Charge	
	6/30/60	6/30/59	6/30/60	6/30/59	6/30/60	6/30/59
	(in thousands)					
...stic:						
...strial organizations	$82,994	$58,909	$47,816	$37,080	$35,178	$21,829
...cational and research institutions	8,074	8,355	32		8,042	8,355
...er Federal agencies	903	1,354			903	1,354
...n countries	6,731	3,389	6,731	3,389		
Total	$98,702	$72,007	$54,579	$40,469	$44,123	$31,538

*...established prices.

Sales of Radioisotopes

Radioisotope sales in fiscal year 1960 amounted to $2.4 million as compared to [illegible] for fiscal year 1959. Foreign sales of radioisotopes decreased to $391 thousand [illegible] less than in fiscal year 1959.

The chart below shows sales of radioisotopes from FY 1951 through FY 1960. The [illegible] of sales has leveled off due to substantial price reductions in recent years in the [illegible] radioisotopes such as Cobalt-60, Iodine-131, and Carbon-14.



The following table shows a comparison of sales of radioisotopes for fiscal years [illegible]

	Sales			
	Quantity		Dollars*	
	1960	1959	1960	1959
	(curies)		(in thousands)	
Cobalt-60	162,684	208,769	$ 539	$ 659
Polonium-210	4,610	4,882	246	208
Carbon-14	15	12	227	263
Iodine-131	609	748	216	325
Phosphorus-32	129	165	148	171
Cesium-137	72,282	13,885	123	27
Iridium-192	8,767	6,203	62	20
Krypton-85	3,515	2,089	57	35
Tritium	15,952	15,804	32	31
Promethium-147	1,648	501	6	2
Strontium-90	239	88	3	1
All others			767	756
			$2,426	$2,498

* Includes research discounts granted to users under the AEC radioisotope research support program of $259 thousand in 1960 and $304 thousand in 1959.

FINANCIAL I

of licenses granted
June 30, 1960. The follo
organizations:

ORGANIZAT
Medical institut
Industrial organ
Federal and sta
Colleges and un
High schools, fo institutions
Total

progress has been mad
and Richland, Washington
functions including util
established city govern
Housing and Home Financ
has been transferred to
been sold by HHFA. In 1960
were $10.5 million. Howe
assistance to the city gov
established municipalities. Th
made for a 10-year period
was $2.9 million.

investment in completed com

-June 30, 1959
-Fiscal Year 1960
Transfers
Retirements
-June 30, 1960
depreciation
ment-June 30, 1960

30, 1960 there remained at
transferred.

72—61——35

...ber of licenses granted for use of radioisotopes increased 14 per cent from June 30, ... June 30, 1960. The following table gives a comparison of the number of licensees by ... organizations:

ORGANIZATIONS WITH RADIOISOTOPE LICENSES

	June 30	
	1960	1959
Medical institutions and physicians	2,455	2,098
Industrial organizations	1,724	1,511
Federal and state laboratories	1,152	1,027
Colleges and universities	277	269
High schools, foundations, and other institutions	106	123
Total	5,714	5,028

COMMUNITIES

...al progress has been made in the disposal of community facilities at Oak Ridge, Ten... and Richland, Washington, as authorized under Public Law 221, approved in 1955. ...y functions including utilities at both Oak Ridge and Richland have been transferred ...ly established city governments. Real estate sales and financing have been conducted ... Housing and Home Finance Agency through 1960. Property with a net book value of ...lion has been transferred to communities and property with a net book value of $73 mil... been sold by HHFA. In 1960 AEC community operating costs totaled $17.6 million. The ... were $10.5 million. However, under Public Law 221, certain costs are being incurred ... assistance to the city governments during the transition period and until they become ...blished municipalities. The Act provides that assistance payments where necessary ... made for a 10-year period from the date of the transfer. The amount of such payments ... was $2.9 million.

...estment in completed community facilities at June 30, 1960 was as follows:

	Total	Oak Ridge	Los Alamos	Richland	Other
			(in millions)		
...-June 30, 1959	$179.0	$65.6	$72.9	$33.6	$6.9
...-Fiscal Year 1960	6.3	3.4	1.1	1.8	
...les	(21.3)	(17.2)		(4.1)	
...ransfers	(73.9)	(47.1)		(26.8)	
...rements	(4.6)	(2.5)	(0.9)	(0.7)	(0.5)
...-June 30, 1960	85.5	2.2	73.1	3.8	6.4
...ed depreciation	(25.6)	(1.0)	(21.1)	(1.5)	(2.0)
...ment-June 30, 1960	$59.9	$1.2	$52.0	$2.3	$4.4

... 30, 1960 there remained at Oak Ridge and Richland $3.5 million in property still to be ...ransferred.

...72—61——35

INTERNATIONAL ACTIVITIES

The United States has 42 active foreign agreements as of June 30, 1960, which provide for co-operation, aid and assistance in developing peaceful uses of atomic energy. In addition, agreements have been entered into which provide support and assistance to the European Atomic Energy Community (EURATOM) and the International Atomic Energy Agency.

REACTOR AND EQUIPMENT GRANTS*

	Approved During FY 1960	Total Approved Through June 30, 1960 (in thousands)	Commitments Outstanding at June 30, 1960
Latin American	$ 163	$1,325	$ 966
European	150	3,398	3,266
Near Eastern	650	1,161	1,084
Asian	491	2,839	2,480
South Pacific		298	298
International Agency	194	194	192
Total	$1,648	$9,215	$8,286

*A major part of the funds required for grants is provided by the Mutual Security Program.

MATERIALS LEASED*

	June 30, 1960		Use Charges Earned Fiscal Year 1960
	SS Material	Heavy Water (in thousands)	
Latin American	$ 283		$ 13
European	3,315	$1,639	125
Near Eastern	112		2
Asian	32	840	1
Total	$3,742	$2,479	$141

*At sales value.

COSTS OF INTERNATIONAL ACTIVITIES
Fiscal Year 1960

	AEC Direct Costs	Mutual Security Program Costs	Total Costs
		(in thousands)	
GRANTS			
Reactor	$ 325	$	$ 325
Equipment		246	246
IAEA Laboratory	600		600
	925	246	1,171
TRAINING AND EDUCATION			
Schools	1,122		1,122
Special courses	167		167
	1,289		1,289
OTHER COSTS			
Special and Topical Conferences	63	44	107
Advisory and Consultant Services	63	68	131
Nuclear Energy Exhibits	824		824
Nuclear Materials Control System	547		547
Direct Salary and Travel Expense	1,345		1,345
Euratom-Research & Development	494		494
IAEA World-Wide Research	114		114
	3,450	112	3,562
Total Costs	$5,664	$358	$6,022

Ten-Year Summary of Financial Data

UNITED STATES ATOMIC ENERGY COMMISSI[illegible] TEN-YEAR SUMMARY OF FINANCIAL DAT[illegible]

(in thousands of dollars)

	1960	1959	1958	19[illegible]	1956	1955
Cost of operations*	$2,619,143	$2,496,648	$2,298,589	$1,91[illegible]	$1,607,973	$1,289,535
Procurement of raw materials	716,507	699,996	596,391	[illegible]	278,946	193,586
Production of nuclear materials	731,348	713,247	750,178	[illegible]	730,972	588,445
Weapons development and fabrication	505,448	491,981	443,536	[illegible]	280,765	258,706
Development of nuclear reactors	399,252	355,600	306,225	[illegible]	168,853	114,557
Civilian	117,786	105,233	78,732	[illegible]	45,880	28,064
Military	213,708	202,328	184,868	[illegible]	101,410	53,011
Other	67,758	48,039	42,625	[illegible]	21,563	33,482
Physical Research	132,845	112,318	87,719	[illegible]	56,547	48,221
Controlled thermonuclear	32,148	27,685	19,012	[illegible]	7,066	4,718
High energy physics	32,263	27,517	19,146	[illegible]	11,981	8,583
Other	68,434	57,116	49,561	[illegible]	37,500	34,920
Biology and medicine research	48,878	42,781	35,958	[illegible]	29,849	28,898
Community operations – net	7,090	9,892	11,162	[illegible]	8,954	10,321
Administrative expenses	51,197	50,135	46,435	[illegible]	38,195	34,027
Other expenses and income – net	26,578	20,698	20,985	[illegible]	14,892	12,774
Plant construction and equipment costs incurred during the year	$ 331,516	$ 298,979	$ 289,744	$ [illegible]	$ 301,682	$ 842,504
Total AEC assets, excluding inventories of certain products at June 30	$7,740,629	$7,764,770	$7,652,784	$7,[illegible]	$7,368,272	$8,077,836
Plant investment at June 30 (gross)	$7,344,751	$7,292,784	$7,110,797	$6,[illegible]	$6,713,061	$6,487,301
Production plants	5,458,201	5,552,646	5,494,440	5,[illegible]	5,212,776	4,645,750
Research and development facilities	1,271,253	1,124,543	937,682	[illegible]	753,468	707,107
Communities	85,523	179,013	229,197	[illegible]	299,292	299,290
Other	203,085	186,825	178,332	[illegible]	200,501	206,202
Plant construction in progress at June 30	326,689	249,757	271,146	[illegible]	247,024	628,952
Funds appropriated – net	$2,649,614	$2,635,335	$2,333,974	$1,[illegible]	$ 834,227	$1,209,860
Operations	2,387,114	2,385,406	2,225,470	1,[illegible]	1,146,400†	1,098,978
Plant acquisition and construction	262,500	249,929	108,504	[illegible]	(312,173)†	110,882
Employment at June 30	122,646	121,858	120,973	[illegible]	110,143	112,555
AEC employees	6,835	6,785	7,021	[illegible]	6,583	6,013
Operating contractor employees	104,612	105,195	103,290	[illegible]	90,238	82,936
Construction contractor employees	11,199	9,878	10,662	[illegible]	13,322	23,606

*Includes depreciation.

† Includes transfer to operations of $571 million appropriated in prior years as plant and equipment funds.

ES ATOMIC ENERGY COMMISSION

SUMMARY OF FINANCIAL DATA

(in thousands of dollars)

	1957	1956	1955	1954	1953	1952	1951
9	$1,918,254	$1,607,973	$1,289,535	$1,039,178	$ 904,596	$ 684,181	$ 494,638
1	397,813	278,946	193,586	142,793	82,153	72,510	47,490
8	762,815	730,972	588,445	409,735	318,255	205,746	140,822
6	337,183	280,765	258,706	250,025	257,488	229,178	163,594
5	255,047	168,853	114,557	99,334	104,091	64,448	44,472
2	58,196	45,880	28,064	20,103	10,201	5,903	3,202
8	168,720	101,410	53,011	42,010	53,209	39,501	30,011
5	28,742	21,563	33,482	37,221	40,681	19,044	11,259
9	69,657	56,547	48,221	43,630	41,846	34,671	29,833
2	11,126	7,066	4,718	1,741	800	150	50
6	17,505	11,981	8,583	7,802	8,644	5,948	5,262
1	40,934	37,500	34,920	34,087	32,402	28,573	24,521
8	33,148	29,849	28,898	26,974	26,295	24,536	21,245
2	8,897	8,954	10,321	11,822	15,157	16,363	17,322
5	38,496	38,195	34,027	34,671	35,514	31,432	24,541
5	14,579	14,892	12,774	20,194	23,797	5,297	5,319
4	$ 317,022	$ 301,682	$ 842,504	$1,215,141	$1,125,579	$1,082,174	$ 459,192
4	$7,397,911	$7,368,272	$8,077,836	$8,144,414	$8,014,455	$4,692,584	$3,680,333
7	$6,907,894	$4,713,061	$6,487,301	$5,705,405	$4,579,089	$3,496,957	$2,516,014
0	5,392,464	5,212,776	4,645,750	2,957,784	2,118,137	1,327,335	1,287,447
2	792,633	753,468	707,107	616,548	548,009	338,836	233,702
7	267,283	299,292	299,290	300,248	298,454	287,999	281,727
2	144,289	200,501	206,202	215,691	184,913	179,705	121,936
6	311,217	247,024	628,952	1,615,134	1,429,576	1,363,082	591,202
4	$1,896,706	$ 834,227	$1,209,860	$1,042,492	$4,136,476	$1,605,756	$2,032,143
0	1,740,406	1,146,400†	1,098,978	886,483	808,935		
4	156,300	(312,173)†	110,882	156,009	3,327,541		
3	119,388	110,143	112,555	141,949	148,799	149,371	99,126
1	6,623	6,583	6,013	6,123	6,894	6,662	5,646
0	98,176	90,238	82,936	73,312	71,775	58,101	47,745
2	14,388	13,322	23,606	62,514	70,130	84,608	45,735

ant and equip-

Plant and Equipment

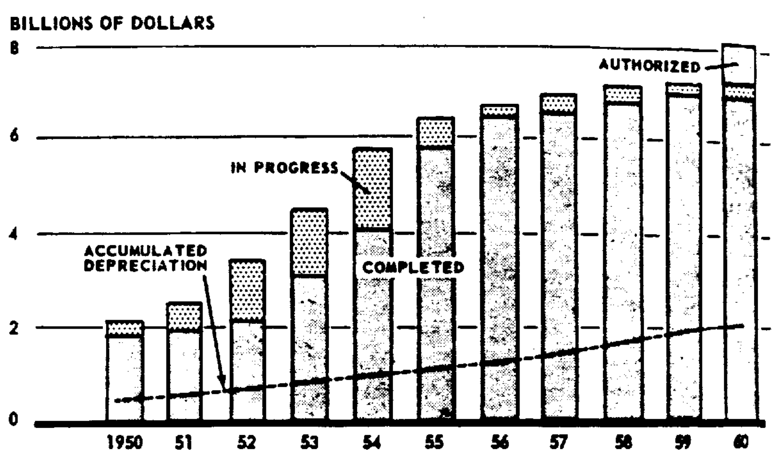
PLANT AND EQUIPMENT

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 $7.0 billion at June 30, 1960—substantially the same as at June 30, 1959.

The estimated cost of plant under construction or authorized at June 30, 1960 totaled $1,1[illegible] million. Costs incurred through June 30, 1960 on plant under construction amounted to $[illegible] million, leaving the estimated costs to be incurred subsequent to June 30, 1960 at $839 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 1951 through 1960. For fiscal year 1960, the chart also shows plant projects authorized prior to June 30, 1960 for construction or completion in subsequent periods.

INVESTMENT IN PLANT & EQUIPMENT



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INVES

Production
Raw materials
Feed materials
Gaseous diffusion plants
Production reactors and separations areas
Weapons production and storage
Heavy water
Other production facilities
Total production

Research and development
Laboratories
Reactors
Accelerators
Weapons test facilities
Total research

Communities
Other
Total

...s in investment in plant and e

Investment—June 30, 1959
Construction and equipment costs
Additions to completed plant
Plant transfers and retirements
Sale of community facilities by HHFA
Investment—June 30, 1960

INVESTMENT IN PLANT AND EQUIPMENT

June 30, 1960

(at cost)

	Completed Plant	Construction in Progress *(in thousands)*	Total
...ction			
...w materials	$ 9,910	$ 10	$ 9,920
...ed materials	253,441	2,988	256,429
...eous diffusion plants	2,333,564	8,970	2,342,534
...duction reactors and separations areas	1,622,435	34,512	1,656,947
...apons production and storage	803,182	17,870	821,052
...vy water	163,365		163,365
...er production facilities	272,304	5,884	278,188
Total production	5,458,201	70,234	5,528,435
...rch and development			
...oratories	898,546	83,585	982,131
...ctors	244,382	121,519	365,901
...celerators	69,652	44,917	114,569
...apons test facilities	58,673	201	58,874
Total research	1,271,253	250,222	1,521,475
...unities	85,523	7	85,530
...	203,085	6,226	209,311
Total	$7,018,062	$326,689	$7,344,751

... investment in plant and equipment during the fiscal year are as follows:

	Completed Plant	Construction in Progress *(in thousands)*	Total
...ment–June 30, 1959	$7,043,027	$249,757	$7,292,784
...uction and equipment ...		331,516	331,516
...s to completed plant	254,584	(254,584)	
...nsfers and retirements	(258,247)		(258,247)
... community facilities ...EFA	(21,302)		(21,302)
...ment–June 30, 1960	$7,018,062	$326,689	$7,344,751

5007125

AEC PLANT AND EQUIPMENT
(at cost)

By Location
June 30, 1960

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
		(in millions)		
CALIFORNIA				
Lawrence Radiation Laboratory, University of California				
Berkeley	$ 40.1	$ 10.6	$ 12.7	[illegible]
Livermore	67.8	13.4	2.7	[illegible]
Research facilities, Sandia Corporation, Livermore	9.0			[illegible]
Medical research facilities, University of California, Los Angeles	1.2		.2	[illegible]
Salton Sea Base, Sandia Corporation, Salton Sea	7.6			[illegible]
Research facilities, California Institute of Technology, Pasadena	1.9			[illegible]
Reactor and research facilities, Atomics International Division, North American Aviation, Inc., Canoga Park	16.5	8.3	1.5	[illegible]
COLORADO				
Uranium handling, sampling, and general facilities, Lucius Pitkin, Inc., Grand Junction	5.3			[illegible]
Rocky Flats Plant, Dow Chemical Company, Boulder	73.2	4.5	.4	[illegible]
CONNECTICUT				
Connecticut Aircraft Nuclear Engine Laboratory, Pratt and Whitney, Middletown	4.6*†			[illegible]
Linear accelerators, Yale University, New Haven	2.8	1.0		[illegible]
Submarine reactor facilities, Combustion Engineering, Inc., Windsor	12.8	1.7		[illegible]
FLORIDA				
Pinellas Plant, General Electric Company, Clearwater	10.6	1.0	.1	[illegible]
IDAHO				
National Reactor Testing Station Phillips Petroleum Company				
Chemical processing plant	49.9	12.6	3.2	[illegible]
Materials testing reactor	14.3	1.2		[illegible]
Engineering test reactor	12.5	.1		[illegible]
Reactor facilities	15.2	13.1	7.1	[illegible]
General facilities	19.2	3.9		[illegible]
Total	111.1	30.9	10.3	[illegible]

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
	(in millions)			
IDAHO Cont'd				
Westinghouse Electric Corporation				
Large ship reactor	$ 28.8	$ 2.2		$ 31.0
Submarine thermal reactor	12.0			12.0
Other research facilities	16.5	1.8		18.3
Total	57.3	4.0		61.3
Aircraft nuclear propulsion facilities, General Electric Company	36.6	16.4		53.0
Reactor facilities, Argonne National Laboratory	2.9	34.1		37.0
Organic moderated reactor experiment, North American Aviation, Inc.	2.4	.6		3.0
Knolls Atomic Power Laboratory, General Electric Company	1.6		$18.5	20.1
Total, NRTS	211.9	86.0	28.8	326.7
ILLINOIS				
Argonne National Laboratory, University of Chicago, Argonne	114.4	81.6	3.6	199.6
Argonne Cancer Research Hospital, University of Chicago, Chicago	4.6	.2		4.8
Materials Research Laboratory, University of Illinois, Champaign			5.6	5.6
INDIANA				
Radiation Laboratory, University of Notre Dame, Notre Dame			2.2	2.2
IOWA				
Research Laboratory, Iowa State College, Ames	7.9	2.4	3.6	13.9
Iowa Ordnance Plant, Mason and Hanger, Burlington	30.3‡	1.8	.4	32.5
KENTUCKY				
Paducah				
Gaseous Diffusion Plant, Union Carbide Nuclear Company	753.7	3.8	1.0	758.5
Feed Materials Plant, Union Carbide Nuclear Company	25.8	.4		26.2
Total, Paducah	779.5	4.2	1.0	784.7

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
	(in millions)			
MARYLAND				
AEC Headquarters, Germantown	$ 16.6	$ .7	$ .6	$ [illegible]
MASSACHUSETTS				
Cambridge electron accelerator, Harvard University, Cambridge	3.8	8.1		[illegible]
Raw materials development laboratory, National Lead Company, Winchester	1.3			[illegible]
MINNESOTA				
Linear accelerator, University of Minnesota, Minneapolis	1.8*			[illegible]
Boiling water power reactor, Rural Cooperative Power Association, Elk River		9.5		[illegible]
MISSOURI				
Kansas City Plant, Bendix Aviation Corporation, Kansas City	27.9§	5.3	2.9	[illegible]
Feed Materials Plant, Mallinckrodt Chemical Works, Weldon Spring	56.7	.9	.6	[illegible]
NEBRASKA				
Sodium graphite power reactor, Consumers Public Power District, Hallam	.3	26.7		[illegible]
NEVADA				
Mercury				
Nevada Test Site, Reynolds Electrical and Engineering Company	37.8	15.0	19.5	[illegible]
Laboratory facilities, Lawrence Radiation Laboratory	1.4	14.2		[illegible]
Total, Mercury	39.2	29.2	19.5	[illegible]
Tonopah				
Research facilities, Reynolds Electrical and Engineering Company	.6		.3	[illegible]
Research facilities, Sandia Corporation	1.3	.4		[illegible]
Total, Tonopah	1.9	.4	.3	[illegible]

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
	(in millions)			
NEW JERSEY				
Merchant ship reactor, Camden		$ 27.8		$ 27.8
New Brunswick Laboratory, Atomic Energy Commission, New Brunswick	$ 2.1			2.1
Picatinny Arsenal Ordnance Facility, Atomic Energy Commission, Dover	1.4‡			1.4
Princeton				
Princeton-Pennsylvania proton accelerator, Princeton University	.8	10.3	$11.7	22.8
Model C stellarator facilities, Princeton University	4.6	5.2		9.8
Research facilities, Princeton University	4.3	.1		4.4
Total, Princeton	9.7	15.6	11.7	37.0
NEW MEXICO				
Albuquerque				
Sandia Laboratory, Sandia Corporation	77.3	11.4	4.6	93.3
South Albuquerque Works, ACF Industries, Inc.	20.8	.1	.1	21.0
Total, Albuquerque	98.1	11.5	4.7	114.3
Los Alamos				
Los Alamos Scientific Laboratory, University of California	143.0	22.5	11.5	177.0
Community and general maintenance facilities, The Zia Company	129.9	3.4	1.2	134.5
Los Alamos Hospital, Los Alamos Medical Center, Inc.	2.9			2.9
Total, Los Alamos	275.8	25.9	12.7	314.4
NEW YORK				
Brookhaven National Laboratory, Associated Universities, Inc., Upton	87.1	30.4	15.4	132.9
New York City				
Computing and other research facilities, New York University	1.5			1.5
Accelerator and research facilities, Columbia University	1.8	.8		2.6
Total, New York City	3.3	.8		4.1

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started
		(in millions)	
NEW YORK Cont'd			
Boron plant, Olin Mathieson Chemical Corp., Niagara Falls	$ 7.8		
Research laboratory, University of Rochester, Rochester	5.0	$ .5	$ .1
Knolls Atomic Power Laboratory, General Electric Company, Schenectady	39.4	1.9	
Knolls Atomic Power Laboratory, General Electric Company, West Milton	33.5	35.5	
OHIO			
Aircraft nuclear propulsion facilities, General Electric Company, Lockland	10.4*†		
Portsmouth			
Portsmouth Gaseous Diffusion Plant, Goodyear Atomic Corporation	754.3	2.8	1.1
Feed Materials Plant, Goodyear Atomic Corporation	8.0		
Total, Portsmouth	762.3	2.8	1.1
Feed Materials Plant, National Lead Company, Fernald	111.6	2.7	3.3
Mound Laboratory, Monsanto Chemical Company, Miamisburg	30.0	3.5	.3
Organic moderated power reactors City of Piqua, Piqua		8.3	
PENNSYLVANIA			
Bettis Plant, Westinghouse Electric Corporation, Pittsburgh	45.2	11.8	
Accelerator and research facilities, Carnegie Institute of Technology, Pittsburgh	1.3		
Pressurized Water Reactor, Duquesne Light Company, Shippingport	48.8	1.0	9.0
SOUTH CAROLINA			
Savannah River Plant, E. I. du Pont de Nemours and Co., Inc., Aiken			
Production reactor facilities	620.7	11.0	8.7
Separations facilities	261.2	15.3	1.6
Feed materials production facilities	6.1		.1

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started	Total
	(in millions)			
SOUTH CAROLINA Cont'd				
Heavy water production facilities	$ 163.4			$ 163.4
Works laboratory	46.3	$ 12.4	$ .2	58.9
General facilities	163.4	6.2	.2	169.8
Total, Aiken	1,261.1	44.9	10.8	1,316.8
TENNESSEE				
Oak Ridge				
Research laboratory, Oak Ridge Institute of Nuclear Studies	3.3	.2	.3	3.8
Agriculture Research Laboratory and Farm, University of Tennessee	1.0	.4	.2	1.6
Experimental gas cooled reactor	.1	30.6		30.7
Oak Ridge Gaseous Diffusion Plant, Union Carbide Nuclear Company	834.7	10.3	2.1	847.1
Fabrication and development facilities, Union Carbide Nuclear Company	379.5	10.0	8.8	398.3
Oak Ridge National Laboratory, Union Carbide Nuclear Company	144.7	41.8	19.0	205.5
Service facilities	21.6	.5		22.1
Total	1,384.9	93.8	30.4	1,509.1
Community services, Oak Ridge	2.2			2.2
TEXAS				
Pantex Plant, Mason and Hanger, Amarillo	24.3‡	.6	.4	25.3
UTAH				
Monticello				
Uranium ore processing plant, Lucius Pitkin, Inc.	5.6			5.6
Community services, Lucius Pitkin, Inc.	.5			.5
Total, Monticello	6.1			6.1
WASHINGTON				
Hanford Works, General Electric Company, Hanford				
Production reactor facilities	484.1	165.1	8.1	657.3
Separations facilities	204.7	4.3	5.8	214.8
Feed materials production facilities	38.3	.1	.8	39.2
Works laboratory	56.4	16.7	3.4	76.5
General facilities	140.7	7.8	.2	148.7
Total	924.2	194.0	18.3	1,136.5

Location and Contractor	Completed Plant and Equipment	Estimated Cost of Projects Under Construction	Projects Authorized Construction Not Started
		(in millions)	
WASHINGTON Cont'd			
Community services, General Electric Company, Richland	$ 3.8		
WEST VIRGINIA			
Huntington pilot plant, International Nickel Company, Huntington	4.7		
WYOMING			
Army Package Power Reactor No. 2, The Martin Co., Sundance	.4	$ 3.0	
PUERTO RICO			
Puerto Rico Nuclear Center, University of Puerto Rico, Mayaguez	.5	3.8	
Nuclear superheat power reactor, Punta Higuera		.4	$ 8.5
JAPAN			
Research facilities, National Academy of Science, Hiroshima	2.0	.1	.1
MARSHALL ISLAND			
Eniwetok Proving Grounds, Holmes and Narver, Inc., Eniwetok	35.5¶		
ALL OTHER			
Various locations			
Weapons storage facilities	186.4	2.2	
Other	57.7	18.6	114.1
Total, All other	244.1	20.8	114.1
Total	$7,018.1	$838.9	$327.6**

* Equipment only.
† Basic plant owned by U. S. Air Force.
‡ Basic plant owned by U. S. Army.
§ Basic plant owned by U. S. Navy.
¶ Transferred to the Department of Defense in July 1960.
** Includes plant projects of $221 million authorized in Public Law 86-457 approved May 13, 19[illegible]