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UNITED STATES ATOMIC ENERGY COMMISSION

# *Annual Report to Congress*

OF THE

# ATOMIC ENERGY COMMISSION

FOR

# 1964

January 1965

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

# ERRATA SHEET

## ANNUAL REPORT TO CONGRESS – 1964

and

## MAJOR ACTIVITIES IN THE ATOMIC ENERGY PROGRAM
JANUARY - DECEMBER 1964

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# LETTER OF SUBMITTAL

WASHINGTON, D.C.,
*January 29, 1965.*

SIRS: We have the honor to submit herewith the Annual Report of the United States Atomic Energy Commission for 1964 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
MARY I. BUNTING.
JOHN G. PALFREY.
JAMES T. RAMEY.
GERALD F. TAPE.
GLENN T. SEABORG, *Chairman.*

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

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## Part One

# The Atomic Energy Program—1964

The Atomic Energy Commission, in order to fulfill the statutory policies of the Atomic Energy Act of 1954, as amended, has established the following missions:

(*1*) To conduct basic research to increase knowledge of natural phenomena and environments and to apply scientific data to a wide range of nuclear applications and to resolution of related problems.

(*2*) To develop technology for specific applications and to test and demonstrate nuclear processes and prototypes for government and industrial uses.

(*3*) To foster the participation of educational, industrial, and international communities in atomic energy activities, and to disseminate scientific and technical information so as to encourage scientific and industrial progress.

(*4*) To provide those basic materials and related services essential to the production of nuclear weapons and for civilian and other military applications where needed.

(*5*) To develop, test, and produce safe and reliable atomic weapons in accordance with national requirements.

(*6*) To regulate the possession, use, and production of atomic energy and special nuclear materials in the interest of the common defense and security and the national welfare.

*Commissioners and The President.* Dr. Mary I. Bunting, President of Radcliffe College, Cambridge, Mass., became the first biologist to be appointed a member of the Atomic Energy Commission when she was sworn in by President Johnson on June 29. Dr. Bunting was appointed to fill the unexpired term (ending June 30, 1965) of the late former Commissioner Robert E. Wilson who had retired on February 1, 1964. Photo shows, *left to right*, Commissioner James T. Ramey, Commission Chairman Glenn T. Seaborg, President Johnson, Commissioner Bunting, Commissioner John G. Palfrey, Commissioner Gerald F. Tape, and former Commissioner Wilson, who passed away on September 1 while serving as an advisor to the Third United Nations Conference on Peaceful Uses of Atomic Energy in Geneva, Switzerland.

# THE ATOMIC ENERGY PROGRAM—1964

The year 1964 was marked by great steps taken in the continuing effort to make the Nation's atomic energy program less a Government monopoly and more a cooperative partnership in which private enterprise performs an increasingly important role. These steps, large and small, are indicated throughout this Annual Report to Congress for 1964.[1]

Part One—The Atomic Energy Program—1964, summarizes very briefly: (*a*) the year's more noteworthy actions and events in "highlight" form in the same order as they appear in this report; (*b*) actions and decisions of the five-member Commission which can have a broad effect upon the atomic energy program; (*c*) the Commission's adjudicatory activities; and (*d*) a list of those individuals honored for their individual contributions to the atomic energy effort.

A supplemental report, Fundamental Nuclear Energy Research—1964,[2] describes some of the many recent advances under Commission-sponsored fundamental research and development.

## HIGHLIGHTS OF 1964

### *Private Ownership of Nuclear Materials*

• Legislation initiated by the Commission to end mandatory Government ownership of special nuclear materials in the United States became law. (Part One)

### *Production Cutback*

• President Johnson announced reductions in the production rate for plutonium and enriched uranium in his State of the Union Message on January 8; in April, he announced a further reduction for enriched uranium. (Parts One and Two)

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[1] This Annual Report to Congress for 1964 is available to the public under an alternate title, "Major Activities in the Atomic Energy Programs—January–December 1964," from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for (*UPDATE*).

[2] "Fundamental Nuclear Energy Research—1964" is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for (*UPDATE*).

### *Replacement of Operating Contractor*

• At the Hanford Plant, near Richland, Wash., AEC laboratory and production operations are being changed from a single-contractor to a multicontractor operation. Selection of new contractors will take into account the firms' plans to assist in the diversification of the local area. Battelle Memorial Institute has been selected to operate the Hanford Laboratories (being renamed Pacific Northwest Laboratory) for the AEC and, to the extent compatible with AEC programs, also will be allowed use of the Government-owned facilities for private work. (Part One)

### *Raw Materials*

• Five contract modifications, providing for deferment of deliveries in accordance with the "stretch-out" program announced in November 1962, were signed in 1964 with companies supplying uranium concentrates to the AEC. These together with five others on which negotiations are continuing, and the one signed in 1963, are expected to result in deferment of about 15,000 tons of $U_3O_8$ previously contracted for delivery by the end of 1966. (Part Two)

### *Production*

• Oak Ridge's K–25 and K–27 buildings at the gaseous diffusion plant and Savannah River's R reactor were the initial facilities shut down as a result of the announced cutbacks in production. (Part Two)

• The Idaho Waste Calcining Facility completed a successful 10-month initial operating period of processing high-level radioactive liquid wastes into dry solids. (Part Two)

### *Military Application*

• The Commission announced 29 underground nuclear weapons tests during the year. The conduct of an airborne exercise during October, the completion of necessary Pacific area construction, and the stocking of materials showed a readiness posture to resume atmospheric testing should the limited nuclear Test Ban Treaty be broken by others. (Part Two)

### *Civilian Nuclear Power*

• President Johnson, in a speech to a graduating class at Holy Cross College, Worcester, Mass., on June 10, noted the economic progress made in the use of large-scale reactors for commercial power and that the Nation's civilian nuclear power program is ahead of schedule. (Part Three)

• Construction started on three large nuclear power plants—Southern California Edison's San Onofre plant, the Connecticut Yankee facility at Haddam Neck, Conn., and Jersey Central's Oyster Creek plant—and the Commission accepted, as the basis for negotiations, proposals to undertake, under joint cooperative arrangements, the design, construction, and operation of a prototype high-temperature gas-cooled reactor plant in New York, and a large seed-blanket nuclear power plant in California which may also be used for desalting of sea water.

### *Space Applications*

• The successful conduct of three major nuclear propulsion reactor experiments completed the Kiwi phase of the Rover program. The first NERVA reactor power experiment was also successfully completed in connection with the Rover program. Effort is now being concentrated on the continued development of the NERVA engine technology project and the advanced graphite reactor technology project called Phoebus. (Part Three)

### *SNAP Reactor Units*

• The first nuclear flight design of the SNAP–10A began ground test operation and the flight test of a SNAP–10A was scheduled for the spring of 1965. (Part Three)

### *Army Reactors*

• The Mobile Low Power Plant No. 1 (ML–1) underwent a highly successful limited-endurance and full-power test during which the plant accumulated more than 664 hours of operation. (Part Three)

### *Naval Reactors*

• A very high-powered, two-reactor nuclear propulsion plant is under development for use in future aircraft carriers. (Part Three)

### *Pluto Program*

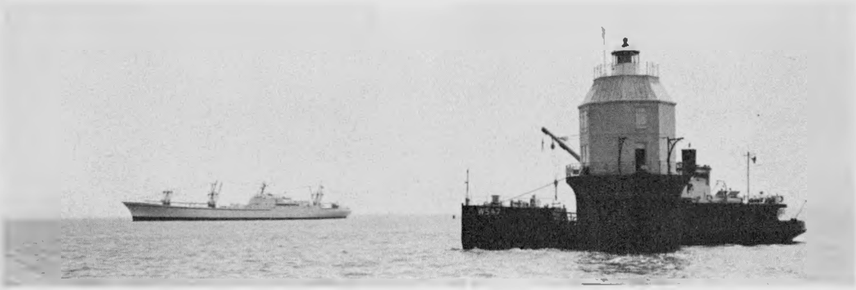
• The nuclear ramjet Tory IIC reactor was successfully ground tested at full power under simulated flight conditions of sea level and


*Reactor Clustering.* A major milestone toward future use of nuclear reactors for space propulsion was achieved on August 26 when, for the first time, two Kiwi-type reactors were safely brought to criticality at the same time while within a few inches of each other and then operated as a single reactor system. The Los Alamos Scientific Laboratory experiment, conducted under the AEC's Rover nuclear rocket propulsion program, showed the possibility of using the tremendous thrust of "clustered" nuclear rocket engines for space exploration. The two Kiwi-type reactors shown *above* without their exhausts, were initially placed 12 feet apart and were slowly "inched" together over a period of a month. Because of cooling and shielding problems at the laboratory site, the power level of each reactor was held below 1,000 watts, although each is capable of a thousand times as much energy. The reactors were similar to the Kiwi-B4, the last in the Kiwi series of experiments, which was operated at the Nuclear Rocket Development Station in Nevada at high power for more than 8 minutes on August 28 and then, on September 10, successfully restarted and again operated near design power—proving the restart capability of such a reactor.

a Mach 2.8 design speed. The project was then phased out by the AEC because of a decision by the Department of Defense against pursuing a flight test objective. (Part Three)

### *Aerospace Safety Program*

• Two major safety tests were conducted on SNAP systems: one to determine the consequences of a nuclear excursion that could be caused by the inadvertent water immersion of a SNAP–10A reactor, the other to demonstrate that an isotopic generator would disassemble and its radioactive fuel capsules would be burned up upon reentering the earth's atmosphere from an orbit. (Part Three)



*Nuclear Lighthouse and Ship.* As the Baltimore lighthouse in Chesapeake Bay, Md., became the first lighthouse in the world to be operated by nuclear energy, the world's first nuclear-powered merchant ship NS *Savannah* passed by on May 20, 1694. Behind the lighthouse is the U.S. Coast Guard buoy tender *White Pine* from which the SNAP–7B radioisotope generator is just being lifted from the deck (to *left* of lighthouse) for installation in the navigational aid. The 60-watt, strontium 90-fueled SNAP–7B electric power generator is designed to operate unattended for 10 years.

### *Plowshare Program*

• There was impressive activity in the Commission's Plowshare program to develop peaceful uses for nuclear explosives, with seven experiments being carried out during the year. Six of these were nuclear detonations and one was a high explosive experiment. Data from these experiments should make possible further advances in all of the major areas of the Plowshare program: excavation, industrial engineering, and scientific research. One of these experiments, Project Sulky, was the first nuclear cratering detonation to be carried out under the terms of the limited nuclear Test Ban Treaty, another experiment, Par, was a major breakthrough in developing nuclear explosives for producing heavy elements and perhaps obtaining new elements.

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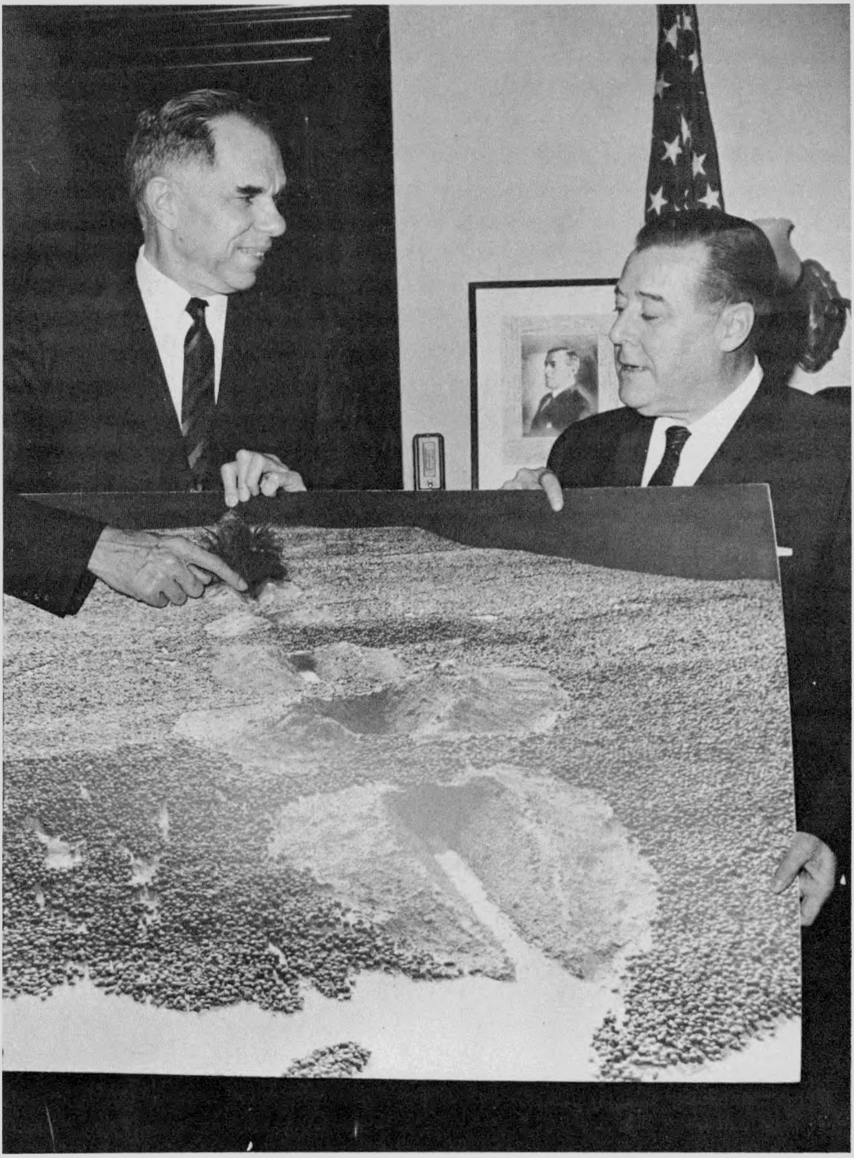


*Canal-digging Technique.* During the year, a Federal study was authorized to determine the most suitable American trans-isthmian site for a possible new sea-level canal to connect the Atlantic and Pacific Oceans and the most feasible method of construction—conventional or nuclear excavation. Photo shows AEC Chairman Glenn T. Seaborg explaining to Senator Warren G. Magnuson of Washington a nuclear explosives canal-digging technique proposed by the Lawrence Radiation Laboratory—Livermore. As shown in the large photo of a Livermore-built model, a series of trenches could first be excavated by nuclear detonations on a "leap-frog" basis; a second series of detonations would excavate the remaining sections to form a continuous canal.

### *Isotopes Development*

• The Commission withdrew from production and distribution of six radioisotopes now available commercially. Progress in radiation pasteurization of food, the first really promising new principle of food preservation since the art of canning was discovered in 1809, was evidenced by Food and Drug Administration approval of the use of cesium 137 for radiation sterilization of bacon and for disinfestation of wheat and wheat products, and cobalt 60 for sprout inhibition of white potatoes and approved certain packaging materials for radiation processed foods. Radiation produced wood-plastic combinations were selected by Science Service as one of the top ten scientific, medical, and technical advances in 1964. (Part Four)

### *International Activities*

• Trilateral agreements have been concluded with eleven countries for administration by the International Atomic Energy Agency of safeguards against the diversion to military use of materials supplied for peaceful purposes; the IAEA made its first safeguard inspection of the Yankee reactor at Rowe, Mass. Several countries showed interest for cooperative studies on dual-purpose nuclear power/water desalting reactors. (Part Four)

### *International Conferences and Exhibits*

• The United States had an official delegation of 196, plus 219 persons who paid their own way, to the Third United Nations International Conference on Peaceful Uses of Atomic Energy at Geneva, Switzerland. An 18,000-square-foot exhibit supplemented the presentation of 98 technical papers by U.S. participants. (Part Four)

### *Biology and Medicine*

• Under the AEC's program of nuclear energy civil effects, a Civil Defense research project was established at the Oak Ridge National Laboratory. Progress has been made in dosimetry studies of the survivors of the Hiroshima and Nagasaki bombings, and a linear accelerator will be used in a field operation to further these studies. (Part Four)

### *Physical Research*

• Construction of the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory was completed in September. The new research facility provides an extremely high flux of neutrons which will greatly enhance basic studies on the structure of matter. (Part Four)

***Education and Training***

• University-AEC Laboratory cooperative programs—which permit participation of university faculty and graduate students in research activities in AEC national laboratories—was expanded at Savannah River Laboratory; Hanford Laboratories; National Reactor Testing Station; Ames Laboratory; Los Alamos Scientific Laboratory; Lawrence Radiation Laboratory; and Sandia Laboratory. (Part Four)

***Technical Information***

• A 6-month cooperative effort to develop compatible systems for computer storage and retrieval of technical information was undertaken by the AEC and the European Atomic Energy Community (Euratom). (Part Four)

***Industrial Participation***

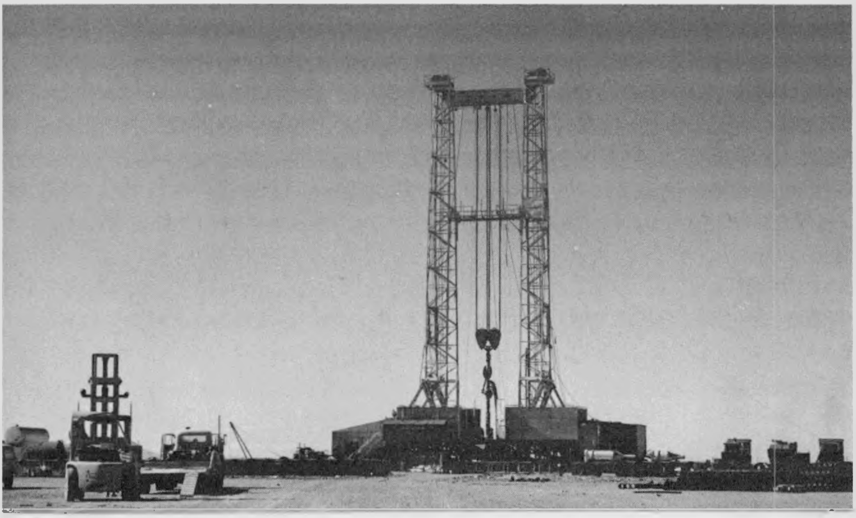
• The year was marked by continued close collaboration between the AEC and the growing private industry in advancing the nation's nuclear economy as the annual survey of shipments of industrial atomic energy products showed an uptrend. (Part Five)

***Industrial Relations***

• About 185,000 persons were engaged in atomic energy work. Man-hours lost due to strikes at AEC-owned contractor-operated installations were 0.17 percent of scheduled man-hours, as compared with 0.5 percent in 1963. (Part Five)

***Operational Safety***

• The AEC continued to make safety a way of life in its operations as the 1964 overall accident frequency rate of 1.96 was well below the all-industrial average of 6.12 rate as reported by the National Safety Council. (Part Five)



*"Technology Spin-off."* The AEC-Department of Defense underground weapons test program in Nevada is providing new technology for the drilling industry. The size and depth—up to 160 inches in diameter, and as much as 5,000 feet deep—of the drilled verticle shafts and the associated geological and hydrological conditions have forced radical departures in drilling techniques. For example, photo *above* shows a giant dual-mast drill rig—an innovation never before used. The dual-mast setup greatly increases the capacity for racking pipe and makes for faster raising and lowering of the drill bit and stem, thus greatly reducing the cost of drilling. At *left* is one of the big drill bit assemblies—considerably larger than the conventional oil well bit—used to dig a weapons test shaft. One reason for the large-diameter shafts is that miners and equipment must be lowered into the hole to dig the subterranean "shot chambers."

### *Nuclear Materials Management*

- A basic supply agreement was developed and put into effect in August enabling any contractor making end-products of nuclear materials for the Government to consolidate the separate inventories used under several contracts; savings are anticipated to benefit both the AEC and industry. (Part Five)

### *Patent Matters*

- An additional 230 U.S. patents were made available for licensing during the year, bringing the total to 3,409, and 388 foreign patents increased the current total to 1,882 foreign patents available for licensing. (Part Five)

### *Regulatory Activities*

- (Highlights of the AEC's regulatory activities are shown in Part Six, page 314.)

### *Financial*

- The AEC net cost of operations in fiscal year 1964 amounted to $2.7 billion, approximately the same as for 1963; costs of procuring raw materials and producing nuclear materials dropped about $168 million below those of previous years; and weapons fabrication and development (including testing) increased $108 million as other AEC research and development increased some $82 million. (Appendix 8)

## BROAD COMMISSION ACTIONS AND DECISIONS

### PRIVATE OWNERSHIP OF SPECIAL NUCLEAR MATERIAL

Mandatory Government ownership of special nuclear material in the United States was ended on August 26, 1964, when the President signed into law the Private Ownership of Special Nuclear Materials Act (Public Law 88–489). The new law provides for a transition period for the changeover from Government to private ownership—upon enactment, private ownership became permissive; private ownership of power reactor fuels becomes mandatory after June 30, 1973.

The new law included changes, based on public hearings held in 1963 and 1964, made by the Joint Committee on Atomic Energy in the original bill which had been submitted by the Commission in March of 1963. Both the AEC and industry representatives had testified and submitted material for the record in support of the measure.

*Private Ownership Signing.* Long-sought private ownership of special nuclear materials, such as the enriched uranium used in reactor fuels, became possible on August 26, when President Johnson signed Public Law 88–489 ending the 18-year mandatory Government monopoly on these materials. The changeover had been informally considered by industry, the Commission, and the Joint Committee on Atomic Energy (JCAE) for several years before the legislation was formally proposed to Congress by the Commission in March 1963. Photo shows President Johnson handing one of the pens used in signing the new law to AEC Chairman Glenn T. Seaborg. Looking on, from *left to right*, are: Representative Chet Holifield (California), Vice Chairman of the JCAE; Representatives Melvin Price (Illinois) and Jack Westland (Washington) of the JCAE; Commissioners Gerald F. Tape, James T. Ramey, and Mary I. Bunting; and (*extreme right*) Ernest Tremmel, Director of the AEC's Division of Industrial Participation.

### *New Provisions*

The major new provisions of the act are:

(*1*) The statutory requirement that the Government own all special nuclear material in or under the jurisdiction of the United States is repealed. Government licensing and control for health, safety, and national security purposes continues. Exports must be in accordance with an Agreement for Cooperation with the concerned foreign nation.

(*2*) The AEC may sell special nuclear material to private parties in the United States. After December 31, 1970, new distributions of reactor fuel to power reactor operators by the AEC must be by sale or "toll enrichment" (the processing, for a fee, in AEC facilities of privately owned uranium to produce more highly enriched uranium). On June 30, 1973, all Government-owned reactor fuel previously leased to power reactor operators must be purchased from, or returned to, the Government. The AEC is authorized to repurchase material sold and not consumed.

(*3*) Through December 31, 1970, the AEC must guarantee to purchase plutonium produced in domestic (section 140) reactors through the use of fuel sold or leased by the AEC. The AEC must also guarantee, for a period or periods not to exceed 10 years as to each such period to purchase uranium enriched in the isotope 233 similarly produced. The guaranteed purchase prices to be established by the AEC are not to exceed the estimated value of the materials as fuel in nuclear reactors. (This value is commonly considered to be based on the conceptual substitution in a power reactor of the bred fuel for U–235 valued on the basis of the AEC schedule of charges for enriched uranium.) During the period of domestic guaranteed purchase prices, the AEC can purchase plutonium or uranium enriched in the isotope 233 produced in foreign reactors through the use of fuel sold or leased by the AEC.

(*4*) Beginning January 1, 1969, the AEC may use its gaseous diffusion plants to enrich privately owned uranium for domestic or foreign customers. Contracts for this enrichment service may be executed prior to this date. However, to the extent necessary to assure maintenance of a viable domestic uranium industry, the AEC may not toll enrich foreign uranium for use in domestic reactors.

### *Financial Impact*

The new law is expected to have no significant financial effect on the Government prior to 1969, since most inventories for domestic nuclear power reactors will probably remain on lease. Subsequent to 1969, the new law will result in significant increases in revenues to the Government. The major long-term financial impact, however, will be the elimination of Government investment in enriched uranium for power reactor inventories; this otherwise might have amounted to three or four billion dollars by 1980.

For industry, the requirement that domestic nuclear power reactor operators purchase their fuel inventories may impose a small increase in power costs (about 0.2 to 0.4 mills per kilowatt-hour for most reactors, depending upon financing costs) but the availability of enrichment services and the enlarged opportunity for operation of the competitive forces of private enterprise are expected to neutralize this effect in the 1970's.

The availability of the enriching service on January 1, 1969, is expected to encourage the use of nuclear power abroad and the foreign sale of U.S.-designed reactor systems utilizing enriched uranium.

The initiation of the enrichment service will provide a very important commercial outlet for U.S. uranium producers since the AEC commitments to purchase uranium do not extend beyond December 31, 1970.

## ACTIONS ON FINDING OF PRACTICAL VALUE

Under the Atomic Energy Act of 1954, as amended, there are two broad categories of licenses for facilities, such as nuclear reactors: section 104 pertains to licenses for facilities involved in the conduct of research and development or used in medical therapy, and section 103 concerns commercial licenses. Section 102 provides that whenever the Commission has made a finding in writing that any type of utilization or production facility has been sufficiently developed to be of practical value for industrial or commercial purposes, the Commission may thereafter issue licenses for such type of facility pursuant to section 103.

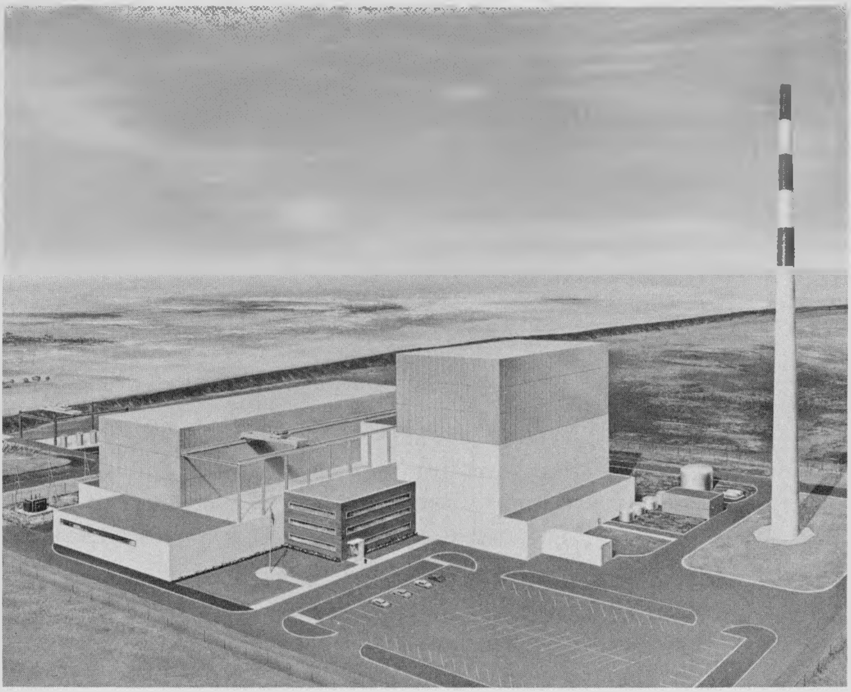
No commercial licenses for facilities have been issued under section 103 since no finding of practical value has yet been made by the Commission. All power reactors have been licensed under section 104b as facilities involved in the conduct of research and development activities leading to the demonstration of practical value for industrial or commercial purposes.

The Commission, in the fall of 1963, had initiated a study of the question as to whether it would now be appropriate to make a finding, pursuant to section 102 of the Act, that any type or types of reactors have been sufficiently developed to be of practical value for industrial or commercial purposes. This finding, if made, would, in essence, be a determination that direct Federal financial assistance will no longer be available for certain types of new reactors.

### *Notices Published*

On July 10, the Commission published a *Federal Register* (29 F.R. 9458) notice requesting public comments and suggestions with respect to the question whether a finding of practical value should be made pursuant to section 102 for some types of light water, nuclear power reactors.

On August 22, the Commission published a notice in the *Federal Register* (29 F.R. 12035) with respect to a petition received on May



*Oyster Creek Plant.* Artist's drawing of the Jersey Central Power & Light Co.'s proposed Oyster Creek 515,000 electrical kilowatt boiling water-type nuclear powerplant, 35 miles north of Atlantic City. The company announced early in 1964 that a nuclear generating facility had been selected for construction "on a competitive basis" with fossil fuel. The plant would be built without AEC financial assistance. A provisional construction permit for the facility was issued by the AEC on December 15, 1964.

14 from the National Coal Policy Conference, Inc., the National Coal Association, and the United Mine Workers of America. The petition requested Commission issuance of a rule finding that boiling and pressurized water reactors which use light water as coolants and moderator are types of facilities sufficiently developed to be of practical value for commercial or industrial purposes. This second notice invited public comments and suggestions with respect to the finding requested by the petitioners and the basis for the request as described in the petition. The proceeding on this petition has been consolidated with the proceeding on the general question, set forth in the first notice, of whether a finding should be made with respect to some type or types of light water, nuclear power reactors.

More than 100 comments were received in response to these two *Federal Register* notices.

### *Hearing Scheduled*

A third notice, published in the *Federal Register* (29 F.R. 15957) on December 1, 1964, announced the holding of a legislative-type public hearing on the consolidated rule making proceeding on January 28, 1965, and the holding of an informal conference on December 17, 1964, for the purpose of focusing on the issues to be covered at the hearing.

## IMPACT OF PRODUCTION CUTBACK

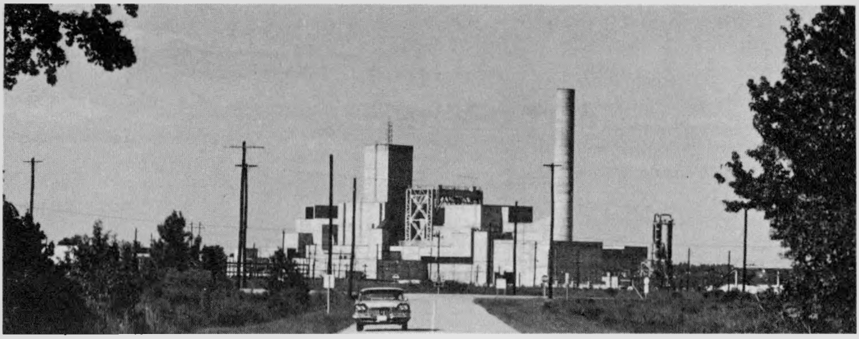
### *Presidential Announcement*

The reduction in plutonium and enriched uranium production announced by the President in his State of the Union message on January 8, 1964, followed studies by the Department of Defense (DOD) and the Commission on their long-range requirements for national defense and peaceful uses of these materials. Subsequently, in April, the President announced a further reduction for enriched uranium production.

*Implementation.* To put the reduction of plutonium production into effect four of the AEC's 14 plutonium-producing reactors were identified for shutdown. The "R" reactor at the Savannah River Plant, S.C., was closed last June and three at the Hanford Plant Wash., are being shut down, the first on December 30, 1964. For the reduction in enriched uranium production, the combined electric energy usage in the gaseous diffusion plant operations at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio, is currently being curtailed by about 25 percent below the fiscal year 1964 level of 5,250 megawatts. Further power cutbacks will take effect gradually and when completed in 1968 will mean overall production of enriched uranium will be 40 percent below that previously planned. The reductions in electric power usage will total 805 megawatts at Oak Ridge, 375 megawatts at Paducah, and 1,100 megawatts at Portsmouth. (See Production section, Part Two.)

The cutback of fissionable materials production will not affect AEC uranium concentrate procurement under existing commitments; procurement of ore concentrates through 1970 will be carried out in accordance with the established program. (See Raw Materials section, Part Two.)

*Employment effect.* The January announcement of reduction in the production of plutonium stated that a reduction of about 24 percent of a total employment of 8,300 would be effected at Hanford (more recent estimates are that the reduction may be somewhat smaller



*Production Cutback.* The first AEC production reactor to be closed as the result of the 1964 cutback in production of plutonium was the "R" reactor at the Savannah River, S.C., plant. The reactor, which was shut down on June 15, had been in service for 10 years as a plutonium and tritium producer. The actual shutdown operation was conducted in the nature of a successful experiment, in that the "last ditch" safety system—injection of gadolinium nitrate to instantaneously quench the fission process—was purposely tripped. It was the first actual use of the system at any of the Savannah River reactors. A group of southeastern utilities has since shown an interest in studying the feasibility of converting the reactor to commercial use. Three other production reactors—of the AEC's 14—are scheduled to be closed at the Hanford, Wash., works.

than this), and about 500 positions out of 6,300 would be affected at the Savannah River Plant. (Actually, a 584-employee reduction was made at Savannah River with only 30 persons separated involuntarily.) The January reduction in enriched uranium production was forecast to include reductions of 380 positions in the AEC's gaseous diffusion plants—180 at Oak Ridge, 120 at Paducah, and 80 at Portsmouth—from a total employment in these plants of 5,100. The additional April reduction meant that an estimated 125 more positions would be eliminated at Oak Ridge and Portsmouth between 1966 and 1968. The employment reductions are, in general, being made gradually as the various production operations are phased-out; at Hanford, for instance, they will not be completed until 1967 or later. As an aid to finding employment for the skilled manpower being displaced, the Commission has inaugurated a job placement system among its major contractors under which monthly lists of recruitment needs and surplus manpower are circulated. (See Industrial Relations section, Part Five.)

*Weapons program change.* In the military applications program, studies associated with long-range DOD–AEC requirements led to a decision by the Commission to close weapons modification facilities at San Antonio, Tex., and Clarksville, Tenn., and consolidate the work done at these plants with operations now conducted at Burlington, Iowa, and Amarillo, Tex. The change-over is scheduled to be completed by mid-1966. (See Military Applications section, Part Two.)

*Related actions.* The plutonium-uranium production cutback resulted in several actions by the Commission, as described below.

## OFFICE OF ECONOMIC IMPACT AND CONVERSION ESTABLISHED

Effective May 6, 1964, an Office of Economic Impact and Conversion was established in the AEC Headquarters to coordinate analysis and review of management activities designed to cope with the broad economic impact resulting from program cutbacks. The new office participates in (*a*) the planning associated with potential program adjustments, (*b*) the conduct of studies to determine the magnitude of economic impacts, (*c*) the analysis of current and projected programs to evaluate possible alternate uses of facilities affected by cutbacks, and (d) the transfer of current single-contractor project functions at Hanford to other contractors. The office also serves as the focal point within AEC headquarters for inter-governmental activities relating to economic impact matters.

For several years, the Commission had been aware that any large-scale reduction in AEC operations would have a serious impact on local communities where the AEC facilities constitute the major economic force. Following a 1962 study,[3] the Commission intensified its efforts to cooperate with such communities to diversify their economic base. The program changes announced in 1964 increased the Commission's attention to such matters, particularly at such locations as Richland, Wash.; Oak Ridge, Tenn.; Paducah, Ky.; Portsmouth, Ohio; San Antonio, Tex.; and Savannah River, S.C.

Because of the scope of employment reductions at Hanford, and since the nearby community of Richland was built by the Government and later sold to the residents with the AEC obligated to make financial assistance payments to the community until 1969, a special Commission interest exists. Accordingly, the Commission has worked with the local community representatives to mitigate the economic impact of reductions through a cooperative effort to diversify the local economy.

## HANFORD CONTRACTOR REPLACEMENT AND DIVERSIFICATION

In January 1964, the Atomic Energy Commission and the General Electric Co. announced that they had mutually concluded that transfer

[3] See pp. 76–80, Annual Report to Congress for 1962.

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of contract work at the Hanford Plant to other contractors over a period of several years would be in the best interests of the Government and General Electric, and should contribute to the future development of the communities in the Hanford area. In February 1964, the Office of Contractor Replacement was established in the AEC Richland Operations Office for the primary purpose of coordinating the transfer of activities to new contractors. A counterpart was established in the General Electric organization and named the Business Planning and Transfer Operation. General Electric has been the AEC's operating contractor for Hanford since 1946.

### *Operating Components and Activities*

Six functional components or activities have been identified as appropriate for operation or performance by separate contractor organizations. The first component, the Hanford Laboratories, has been renamed the Pacific Northwest Laboratory as of January 1, 1965, and will be operated for the AEC by Battelle Memorial Institute of Columbus, Ohio. Battelle expects to invest the major portion of its fee in construction of new facilities for the conduct of its own private work in the area, and has announced its intention to achieve an annual level approximating $20 million in private work.

The second activity, radiation protection services, will be performed by the United States Testing Co.,[4] of Hoboken, N.J., starting in January 1965. The U.S. Testing Co. has constructed a 15,000-square-foot laboratory in North Richland, and anticipates employing the 22 General Electric Employees who did this work previously as well as adding 27 new employees in the future because of the diversified functions to be performed in the new laboratory.

Other components identified for contractor replacement are: reactor operations and fuel preparation, chemical separations and fission product conversion and encapsulation, support services, and automatic data processing services. General Electric will continue to operate the recently completed "N" reactor until its performance has been demonstrated, at which time the Commission intends to transfer it to the new contractor responsible for other production reactor operations and the associated fuels preparation.

Proposals have been received from eight firms and are being evaluated for the management and operation of the reactor and fuel fabrication facilities.

Since private industry had previously indicated an interest in building and operating a fission products conversion and encapsulation plant at Hanford on a commercial basis, and in operating the chemical separations and waste management facilities at Hanford for the

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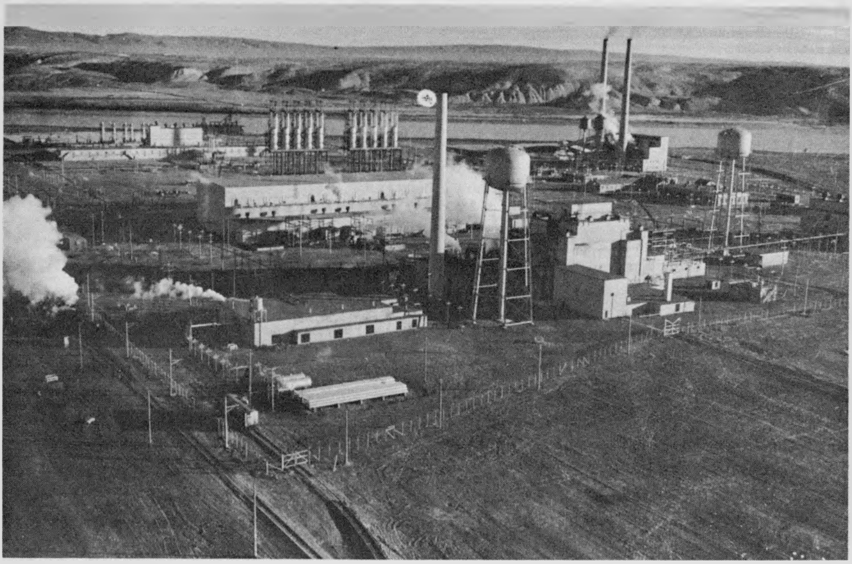
[4] Not an affiliate of the U.S. Government.



*Hanford "F" Reactor Area.* As one of several steps aimed to help alleviate the economic impact to the Richland, Wash., area of the plutonium production cutback, the Commission requested expressions of interest in possible use of the "F" production reactor and/or its auxiliary facilities at the Hanford Works by private industry. Photo shows the "F" reactor area, one of the three production reactors at Hanford scheduled to be shut down in the first half of 1965, with the Columbia River in the background. The auxiliaries include pumping and water treatment plants, a coal-fired steam plant, large storage areas, a 12-million-gallon water retention basin, a building housing refrigeration equipment, office space, and shop and maintenance buildings. These facilities are considered to have possible industrial use, particularly for industries requiring a large supply of treated water.

AEC, the Commission has invited combined proposals in accordance with expressed interest of industry. Three proposals have been received, two of which are joint ventures, and are now being evaluated. If none of the proposals is acceptable, the Government has the option to negotiate management and operation of the chemical separations area on a cost-plus-fixed-fee (CPFF) basis or to construct the facility for contract-operation in view of the long-range significance of this program.

At year's end invitations for proposals to perform the support services were being solicited, and five proposals had been received for the computer services.

### *New Legislation*

On August 1, 1964, President Johnson signed Public Law 88–394 which authorizes the AEC to lease Hanford reservation land, and to sell or lease improvements on the land, and equipment and other property as is determined to be directly related to the land. Such leases or sales can be made if the Commission determines that this step would prevent or reduce adverse economic impact of actual or anticipated reductions in Commission programs in that area. In furtherance of this policy, PL 88–577, enacted August 31, 1964, transferred to AEC jurisdiction over certain public lands within the Hanford reservation in exchange for certain AEC-acquired lands that were given the status of public lands. The public lands transferred to AEC jurisdiction are in a compact unit of an area which is suitable for use as industrial sites.

### *Diversification of Local Economy*

A principal purpose in dividing the Hanford operation among several contractors has been to create an economic climate which will encourage private business interests to locate in the "Tri City Area" of Richland-Kennewick-Pasco, Wash. Studies have indicated that 75 percent of the total local employment is either at the Hanford Plant or depends on Hanford as the major basic payroll in the area. Local community leaders are involved in a continuing and vigorous effort to encourage the development of additional industry, both nuclear and non-nuclear, to reduce the degree of economic dependence upon AEC programs.

Other Federal agencies, as well as the AEC, have been cooperating fully to assist in the local efforts. The Small Business Administration (SBA) has worked cooperatively to help improve the area's capability for effective industrial development through organization of a local development company qualified to participate in the SBA program for assistance in financing such companies. The Bureau of Employment Security, Department of Labor, has assisted by conducting an area skills survey to enable identification of available human resources in the area. The findings will be available to industry. Representatives of the AEC and other Federal agencies regard the Richland situation as an opportunity to bring to bear the full resources of a cooperative Federal-State-local effort to offset the adverse consequences of a major reduction in defense expenditures by finding other productive uses for the human and physical resources available. Further, the President's Committee on the Economic Impact of Defense and Disarmament is watching carefully the diversification activities at Hanford to determine if the experience there might suggest approaches that would be helpful in coping with similar problems elsewhere.

## ASSISTANCE TO OTHER AREAS

The AEC is interested in assisting diversification efforts at other locations and in finding local employment for workers released from AEC work. For example, the Commission is cooperating with the Southern Interstate Nuclear Board (SINB) in developing measures to aid in reducing the dependence on AEC programs of communities near the Savannah River, S.C., and Oak Ridge, Tenn., installations. This consists, in part, of seeking means by which the physical plant facilities no longer needed by AEC can be continued in productive use by other Federal agencies or by private industry so as to provide continuing employment opportunities in the communities. AEC and SBA representatives have met with local business leaders at Oak Ridge to acquaint them more fully with the assistance to local development available through the SBA's programs. At the Medina Base in San Antonio, the AEC and General Services Administration (GSA) are working cooperatively to facilitate earliest possible advertising of the facilities to be available at Medina when AEC operations end there, in the hope that a new user of the facility can be found, and his take-over result in minimizing idle time and resulting unemployment.

### *Savannah River R Reactor*

Early in 1965, a group of 11 private utilities will complete a study made at their expense on the feasibility of converting to commercial use the R Production Reactor at the Savannah River Plant near Aiken, S.C. This reactor was shut down on June 15, 1964. The Commission also announced that it was willing to enter into similar study agreements with other qualified organizations having a legitimate interest; however, except for several informal inquiries, no other group has undertaken a comparable study.

## ARGONNE NATIONAL LABORATORY CHANGE

The Commission announced in October its approval in principle of a proposal that the prime contract for the operation and management of the Argonne National Laboratory be changed to a tripartite agreement which would include the AEC, a not-for-profit corporation to be organized by a group of midwestern universities, and the University of Chicago. The new plan is intended to stimulate scientific growth in the Midwest by fostering closer cooperation among the area's universities and Argonne on research and development programs. Under the proposed tripartite contract, the new corporation will formulate the laboratory's policies and programs. A board of directors to be composed of representatives of midwestern universities, the scientific community, and the industrial community will head the corporation.

The University of Chicago, which has operated Argonne from its inception in 1946, will continue to operate the laboratory responsive to the policies of the corporation within the terms of the contract and in accordance with the policies and requirements of the AEC.

The new plan was proposed by a seven-man ad hoc committee made up of representatives of the Midwestern Universities Research Association (MURA), the Associated Midwest Universities (AMU), the University of Chicago, and Argonne Laboratory itself. At year's end, details for the change were being worked out.

## COMMUNITIES

### *Los Alamos*

During 1964, the Commission was engaged in a wide range of activities preparatory to the termination of AEC ownership and management of the community facilities at Los Alamos, N. Mex.[5] It is anticipated that AEC ownership and operation of Los Alamos will be transferred to municipal and private ownership. Municipal functions and facilities are planned for transfer to Los Alamos County by September 1967.

*Utility systems.* The AEC began negotiations for transferring the Federally-owned electric and gas distribution systems to the county government. Extended study of the positions of two telephone companies which are vigorously pressing for the opportunity to provide telephone service to the community after AEC withdrawal, preceded a Commission announcement in June that it would solicit formal proposals; terms and conditions of the solicitation are being studied.

*County assumption of additional municipal responsibilities.* Additional AEC-County operation and maintenance contracts became effective, providing for county operation of the Federally owned public library and public golf course in July and September, respectively. The process of moving day-to-day responsibility for particular municipal services including community water-distribution, sewage collection and treatment, and refuse collection to the county government through operating contracts will be continued, pending

[5] As authorized by the September 28, 1962 amendments to the Atomic Energy Community Act of 1955, extending the provisions of the Act to the Los Alamos Community.

*Geneva Conference Set.* As a part of its participation in the Third United Nations International Conference on the Peaceful Uses of Atomic Energy, the AEC published a four-volume set of books dealing with U.S. progress in the fields of nuclear education, nuclear power, nuclear research, and radioisotopes and radiation. The sets were presented to officials of the United Nations, the International Atomic Energy Agency, and the principal representatives of the 77 nations participating in the conference. Photo shows AEC Chairman Glenn T. Seaborg, who co-authored one of the volumes, presenting a set of the books to President Johnson who provided the foreword for each volume.

eventual transfer by the AEC of the municipal facilities to county ownership. The AEC is continuing to assist the county financially in developing the prerequisite administrative organization, by providing financial support for employment of a full-time administrative officer, a full-time county staff planner, and other specialists, and for acquiring the services of consultant firms in several fields.

*Preparations for sale of real property.* Pending completion of planning, Federal Housing Administration appraisal personnel have been making preliminary studies to provide a basis for determining "the current fair market value of the government interest" in properties to be sold, as called for by the Community Act.

Housing assignments to the substandard quarters in wartime-constructed buildings, considered not suitable for retention in the community on a permanent basis, was discontinued in 1964, to begin the process of vacating such buildings by attrition. Removal of vacated buildings was begun in the fall of 1964.

*Predisposal construction projects.* The 1962 amendments making the community act applicable to Los Alamos authorized a substantial amount of community construction work. In 1964, the AEC completed a new, centrally-located north community fire station, so situated as to serve the expanding real-estate development on Barranca Mesa; developed and opened a new subdivision for construction of private housing on Barranca Mesa; constructed a new sewage-treatment plant; enlarged several schools; commenced a program of road and street improvements; and began the rehabilitation and improvement of the water-supply system. Utility lines and walkways serving two-family housing structures which have been determined to be separable for sale purposes have been divided. An architect-engineer firm has been engaged to design a court and administrative facility for the local government. Three additional contracts were entered into during 1964 for new privately financed residential development of sub-divisions in the White Rock and Pajarito areas, approximately 500 acres of undeveloped, usable land remain available for future housing development in the two areas.

### *Nevada Site*

The Commission, on January 24, 1964, requested by letter that the Joint Committee on Atomic Energy at that time take no further action on the proposed legislation (initiated by AEC on August 6, 1963) which would provide limited Government assistance for establishing a new community near the Nuclear Rocket Development Station in Nevada. The AEC, with the concurrence of the National Aeronautics


*Cost Reduction Campaign.* President Johnson's interest in frugality and economy led the AEC and its 73 major cost-reimbursable contractors to intensify efforts in cost reductions; 2,658 deliberate economy actions during 1964 are expected to save the Government some $66 million. Photo shows, *left to right,* AEC Cost Reduction Coordinator Charles G. Manly, Chairman Glenn T. Seaborg, and General Manager Robert E. Hollingsworth looking at a display board depicting some examples of savings made in the current campaign. Photo *below* shows three members of the AEC's New York Operations Office staff receiving a Presidential Citation on December 4 in recognition of the savings—an estimated $500,000 a year—they made in negotiating a discount-type contract for purchase of computers by the overall AEC organization. *Left to right* are: AEC Chairman Glenn T. Seaborg; Peter Devine, Alice Hodnett, and Samuel Hack of the New York Office; President Johnson; and Major General Chester V. Clifton, military aide to the President. Thirty Federal career employees were honored at the ceremony held on the Tenth Anniversary of the Government Incentive Awards Act for their role in carrying out President Johnson's economy objectives.

and Space Administration, made the request in view of the changes in the joint AEC–NASA Nuclear Rocket Development (Rover) program. As a result of those changes, it was concluded there will be no near-term significant increase in personnel at the rocket station. (See Nuclear Reactor Development, Part 3.)

## ADJUDICATORY ACTIVITIES OF THE COMMISSION

### FACILITY LICENSING

#### *Procedural Changes*

*Additional time for review.* In order to allow additional time—45 days instead of the current 30 days—to conduct its informal review of facilities licensing decisions, the Commission adopted an amendment of its regulations which, effective January 7, 1965, allows it 45 days after an initial decision to review and act on the decision on its own initiative.

*Preliminary informal review.* The Commission reviews informally each decision of an atomic safety and licensing board or of a hearing examiner in a facility licensing proceeding, even if no petition for review is filed. The Commission introduced during the year, an additional stage of informal review when an initial decision authorizes issuance of a construction permit or operating license and directs that the decision become effective prior to the expiration of the normal time within which the Commission may review it and make an order on its own motion or on a petition for review. The Commission now conducts a preliminary informal review prior to the effective date of the initial decision, as well as the more comprehensive review.

#### *Matters Considered*

In the *Matter of Connecticut Yankee Atomic Power Co.*, an atomic safety and licensing board had granted a provisional construction permit to Connecticut Yankee for its reactor plant at Haddam Neck, Conn., and had allowed the applicant an interim exemption for a period of 1 year from the requirement that it demonstrate its financial qualifications, on condition that it submit certain preliminary evidence of such qualifications within 60 days. After informal review, the Commission made an order, on its own motion, modifying the construction permit to allow the applicant to ask the board for extension of time to submit the preliminary evidence. (See also Nuclear Reactor Development, Part Three, and Regulatory Activities, Part Six.)

In the *Matter of Malibu Nuclear Plant*, the Marblehead Land Co. and Malibu Citizens For Conservation, Inc., filed petitions with the Commission for leave to intervene as parties in the proceeding for the issuance of a construction permit and operating license for a nuclear power reactor under an application filed by the Department of Water and Power of the City of Los Angeles, Calif. The Commission referred the petitions to an atomic safety and licensing board—to be designated by the Commission for the proceeding. (See also Nuclear Reactor Development, Part Three, and Regulatory Activities, Part Six.)

## MATERIALS LICENSING

### *Matters Considered*

In the *Matter of Hamlin Testing Laboratories, Inc.*, of Roseville, Mich., the AEC staff had issued a notice of denial for renewal of a byproduct material license which authorized the use of sealed sources for industrial radiography. The licensee demanded a hearing. A hearing examiner found that a considerable number of violations of the regulations and conditions of the license had been committed, but that none of them was willful. He directed renewal of the license on certain conditions, holding that there had been lack of due process of law in the staff's dealings with the licensee, and that in case of withdrawal of a license the licensee must first be given notice of violation and the opportunity to achieve compliance. Upon review the Commission reversed the hearing examiner's decision and denied renewal of the license. It held that the violations had been willful, and that there had been no violation of due process of law on the part of the staff. It also held that denial of renewal is not withdrawal and that prior notice of violation was thus not required; and that, even if it were, the requirement was dispensed with because the violations were willful. The licensee filed a petition for review in the United States Court of Appeals for the Sixth Circuit, and made a motion for a stay of the Commission's order pending the determination of the appeal. A temporary restraining order was granted by the Court pending the decision of the motion. The licensee's motion for a stay pending the determination of the appeal was later denied, and the temporary restraining order vacated.

## CONTRACT APPEALS

In August 1964, the Commission adopted new rules which established a Board of Contract Appeals to determine appeals from decisions of contracting officers, under new rules designed to provide improved procedures. Appeals from decisions of contracting officers under disputes articles of contracts had, since 1959, been determined by hearing examiners and were subject to review by the Commission. Since 1961, such appeals had been subject to the Commission's discretionary review procedure. The decisions of the Board will constitute the final action of the agency, and will not be reviewed by the Commission. The chairman of the Board is a lawyer employed by the Commission and devotes full time to the Board's work. The vice-chairman is also an AEC lawyer employee, but devotes only part time to the Board. Other members have varied professional backgrounds and will be appointed from within and outside the AEC.

### *1964 Appeals*

The Commission issued, during the course of the year, two orders granting review in contract appeal cases and five orders denying review. In one case, the Commission limited the order granting review by defining specific issues for consideration.

In two contract appeal cases the Commission, having granted review under the discretionary review procedure, made final decisions on the merits.

*The matter of Nager Electric Co., Inc.*, of New York City, grew out of the construction of facilities at the Knolls Atomic Power Laboratory near West Milton, N.Y., and equitable adjustments made by the contracting officer for deletion of certain work. After granting a contracting officer's petition for review of a hearing examiner's decision in favor of the contractor, the Commission reversed the decision to the extent that it held that no deduction should be made.

*The Matter of S & E Contractors, Inc.*, Dallas, Tex., involved a contract for the construction of a testing facility, consisting of a concrete basin and related structures, at the National Reactor Testing Station in Idaho for experiments on the prototype of the S5G submarine reactor. On a petition of the contracting officer, the Commission reversed a decision of a hearing examiner which had declared a constructive change order by reason of alleged suspension of work by the Government. It directed a modified basis for determining the extent of the equitable adjustment.

In *The Matter of the Beryllium Corp.*, Reading, Pa., petitions for review of a hearing examiner's decision were filed by both the contractor and the contracting officer after a decision by a hearing examiner adjudicating a dispute over the quantity of beryllium to be delivered under the terms of a contract. The proceedings were classified Confidential-Restricted Data. By a November 25 order, the Commission granted the petition of the contracting officer in certain respects and denied the contractor's petition.

## OFFICE OF HEARING EXAMINERS

The Office of Hearing Examiners is responsible to the Commission for the conduct of hearings, including the issuance of orders and decisions with respect thereto, in licensing cases, on appeals from contract disputes decisions by AEC contracting officers (on Nov. 10, 1964, this became the function of a new Board of Contract Appeals), in certain patent licensing matters, and also for such other duties as may be assigned by the Commission.

The Commission's four hearing examiners are among the members of the Atomic Safety and Licensing Board (ASLB) panels, and one of them served as Chairman of the Board in each of three ASLB construction permit proceedings conducted during 1964. These hearings involved large power reactors in California, Connecticut, New Jersey, and New York. Prehearing conferences and hearings were held near the reactor locations. Initial decisions authorizing provisional construction permits, with no exceptions having been filed, became the Commission's decision in the Connecticut and California proceedings; the New Jersey provisional construction permit was to become effective in early January 1965, if no exceptions were filed; and the New York proceeding was postponed to early 1965.

The Office of Hearing Examiners during 1964 had on its docket a total of 18 proceedings involving appeals under the standard disputes clause used in the Commission's contracts and subcontracts. For these contract proceedings, nine cases went through hearing and decision, three were dismissed, and six appeals are now pending. No patent licensing cases were conducted by hearing examiners in the past year.

# SCIENTIFIC AWARDS

## ENRICO FERMI AWARD

Vice Admiral Hyman G. Rickover (Ret.) was named as recipient of the AEC's Enrico Fermi Award for 1964 in recognition of his outstanding engineering and administrative leadership in the development of safe and reliable nuclear power and its successful application to national security and economic needs. Admiral Rickover directed the development and construction of the Navy's fleet of nuclear submarines and surface ships and the AEC's Shippingport, Pa., nuclear power facility. Currently, he is serving as Director, Division of Naval Reactors, for the AEC and as Assistant Chief, Bureau of Nuclear Propulsion, Bureau of Ships, for the Navy. The 65-year-old Admiral

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OBSERVATION AND ANALYSIS
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retired from the Navy on February 1, 1964, and was immediately recalled to active duty by the Navy. The award consists of a gold medal, a citation, and $25,000.

Admiral Rickover is the first engineer-administrator and the eighth person [6] to receive the award, named for the late Enrico Fermi, leader of the group of scientists who achieved the first sustained, controlled nuclear chain reaction on December 2, 1942, at Stagg Field, Chicago.

The selection of Admiral Rickover for the award was made by the Commission after consideration of recommendations from its statutory General Advisory Committee. The award will be presented at a ceremony in January 1965.

During 1964, the Commission reviewed the history of the Fermi Award and decided it would be desirable to extend the award criteria to recognize not only scientific achievement but also contributions to engineering and technical management in the development of atomic energy. The Commission also decided it would be consistent with the intent of the award if the monetary amount were returned to the level of $25,000 as was awarded Dr. Fermi in 1954.

## E. O. LAWRENCE AWARD

At an April 30 ceremony, the Commission presented its annual E. O. Lawrence Award to five outstanding young scientists:

*Dr. Jacob Bigeleisen*, Senior Chemist, Brookhaven National Laboratory, Upton, Long Island, N.Y., for outstanding theoretical contributions and experimental advances in the separation of isotopes.

*Dr. Albert L. Latter*, The Rand Corp., Santa Monica, Calif., for contributions in the determination of the destructive effects as well as in the decoupling of nuclear explosions and in the design of nuclear weapons.

[6] See pp. 29–31, Annual Report to Congress for 1963.

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*Youth in Science.* Consistent excellence in science fair competition was displayed by Joyce E. Solomon, Columbia, S.C., student who was an Alternate Winner of AEC Special Awards in the 14th National Science Fair-International (NSF–I) at Albuquerque, N. Mex., in 1963. In the 15th NSF–I held in May at Baltimore, she was again chosen as an AEC Special Awards Alternate Winner. She is pictured *above* as she explained her project "Using Nuclear Emulsions to Track Ionizing Particles" to Dr. Richard W. Dodson of the AEC's Brookhaven National Laboratory, one of the 12 scientists who judged the Baltimore entries to pick the AEC Special Awards winners. In August, 10 of the AEC Special Awards Winners, selected at the 15th NSF–I at Baltimore, and their teachers were provided a "Nuclear Research Orientation Week" at the AEC's Argonne National Laboratory. In photo *below*, Dr. Robert Straube, Argonne biologist, shows laboratory mice to winner Joan Keene of Bardstown, Ky., and her science teacher at Bethlehem Convent, Bardstown, Sister Thomas Veronica. Joan employed nuclear research tools in her project on "Germ-Free Chicken Experimentation."

*Dr. Harvey M. Patt*, Division of Biological and Medical Research, Argonne National Laboratory, Argonne, Ill., for exceptionally high quality research in radiobiology, especially in the field of radiation protection and for his important contributions to the present understanding of the dynamics of white blood cell formation.

*Dr. Marshall N. Rosenbluth*, General Atomic Division of General Dynamics Corp., San Diego, Calif., for developing the theory of scattering of electrons by nucleons, for outstanding contributions in planning the first thermonuclear explosion, and for brilliant contributions to the theoretical understanding of plasmas.

*Dr. Theos J. Thompson*, Department of Nuclear Engineering, Massachusetts Institute of Technology, Cambridge, Mass., for leadership in developing safe, useful and economic nuclear reactors, and for inspired teaching of nuclear engineers.

***E. O. Lawrence Awardees.*** **Photo shows AEC Chairman Glenn T. Seaborg and the five young U.S. scientists who received the E. O. Lawrence Award from the Atomic Energy Commission in a ceremony at the National Academy of Sciences, Washington, D.C., on April 30, 1964. The recipients of the Award, *left to right:* Dr. Jacob Bigeleisen, Brookhaven National Laboratory, Upton, Long Island, N.Y.; Dr. Theos J. Thompson, Massachusetts Institute of Technology, Cambridge, Mass.; Dr. Albert L. Latter, the Rand Corp., Santa Monica, Calif.; Chairman Seaborg; Dr. Marshall N. Rosenbluth, General Atomic Division of General Dynamics Corp., San Diego, Calif.; and Dr. Harvey M. Patt, Argonne National Laboratory, Argonne, Ill.**

Each man received a citation, a medal, and $5,000. Since 1960, five young U.S. scientists have been so honored each year. Recipients, who are recommended to the Commission by its General Advisory Committee and approved by the President, must be scientists, not more than

45 years of age, who have made recent and especially meritorious contributions to the nation's atomic energy program.

## AEC CITATION

Three men were named recipients of the Atomic Energy Commission citation during 1964:

*Dr. Robert S. Stone* of San Francisco, Calif., distinguished physician and one of the foremost authorities in the United States on the biomedical aspects of atomic energy. Now retired, Dr. Stone had been Director of the Radiological Laboratory at the University of California School of Medicine in San Francisco.

*Mr. Hood Worthington* of Wilmington, Del., distinguished scientist and administrator formerly with the Atomic Energy Division of E. I. du Pont de Nemours and Co. Now retired, Mr. Worthington had, for 14 years, been a leader in the development of the AEC's Savannah River, S.C., plant after having served as chief supervisor and process manager at the AEC's Hanford, Wash., plutonium production plant during World War II.

*Mr. Clark E. Center* of Kingston, Tenn., present Manager of Production, and former General Manager, of Union Carbide Corp.'s AEC operations at Oak Ridge, Tenn. Since 1943, Mr. Center has occupied positions of leadership and responsibility in the atomic energy program as a principal representative of Union Carbide in its activities carried out under contract initially with the old Manhattan Engineer District and, since January 1947, with the Atomic Energy Commission at Oak Ridge and at Paducah, Ky.

The citation is presented to persons not in the employ of the AEC who have made meritorious contributions to, or have been outstanding in, the nuclear energy program. Private individuals and employees of AEC contractors, of other Federal agencies or departments, including the military forces, and of industrial, educational and research institutions are eligible to receive the award. Formal nominations for the citation are made by a Commissioner or the General Manager and approved by the Commission.

## AEC DISTINGUISHED SERVICE AWARD

Dr. Frank K. Pittman, who made outstanding contributions in developing the AEC's programs over a period of 16 years, received the Commission's Distinguished Service Award on November 19. The award, the highest recognition the AEC can bestow on its employees, was presented to Dr. Pittman, Director of the Division of Reactor Development, for exceptional service in major atomic energy programs. The award consists of a gold medal, a certificate, and a citation.

The citation presented to Dr. Pittman, at the time he was leaving AEC employment, points to his direction of the Division of Reactor Development for six years and noted that "his foresight and outstanding technical and managerial leadership have resulted in not only unique civilian and military applications of nuclear energy, but also in developing the technology on which the private nuclear power industry of the nation will build for years to come."

# Part Two
# Production and Weapons Programs

A major responsibility of the Commission is to meet the nuclear requirements of the national defense programs and to supply materials and services essential for growing civilian needs not otherwise available. The raw materials-production-weapons programs currently account for about 64 percent of the Commission's annual operating costs.

# RAW MATERIALS

## *Uranium Procurement*

As a result of the AEC's "stretch-out" [1] program for rate of delivery of uranium concentrate under existing contracts, total procurement of $U_3O_8$ in 1964 was approximately 6,000 tons less than in 1963. The following table shows the sources and the quantities for the years 1963 and 1964.

| | Tons of $U_3O_8$ | |
|---|---|---|
| | 1963 | 1964 |
| U.S.A. | 14, 218 | 11, 847 |
| Canada | 4, 651 | 1, 763 |
| South Africa | 4, 134 | 3, 534 |
| Australia | 17 | None |
| | 23, 020 | 17, 144 |

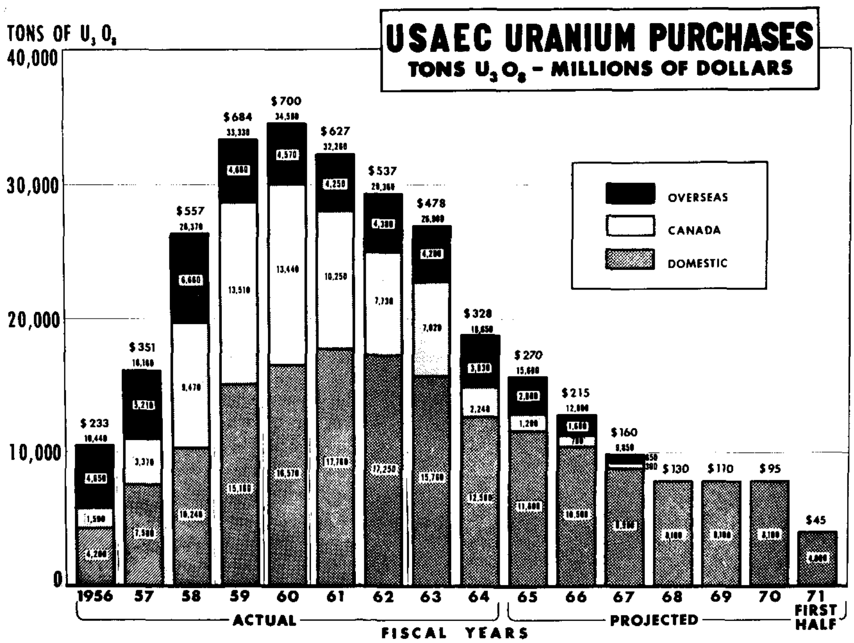
Shipments from Australia were completed early in 1963. Shipments from Canada and South Africa are being made under contracts entered into during the early stages of the procurement program. These contracts have incompleted balances of approximately 1,435 and 3,263 tons respectively and are due to be completed in 1966.

## *"Stretch-out" Program*

Contract negotiations to implement the domestic "stretch-out" program continued during 1964. Six contracts (indicated in Table 1 by the December 31, 1970, contract expiration date) have been modified covering the operation of seven uranium mills. Negotiations are con-

[1] Under the "stretch-out" program, which was announced in November 1962, U.S. uranium producers were invited to submit proposals for deferral to the years 1967 and 1968 of a portion of the concentrates originally contracted for delivery by December 31, 1966. An additional quantity of concentrates, equal to that amount deferred and delivered in 1967 and 1968, would be purchased by the AEC during 1969 and 1970. In addition, AEC may purchase up to a maximum of 1,900 tons of $U_3O_8$ in concentrates during the period 1967–1970 from small independent producers. Previously, in November 1959, the Commission had announced a "stretch-out" for Canadian procurement that would extend deliveries through December 31, 1966.

tinuing on five others. These together with the contract modifications already signed are expected to result in deferment of deliveries of a total of about 15,000 tons. Purchases of an equivalent amount in 1969 and 1970 are expected to be at an average price between \$5.50 and \$6.00 per pound. The extension of the AEC's uranium purchase program through 1970 will provide a sustaining market for the uranium industry during the period when the commercial demand is expected to be low, and place the industry in a better position to compete for the expanding commercial market expected in the years after 1970.




*Uranimum Procurement.*—Chart shows the AEC's actual uranium concentrate ($U_3O_8$) procurement for the past 9 fiscal years, and that projected for the next 6½ years under the "stretch-out" program. After 1966, only domestic uranium will be purchased. A price of between \$5.50 and \$6.00 per pound will be paid after 1968 instead of the current \$8.00 a pound for $U_3O_8$ concentrates. The stretch-out program, under which contractual deliveries are deferred until later years with the AEC subsequently buying an additional amount equivalent to that deferred, should help to sustain the uranium industry's market until an anticipated expanding commercial market develops after 1970.

TABLE 1.—$U_3O_8$ CONCENTRATE PROCUREMENT CONTRACTS

| Company | Location of mill | Contract expiration date | Tons $U_3O_8$ deliverable under contract from Jan. 1, 1964 |
|---|---|---|---|
| American Metal Climax, Inc | Grand Junction, Colo | 12/31/66 | 1,494 |
| Anaconda Co | Grants, N. Mex | 12/31/70 | 5,221 |
| Atlas Corp | Moab, Utah | 12/31/70 | 7,719 |
| Atlas Corp | Mexican Hat, Utah | | |
| Cotter Corp | Canon City, Colo | 2/28/65 | 239 |
| Dawn Mining Co | Ford, Wash | 12/31/66 | 864 |
| El Paso Natural Gas Co | Tuba City, Ariz | 12/31/66 | 820 |
| Federal-Radorock-Gas Hills Partners.[1] | Fremont County, Wyo | *12/31/66 | 2,186 |
| Homestake-Sapin Partners | Grants, N. Mex | *12/31/66 | 5,490 |
| United Nuclear Corp.[2] | Grants, N. Mex | *12/31/66 | 4,642 |
| Kermac Nuclear Fuels Corp | Grants, N. Mex | 12/31/70 | 11,044 |
| Mines Development, Inc | Edgemont, S. Dak | 12/31/66 | 1,038 |
| Petrotomics Co | Carbon County, Wyo | 12/31/66 | 1,002 |
| Susquehanna-Western, Inc | Falls City, Tex | 12/31/66 | 351 |
| Union Carbide Corp | Natrona County, Wyo | 12/31/70 | 1,550 |
| Union Carbide Corp | Rifle, Colo | *12/31/66 | 4,660 |
| Union Carbide Corp | Uravan, Colo | | |
| Utah Construction & Mining Co. | Fremont County, Wyo | 12/31/70 | 4,257 |
| Vanadium Corp. of America | Shiprock, N. Mex | *12/31/66 | 1,272 |
| Vitro Chemical Co | Salt Lake City, Utah | 12/31/66 | 685 |
| Western Nuclear, Inc | Jeffrey City, Wyo | 12/31/70 | 4,349 |

*NOTE: Of those companies whose contracts expire on 12/31/66 or earlier marked by an asterisk (*) are still negotiating stretch-out agreements.

[1] Federal-Radorock-Gas Hills Partners' mill also produces concentrates for the account of Susquehanna-Western, Inc., Wyo., under a tolling agreement, included in tons deliverable by Federal as shown.

[2] United Nuclear Corp. ore is treated in the Homestake-Sapin Partners mill under a tolling agreement.

Twenty mills had contracts with the AEC for delivery of concentrates at the end of the year, one less than at the end of 1963 due to the closing of the Union Carbide Corp. mill at Maybell, Colo., during the year.

### *Reserves*

Uranium exploration remained at a low level during the year. Although no important new deposits were developed, additions to reserves in the course of mining partially offset mine production. During the last 2 years, an average of 6,600 tons of $U_3O_8$ a year have been added to the known reserves either by exploration or by additions to known ore bodies during mining. Ore reserve and mill stockpiles at the beginning and end of the year are shown in the tabulation below:

| | Tons of ore | Percent $U_3O_8$ (rounded figures) | Contained tons $U_3O_8$ |
|---|---|---|---|
| Estimated reserves Jan. 1, 1964 | 66, 000, 000 | . 24 | 160, 000 |
| Additions to reserves in 1964 | 2, 300, 000 | . 24 | 5, 600 |
| Shipments to mills in 1964 | 5, 300, 000 | . 26 | 13, 600 |
| Estimated reserves Dec. 31, 1964 | 63, 000, 000 | . 24 | 152, 000 |
| Stockpiles at mills Jan. 1, 1964 | 760, 000 | . 38 | 2, 900 |
| Stockpiles at mills Dec. 31, 1964 | 850, 000 | . 40 | 3, 300 |

### *Future Uranium Requirements*

Western World uranium production is expected to decline from about 20,000 short tons of $U_3O_8$ per year at present to about 14,000 tons annually by 1970. Shortly thereafter, however, production must rise sharply if it is to keep pace with projected nuclear fuel requirements. Table 2 shows the estimated installed nuclear generating capacity, in megawatts of electricity, projected to 1980 for the United States and other non-Communist countries and based on the most reliable information available.

TABLE 2.—INSTALLED NUCLEAR GENERATING CAPACITY

(In megawatts of electricity)

| | 1964 | 1970 | 1975 | 1980 |
|---|---|---|---|---|
| United States | 940 | 6, 000– 7, 000 | 21, 000–37, 000 | 60, 000– 90, 000 |
| Other Free-World countries | 3, 250 | 14, 000–15, 000 | 35, 000–50, 000 | 80, 000–110, 000 |
| Total Free-World | 4, 190 | 20, 000–22, 000 | 56, 000-87, 000 | 140, 000–200, 000 |

To translate these power growths into uranium requirements, it has been assumed that most new nuclear power plants will be light water moderated and fueled with slightly enriched uranium. Although other types of reactors undoubtedly will also be used, the resulting variation in uranium requirements is expected to be within the degree of precision of the estimates. Recycling of plutonium is assumed to commence in the early 1970's, but it is not anticipated that the impact of breeder reactors on uranium requirements will be significant before 1980.

Table 3 shows the estimated range in $U_3O_8$ requirements for nuclear power for the United States and other non-Communist countries for the years 1970–1980, based on the above assumptions.

TABLE 3.—ESTIMATED URANIUM REQUIREMENTS

(Short tons of $U_3O_8$)

| | 1970 | 1975 | 1980 |
|---|---|---|---|
| United States: | | | |
| Annual | 1,600– 4,200 | 8,900– 14,000 | 19,000– 27,000 |
| Cumulative [1] | 9,400–14,000 | 37,000– 64,000 | 110,000–170,000 |
| Other Free-World: | | | |
| Annual | 6,200– 9,000 | 14,000– 19,000 | 24,000– 32,000 |
| Cumulative [1] | 28,000–33,000 | 80,000–110,000 | 180,000–240,000 |
| Totals (rounded): | | | |
| Annual | 7,800–13,000 | 23,000– 33,000 | 43,000– 59,000 |
| Cumulative [1] | 37,000–47,000 | 120,000–170,000 | 290,000–410,000 |

[1] Beginning with 1965.

### *Effect of Private Ownership Bill*

The Private Ownership of Special Nuclear Materials Act signed on August 26, 1964, is discussed in detail in Part One of this report. That section of the act which enables the AEC to enter into contracts to enrich privately owned uranium beginning January 1, 1969, is of special interest to the miners and processors of uranium ore. Although AEC purchases in the 1967–1970 period will be at a reduced level of about 8,000 tons a year, the uranium mining industry will have the opportunity to sell additional quantities of uranium on the commercial market because of the availability of toll enrichment services. This is in addition to the opportunity to compete for any business that may be available in connection with the AEC's previous authority to enter into *ad hoc* arrangements prior to 1969 with foreign nations under which enriched uranium may be bartered for normal uranium delivered to the AEC.

### *Assistance to Foreign Programs and Personnel*

Thirteen geologists and engineers from Argentina, Belgium, France, India, Italy, Spain, South Africa, Sweden, United Arab Republic, and West Germany visited uranium mines and mills in the United States under the sponsorship of IAEA, AID, or their own atomic energy agencies during 1964. These people generally also visited the AEC's Grand Junction Office for specialized discussions in geology and mineralogy, exploration techniques, resource evaluation methods, and uranium ore processing.

# PRODUCTION

## PRODUCTION CUTBACKS

Following studies by the AEC and the Department of Defense which indicated that full-capacity production was no longer needed, the President announced in his State of the Union message on January 8, his decision to curtail the production of special nuclear materials. Following this determination, the AEC announced plans to shut down four plutonium-producing reactors and to reduce electric power consumption at the three gaseous diffusion (uranium enrichment) plants in fiscal year 1965 to a level approximately 25 percent below the then-current level of 5,250 megawatts. In April, the President announced an additional cutback in enriched uranium production to take place over the next 4 years, bringing the overall decrease to 40 percent below production at the previously planned level.

### *Implementation of Cutbacks*

Reductions in electricity consumption rate during 1964 totaled 360 megawatts (Mw.) in production facilities at Oak Ridge, Tenn. (this was the last increment of a 1,030 Mw. reduction announced in 1961); 375 Mw. at Paducah, Ky., and 600 Mw. at Portsmouth, Ohio. The remainder of the power reductions are scheduled after 1964. The actual power reductions were first effective July 1, but preparations for the cutbacks, including personnel reduction, conversion to standby status, and operational shifts were in progress before that date. The K–25 and K–27 buildings at the Oak Ridge Gaseous Diffusion Plant were placed in standby as of June 30, 1964. Operations in the other process buildings at Oak Ridge, Paducah, and Portsmouth, continued, but at reduced levels. When the power reductions have been completed in 1968, the total power consumption rate for the three diffusion plants will be 2,970 Mw.

One reactor at the Savannah River, S.C., plant and three reactors at the Hanford Works, Wash., are being closed. The first unit, "R" reactor at Savannah River, was shut down on June 15, 1964. Operation of three reactors at Hanford will be discontinued during the first six months of 1965.* Employment reductions at Hanford are not expected to be completed until FY 1967 since closing of auxiliary facilities, principally a chemical separations plant ("Redox"), will not take place until that time.

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*The DR reactor at Hanford was shut down on December 30, 1964.

# PRODUCTION OPERATIONS

## Feed Materials

*Feed plant cutbacks.* The decision to reduce enriched uranium and plutonium production required major cutbacks in the feed materials operations. The uranium hexafluoride ($UF_6$) plant at Paducah which had been producing $UF_6$ for the gaseous diffusion cascades, was placed in a standby status on June 30.

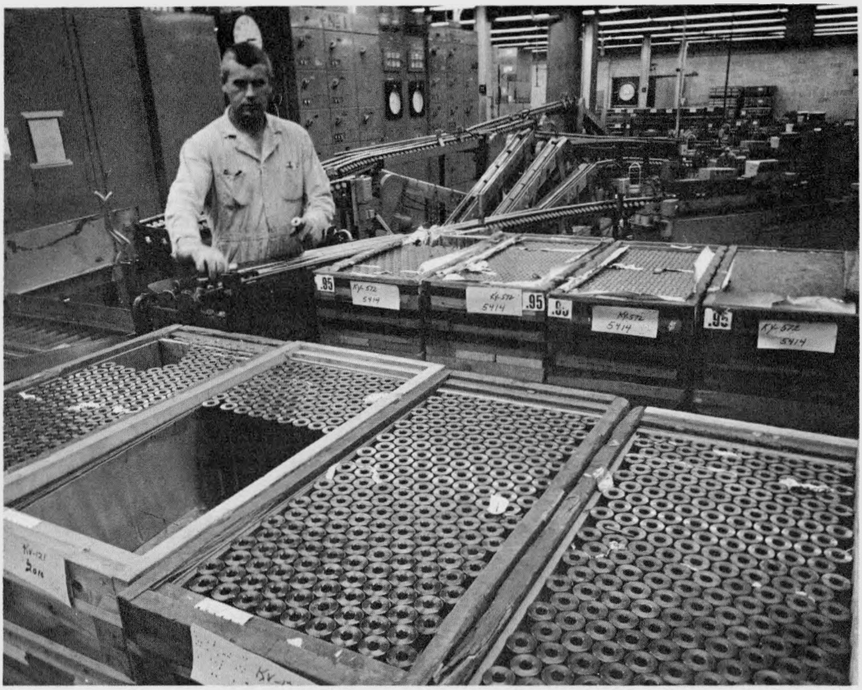
Refinery operations at Weldon Spring, Mo., were reduced concurrently with the shutdown of the Paducah $UF_6$ plant. The full effect of the reduction was partially offset, however, by using the excess refinery capacity to recover both normal and slightly enriched uranium scrap from the fuel element manufacturing operation at Fernald, Ohio.

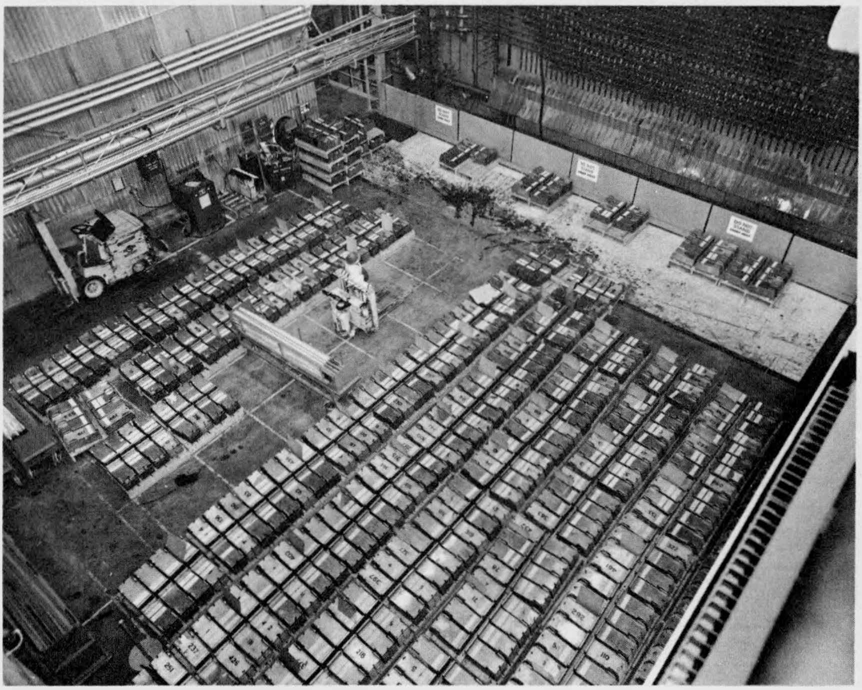
*Commercial magnesium procurement.* Until mid-1964, all of the magnesium used by the AEC was obtained from a Government-owned plant at Canaan, Conn., which was operated for the AEC by the Nelco Metals Division of Chas. A. Pfizer & Co., Inc. Following determination that high-purity magnesium could be obtained from commercial sources, the Canaan plant was sold and the AEC began obtaining high purity magnesium under normal procurement procedures.

The Canaan plant was purchased by Nelco Metals on a bid of $892,990. Subsequently, Nelco was the low bidder on the invitation to supply the AEC's FY 1965 magnesium requirements and was awarded a contract for an estimated 6 million pounds of magnesium; the exact amount to be determined by actual operating requirements, but not to be less than 4 million pounds.

*Fluid bed denitration.* Installation of the continuous fluid bed system to denitrate uranyl nitrate to uranium trioxide, which has been under development and construction for the past several years at Weldon Spring, was completed and the system put in operation during the year. The fluid bed replaces the less-economical batch-pot system and eliminates a possible health hazard associated with the old open pot process.

*Electrolytic reduction.* A 35,000-ampere prototype electrolytic cell for the reduction of uranium was placed in operation in the Weldon Spring plant. The prototype cell is being used first to evaluate the electrolytic method as a more economical means of recycling scrap materials. Later it will be used to evaluate electrolytic reduction as a means of converting uranium oxide ($UO_2$) to metal without going through the relatively expensive uranium tetrafluoride ($UF_4$) and magnesium reduction steps.





*Plutonium Production.*—Although traces of plutonium occur naturally, it is to all practical purposes a man-made element and is produced on a large scale by irradiation of uranium in the AEC's production reactors at Hanford, Wash.,

and Savannah River, S.C. After three reaction and decay phases during the irradiation, the plutonium product is obtained from the irradiated uranium by solvent extraction techniques. Photos on this and opposite page show three steps involved in the process at Hanford. At *top of opposite page*, bare uranium fuel elements destined for a production reactor are shown ready to enter the process stream at the production fuels facility where they will be clad in aluminum and subjected to stringent quality tests. In *lower photo*, magazines containing uranium fuel elements to be charged into a production reactor are shown in work area below reactor's front face (upper right). In photo *above*, hundreds of irradiated fuel elements lie under several feet of water after discharge from one of the huge Hanford plutonium production reactors. The fuel elements will be placed in buckets shown hanging at left, then stored for a time under water before being transported to separations plant where the valuable plutonium and other products created in the fission process are extracted.

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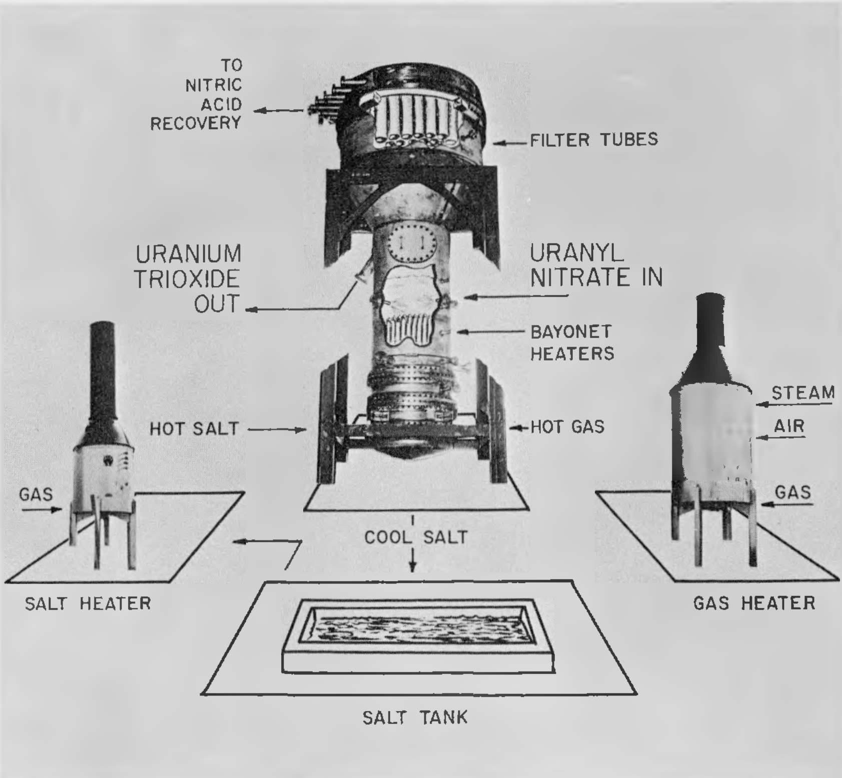


*Denitration Process.* The diagram illustrates the construction and operation of the newly installed fluid bed denitration system located at the AEC's Weldon Spring Feed Materials Plant. In this new fluid bed process, uranyl nitrate solution is sprayed directly into a heated, fluidized bed of uranium trioxide. The uranyl nitrate coats the particles already in the bed and is instantly converted to uranium trioxide. As the powder accumulates, it is continuously removed into the packaging system. Heat needed for the reaction is provided by the circulation of molten salt through a heat exchanger located in the bottom of the bed of powder. Fluidization is maintained by a mixture of steam and air preheated to the reaction temperature and fed to the bottom of the reactor. Filters located at the top of the reactor separate the uranium dust from the exhaust gases. This system, developed by Mallinckrodt Chemical Works, replaces the previous smaller batch process and will result in significant reduction in the cost of converting uranyl nitrate to uranium trioxide.

*Allied Chemical Corp. contract.* The Commission did not exercise its option to extend the contract with the Allied Chemical Corp. to supply $UF_6$ from the firm's Metropolis, Ill., plant beyond June 30, 1964. The plant was originally built by Allied to produce $UF_6$ from Government-owned uranium concentrates under a 5-year contract with the AEC. The original 5-year contract expired on March 31, 1964, but was extended until June 30, 1964.

### *Commercial Cold Uranium Scrap Processing*

During 1964, cold (nonirradiated) enriched scrap was made available to private industrial firms to recover the contained enriched uranium. Twenty-one contracts having a total cost of about $936,572 were awarded to: Nuclear Fuel Services, Inc., Erwin, Tenn.; Nuclear Materials and Equipment Corp., Apollo, Pa.; and United Nuclear Corp., New Haven, Conn.

### *AEC Blending Experience*

Data relative to blending uranium salts and solutions to adjust the isotopic content have been compiled from experience gained at the Y–12 plant at Oak Ridge, the gaseous diffusion plants, and the Fernald feed materials plant. An analysis of the data shows conclusively that accurate isotopic adjustment can be accomplished by blending materials of varying isotopic assay. Although liquid-liquid blending systems appear to be the most accurate, equally acceptable results have been obtained by blending molten salts, molten metal, or by using a reduction-to-metal technique. Powders have also been blended but unless the quantities involved are relatively large and the physical characteristics controlled, less accurate results can be expected.

Generally, by the above methods it is possible to blend varying enrichments to a uniform target enrichment within ±0.001 percent uranium 235 (U–235). The accuracy in any of the blending systems used to date appears to be limited by the ability to determine the amount of uranium in the starting materials and the precision of the isotopic analysis.

### *Very Highly Enriched Uranium*

In April, the AEC announced the availability of limited quantities of uranium containing approximately 97.65 percent by weight of the uranium 235 isotope for both domestic and foreign distribution under conditions precluding use of the material for non-peaceful purposes. The highest assays previously made available in quantity have been around 93 percent. The feasibility of producing the very high assay material for use in reactors and for research purposes was demonstrated in the Portsmouth, Ohio, gaseous diffusion plant.

The base charge per kilogram of uranium containing 97.65 percent U–235 is $12,250.40 corresponding to $12.55 per gram of contained U–235. By comparison, the charge for 93 percent enriched uranium is $11,188 per kilogram or $12.03 per gram U–235. The charges were publicly established in a *Federal Register* notice on April 14, 1964.

### *Gas Centrifuge Studies*

The gas centrifuge development and study program continued during 1964 under the same five contractors (University of Virginia, Union Carbide Corp., AiResearch Division of the Garrett Corp., Yale University, and the du Pont Co.)

Classified AEC-developed information on gas centrifuge technology is no longer available under the access permit program. A notice to this effect was published in the *Federal Register* on June 30, 1964. The Commission found this action to be necessary in the interest of the common defense and security and otherwise in the public interest.

### *Boron 10 Production*

A decision to resume operation of the Government-owned boron isotope separation plant, constructed in 1954 at a cost of about $4 million, at Model City, N.Y. followed studies which showed that current inventories of boron 10 were not sufficient to meet future demands and that commercial facilities were not available to meet this demand.

In May, the AEC negotiated a short-term contract with Hooker Chemical Corp. of Niagara Falls, N.Y., the former plant operator, to reactivate part of the AEC's plant for conversion of the small existing inventory of intermediate products to elemental boron. Subsequently, in August, Nuclear Materials and Equipment Corp., Apollo, Pa., was selected to reactivate the remainder of the plant and to resume full-scale production of boron 10 beginning in early 1965.

### *Heavy Water Production*

Heavy water sales to United States customers totaled 6,102 pounds in 1964—about 2½ times the 1963 sales. Foreign shipments (sales) during the year totaled approximately 63 tons, compared to 52 [2] tons in 1963. The AEC also provided heavy water reprocessing services at its Savannah River facilities for foreign and domestic users.

### *Plutonium Scrap Recovery*

*Plutonium Reclamation Facility.* A significant amount of plutonium scrap is generated during the reduction of plutonium to metal and its fabrication into weapons components. Recycle of this scrap for plutonium recovery constitutes a significant contribution to the maximum utilization of AEC plutonium production.

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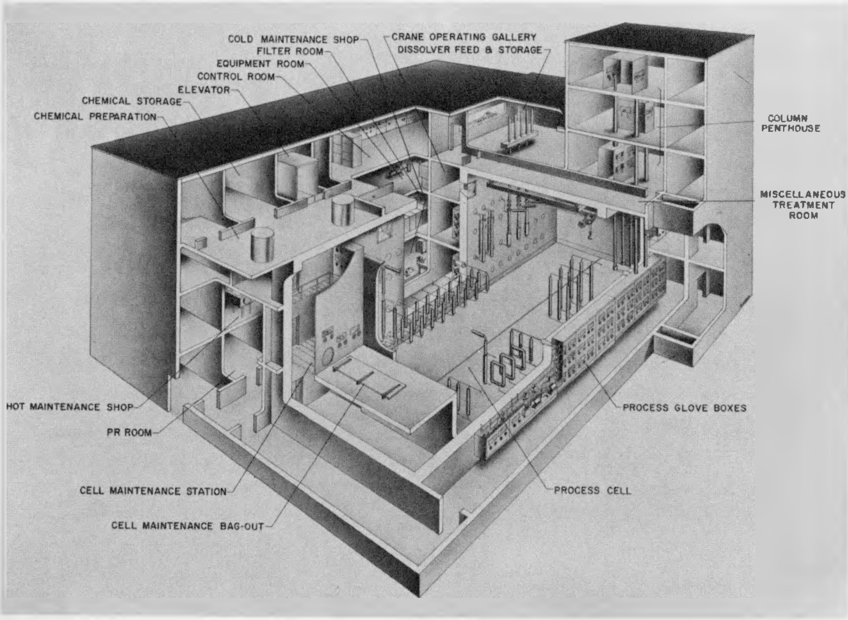
[2] 1963 figure revised from previously-published amount (p. 45, Annual Report to Congress for 1963).




***Plutonium Reclamation Facility.*** **Schematic drawing shows the main features of the new Plutonium Reclamation Facility at Hanford which went into operation during 1964. The facility is used to recover valuable plutonium from contaminated scrap and waste solutions.**

Construction of the Plutonium Reclamation Facility (PRF) was completed at Hanford in 1964 at a cost of $3.2 million. This facility incorporates (*a*) leaching vessels to dissolve plutonium-bearing scrap and (*b*) solvent extraction equipment for the recovery of plutonium from dissolver and other solutions used in treating plutonium contaminated wastes. In May, the PRF started processing plutonium waste solutions and scrap. All effluent liquors and process wastes, from the PRF are given a final ion exchange treatment to recover any remaining trace amounts of plutonium. Also installed near the PRF is an americium recovery unit to treat the facility's effluent liquors for recovery of the trace amounts of americium 241 present in plutonium scrap materials. Americium 241 is a decay product of plutonium 241 and is used as a starting material for the production of curium 242, which has a possible application as fuel for isotopic power sources for space use.

*Residue recovery.* During the past year, a process was developed at Savannah River to recover plutonium from acid insoluble refractory oxides. Such oxides are formed at high temperatures in incinerator ash and analytical residues. In this process, plutonium oxide is reduced by aluminum metal at 1,000° C. in the presence of a mixed fluoride flux within a graphite crucible. The resulting plutonium-aluminum alloy is then treated by conventional means for plutonium recovery. Plutonium residues and ash from other sites have been shipped to Savannah River and the recovered plutonium metal has been made available to the production program.

*Recovery by leaching.* At Hanford an incinerator facility is used to reduce rags, papers, and other combustible plutonium contaminated materials to an ash for easier treatment for plutonium recovery. Early in 1964, a leaching line was installed in this facility to leach noncombustible plutonium contaminated scrap materials. Plutonium contaminated plastic materials and rubber are also leached rather than burned. The leach solutions then are treated for the recovery of their plutonium content by conventional solvent extraction techniques.

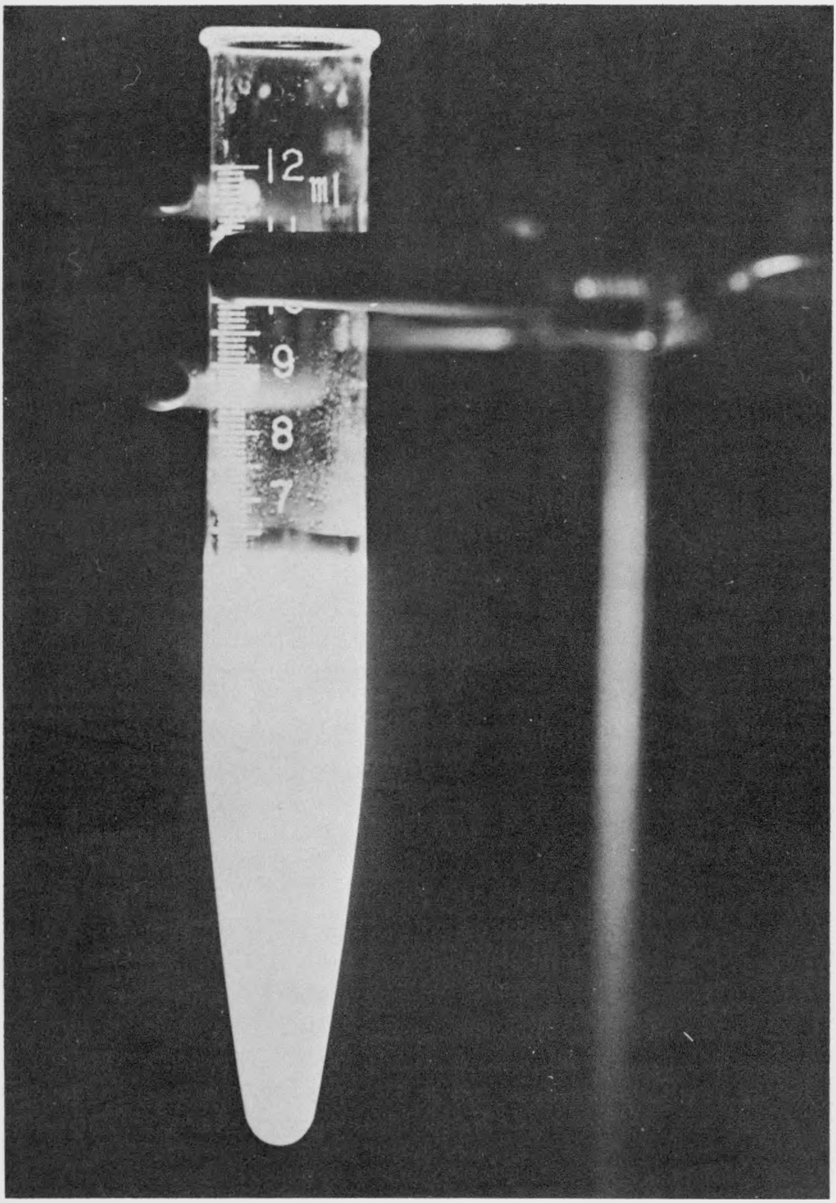
### *Special Reactor Products*

Selected radioisotopes and special products required by AEC programs and research are often provided by irradiating special target materials in production reactors.

*Curium 244.* Irradiation of specially designed plutonium-aluminum (Pu–Al) fuel elements for the production of three kilograms of curium 244 (Cm–244) was begun at Savannah River in May 1964. This irradiation is the first phase of a program which will subsequently entail chemical processing of the Pu–Al elements after irradiation, refabrication of target elements from the recovered plutonium containing mostly plutonium 242, and reirradiation at high flux. This method will minimize the irradiation time required to produce Cm–244. Demonstration of the high flux operation at Savannah River reactors will also greatly enhance future ability to produce sizeable quantities of transplutonium and other isotopes.

*Plutonium 238.* The production of plutonium 238 (Pu–238) at Savannah River was maintained throughout the year and the recovery yield was improved. The product was shipped to Mound Laboratory in nitrate solution, but construction was started on a facility to make and load the product as the dioxide ($PuO_2$) for future shipments. A small amount of byproduct plutonium (containing about 20 percent Pu–238) from the waste stream of the enriched uranium recovery program was recovered. Although lower in quality than the standard Pu–238, it has acceptable power density and may have application for making more powerful neutron sources.

*Uranium 233.* Irradiation of thorium to produce 120 kilograms of uranium 233 (U–233) was completed at Savannah River early in 1964.




*Isotopic Light.* The radioisotope curium 244, when in an aqueous solution, emits a pale yellow light. The above photo was taken at Savannah River in a 5-minute exposure in total darknes except for the light from the tube containing one-quarter of a gram of Cm–244.

The material generated contained from 40 to 500 ppm of uranium 232, an undesirable impurity. The intended use of this U–233 is essentially of a developmental nature. With the advent of the ability of production sites to produce high-purity U–233, which is low in U–232 content, development work in this area is expected to increase in the future. (See High-purity U–233 below.)

### *Other Special Products*

Recently, a growing interest has been shown in high purity uranium 233, cobalt 60 of very high specific activity, and plutonium containing a high percentage of plutonium 240.

*High-purity U–233.* High-purity (or "clean") uranium 233 is defined as U–233 containing a low concentration (less than 5 ppm) of U–232. Since U–232 has a number of gamma emitting short-lived daughter products, its presence as a contaminant requires the use of heavy shielding when handling the U–233. Research and development of the uranium 233-thorium fuel cycle could be expedited if high-purity U–233 can be produced at acceptable costs.

During the past year, studies and irradiation tests at Hanford and Savannah River have shown that it is feasible to produce high-purity U–233 at reasonable costs. One way to accomplish this is by irradiating thorium-oxide of low ionium content in a well-thermalized flux to a relatively low exposure level. A program is underway to produce 200 kilograms of this material for the AEC's nuclear reactor development programs.

*Cobalt 60.* For several years, Savannah River has produced cobalt 60 with specific activity in the range of 5 to 100 curies/gram for use principally in radiotherapy, radiography, and food preservation tests. Interest has now been shown in Co–60 of unusually high specific activity (400 to 500 curies/gram) for use in radiography, process irradiation, and possibly as an isotopic power source. Savannah River is currently producing 415,000 curies of this material for use in experimental work by the Oak Ridge National Laboratory and other organizations.

*Plutonium 240.* The recycle of plutonium as a fuel in power reactors builds in larger and larger quantities of plutonium 240 by virtue of capture of neutrons in Pu–239. The effects on nuclear parameters at varying percentages of Pu–240 are under study in the Plutonium Recycle Program at Hanford. (See Part 3.) Experimental quantities of plutonium containing as much as 40 percent Pu–240 have been produced at Savannah River by long-term irradiation of plutonium.

*Polonium 210.* Both Hanford and Savannah River are developing techniques for large-scale production of low-cost polonium 210. Polonium 210 has promise as a heat source for small rocket engines for space uses.

### *Fission Products Production*

Since 1961, an interim program to produce the selected fission product radioisotopes required by other AEC programs has been carried on at Hanford. These fission products are recovered from the high-level waste solutions resulting from the chemical processing of irradiated production reactor fuel elements. A flexible fission product pilot production complex was developed by adaptation of available facilities and equipment at Hanford. The following table shows the fission product deliveries (off-site shipments) made since the start of these pilot operations. At this time, deliveries have been made only to Oak Ridge National Laboratory and the Martin Co., Quehanna, Pa.

| Fission products | Kilocuries | | |
|---|---|---|---|
| | CY 1962 | CY 1963 | CY 1964 |
| Strontium 90 | 1, 995 | 2, 350 | 1, 400 |
| Cesium 137 | 537 | 736 | 396 |
| Cerium 144 | ---------- | 90 | 500 |
| Promethium 147 | ---------- | 69 | 0 |

## RADIOACTIVE WASTE MANAGEMENT

### *High-Level Waste*

The several million gallons of highly radioactive liquid wastes, which are generated annually by the chemical processing operations at the Hanford, Savannah River, and Idaho facilities contain over 99 percent of the toxic radionuclide byproducts of atomic fission and are stored in specially built underground tanks.[3] During 1964, the construction of four 1 million-gallon carbon steel-lined concrete tanks for self-boiling waste (i.e., heat from radioactive decay causes the solutions to boil) were completed at Hanford and two new 300,000-gallon stainless steel tanks with water cooling coils were completed at Idaho. The total useful waste storage capacity, which excludes the

[3] See pp. 165–166, Annual Report to Congress for 1963; pp. 226–228, Annual Report to Congress for 1962.

nonusable volumes of nine leaking tanks[4] (five at Hanford, and four at Savannah River) and takes into account safe tank fill levels, now is 109 million gallons.

| Site | Number of tanks | Type of construction | Useful waste storage capacity (millions of gallons) | Waste condition |
|---|---|---|---|---|
| Hanford: | | | | |
| Boiling tanks [1] | 19 | Carbon steel lined concrete. | 14.3 | Alkaline sludges and supernates. |
| Nonboiling tanks | 130 | do | 68.4 | Do. |
| Savannah River: | | | | |
| Tanks w/cooling coils. | 16 | Carbon steel tanks in steel lined concrete vault. | 12.2 | Do. |
| Uncooled tanks | 8 | Carbon steel lined concrete. | 10.8 | Do. |
| Idaho: | | | | |
| Tanks w/cooling coils. | 12 | Stainless steel tanks in concrete vaults. | 2.3 | Acidic liquor. |
| Uncooled tanks | 3 | do | 0.8 | Do. |

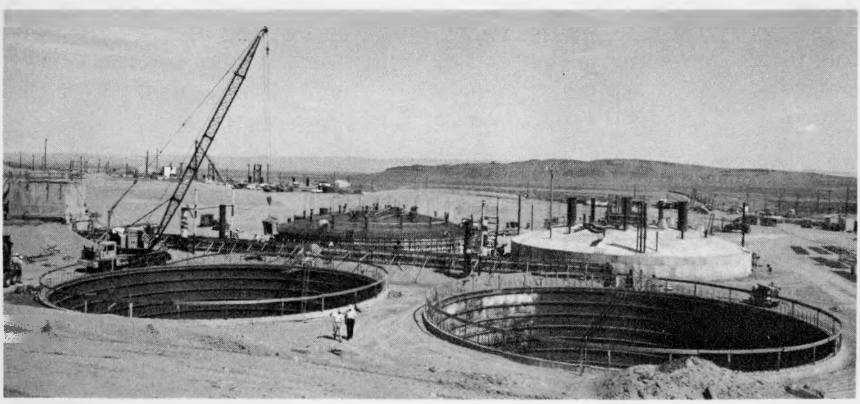
[1] Contain airlifts.

*Tank utilization.* At Hanford, in order to recover space in the tanks capable of storing boiling wastes, settled and aged sludges are being removed from these tanks by sluicing methods after the sludges have been softened by water leaching. The aged sludges and supernates can be transferred to "non-boiling" tanks. Also at Hanford, the first unit for reducing low-heating wastes to a salt cake by intank evaporation has been installed. Exploratory operations of this unit had just started at the end of 1964.

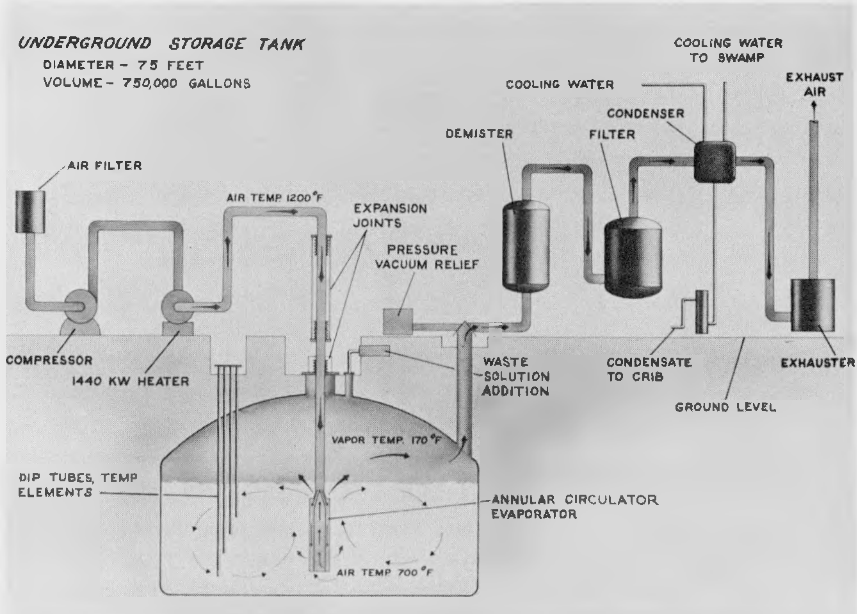
*Calcining facility.* At Idaho, the prototype Waste Calcining Facility (WCF) which uses a fluidized bed principle to evaporate and convert liquid wastes to a granular calcined product, completed a successful 10-month operating period during which time 510,000 gallons (68,000 cubic feet) of aluminum nitrate type of wastes (from processing highly enriched uranium-aluminum alloy fuels) were reduced to 7,600 cubic feet of calcined product or a volume reduction of about nine times. The liquid waste feed rate for the operating period averaged 69 gallons per hour as compared to a designed capacity of 60

[4] The AEC's monitoring program in the tank areas is such that the leakage is detected, and the tanks emptied below the leak point, before there is any significant escape of solutions.

*Tank Farm.* A new four-tank waste storage complex which will have a 4-million-gallon capacity for storage of liquid process wastes, was constructed at Hanford during 1964. Seventy-five feet in diameter, and constructed of reinforced concrete with a steel liner, each of the four tanks will contain 22 air-life circulators to keep solid particles suspended in liquid. The new tanks will be structurally stronger than those now in use and can be used to store 1 million gallons of waste at maximum concentration. A recent development also incorporated into the complex is a built-in leak detection system. A sump, equipped with measuring instruments, catches and holds any possible leakage preventing liquid wastes from entering the soil. The new tank complex also incorporates a diverter station which permits routing of liquid waste to any of the four tanks through use of a discharge line which can be pivoted to any one of the four transfer lines inside the station. This operation can be completed by an operator without the danger of exposure and represents a dramatic improvement over the manual changing of "jumper" lines which is currently used. Photos, taken several months apart, show two stages of the construction. When completed, the tanks are covered with several feet of earth.



gallons per hour. WCF operations were terminated on October 15 when the available calcine bins were full. New bins are being constructed.




*In-tank Solidification.* Schematic drawing of the in-tank solidification process developed at Hanford for reducing low-heating radioactive wastes to a salt cake by evaporation.

### *Low-Level Waste*

Millions of gallons of low-level radioactive liquid wastes are generated annually by the radiochemical processing and waste management operations at Hanford, Savannah River and Idaho. Such low-level wastes are discharged into the ground, without treatment, taking advantage of the natural environmental conditions for absorbing and/or diluting any concentrations of radionuclides to safe levels.

At Hanford, so-called "intermediate level" wastes (0.00005 to 100 microcuries per milliliter ($\mu c$/ml) of beta emission) such as condensate from the evaporation of high-level aqueous wastes, other process condensates, and decontamination washings, are released into the ground by seepage from trenches and underground porous, gravelled-bottom, timbered structures called "cribs". Because of the favorable geological and hydrological conditions of the Hanford site and the capacity of the over 200 feet of underlying sediments to both absorb the radionuclides and retain liquids, these wastes essentially are stored in the ground and eventually decay to the low-level state of radioactivity.

Low-level wastes (less than 0.00005 $\mu c/ml$ of gross beta emission), mostly process cooling water, are released to the ground via discharge into surface ponds.

Waste streams from the chemical processing operations at the Savannah River Plant are released directly into surface streams only when the level of radioactivity is extremely low. Low-level waste which is considered too radioactive for direct release (such as process condensate) is routed to seepage basins. The radioactive releases are controlled by very strict standards so that environmental radioactivity is far below the maximum permissible concentration levels.

At the National Reactor Testing Station (Idaho), low-level aqueous wastes from the chemical processing area's operations are released by use of a 600-foot deep injection well which bottoms 150 feet below the regional water table. In addition, the purge of water from the fuels storage basin in the chemical processing area is released into a seepage pit. Discharge limits are such that radionuclide concentrations at a point of exposure (i.e., use of the underground water) will not exceed one-tenth of the recommended guide for drinking water.

## FUEL REPROCESSING

### *Private Fuel Processing Plant*

*Status of NFS plant.* Construction of the Nuclear Fuel Services, Inc. (NFS) plant[5] for the chemical processing of irradiated reactor fuels is proceeding. NFS expects that construction of this first privately owned reprocessing facility will be completed in the spring of 1965, and that the plant, located in West Valley, N.Y., will be ready to begin commercial operations early in 1966.

*Activities by others.* In August, the Dow Chemical Co. and Westinghouse Electric Corp. publicly announced a joint research and development program on advanced methods for reprocessing nuclear fuels and techniques for fabricating plutonium fuel elements. The program will include construction of a $1.7 million Recycle Fuels Laboratory.

In September, the General Electric Co. announced that it hopes to provide nuclear fuel processing services. Scope design is now in progress and initial plans are to begin construction in 1967 on a plant located in the West. General Electric stated that costs for construction and preoperational testing will exceed $15 million. The plant uses a method that applies fluoride volatility technology to convert uranium to gaseous form for separation from the fission products.

[5] See pp. 53–54, Annual Report to Congress for 1963.

***AEC Reprocessing of Irradiated Private Reactor Fuel***

*Conceptual plant arrangement.* In June, the Commission amended its *Federal Register* Notice (29 FR 7578) which pertains to AEC chemical processing and conversion of irradiated fuel and blanket materials from nuclear reactors. The amendment gives licensees who do not pay "use charges" more liberal limits than previously allowed to batch the materials for delivery to the AEC so as to minimize the "turnaround" increment of the charge assessed for the chemical processing of the materials.

The Commission has offered to reactor operators, in response to their request, an arrangement under which AEC will, for a 2-year period, accept measurements made at the NFS processing plant on products recovered from fuels leased from and scheduled for return to the AEC. The arrangement is feasible at that location since the AEC will have inspectors at the site for acceptance of similar measurements made on products recovered from fuels supplied by the AEC.

*Receipt of "spent" fuels at Savannah River.* In June, the Commission offered reactor operators the option of making deliveries of irradiated uranium-aluminum alloy fuels, highly enriched in uranium 235, to the AEC's Savannah River plant for chemical processing. The offer applies to "spent" fuels from licensed domestic reactors and from foreign reactors. Previously, delivery of such highly enriched fuels could be made only at the AEC's Idaho Chemical Processing Plant at the National Reactor Testing Station.

A tabulation of statistics on all deliveries of commercial fuels, foreign fuels, and processing agreements executed is shown in Table 4.

*Limitation on "use charges".* In January, the Commission gave notice in the *Federal Register* (29 FR 1333) of a limitation on "use charges" under domestic leases for special nuclear material in irradiated fuel elements delivered to commercial plants for chemical processing by June 30, 1970. "Use charge" payments will be limited to the time period allowed for the chemical processing operations on specific batches of irradiated fuel elements. This will protect electric utility companies against excessive "use charges" in event of processing delays or difficulties in expeditiously scheduling the processing of nuclear fuels in a commercial facility during the early years of operation. Thus, the same principles now apply with respect to "use charges" on material delivered to a commercial processing facility as would have been applicable to material delivered to an AEC processing site.

TABLE 4.—FUEL DELIVERED TO AEC UNDER STANDARD CONTRACTS FOR RECEIPT OF IRRADIATED NON-PRODUCTION FUEL

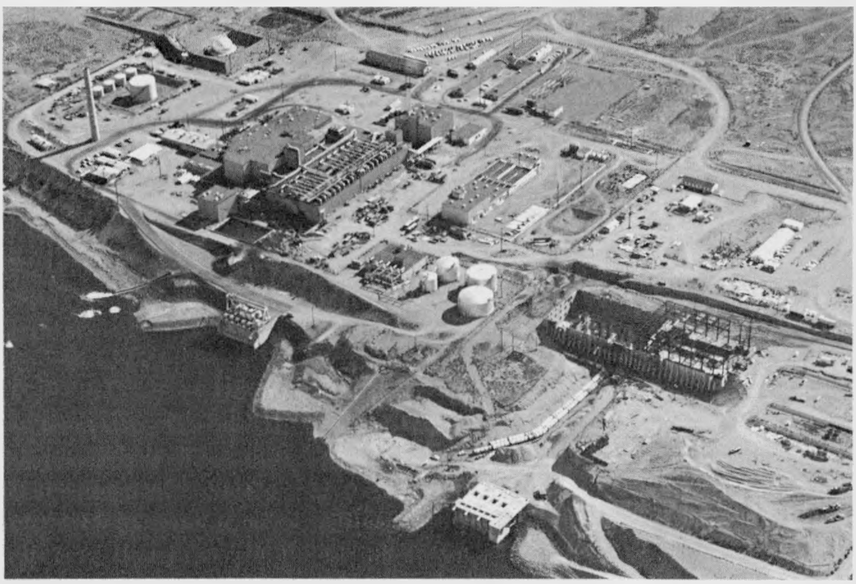
| Contracting party | Reactor | As received | | | | | |
|---|---|---|---|---|---|---|---|
| | | CY | Site | Type of fuel | Total contained uranium—Kgs | Percent $U^{235}$ enrichment | Total contained plutonium—Kgs |
| From foreign governments: | | | | | | | |
| Canada | McMaster Univ | 1964 | ID[1] | U–Al alloy | 1.5 | 73 | |
| Do | NRU | 1964 | ID | do | 8.9 | 77 | |
| Do | NRX | 1964 | ID | do | 13.3 | 82 | |
| Sweden | R–2 | 1964 | ID | do | 25.1 | 82 | |
| Do | R–2 | 1964 | SR[2] | do | 23.3 | 82 | |
| From domestic research and test reactors: | | | | | | | |
| Battelle Memorial Institute | Research-pool | 1961–62 | ID | U–Al alloy (scrap) | 1.7 | 93.2 | |
| Do | do | 1963 | ID | U–Al alloy | 17.5 | 89 | |
| Do | Research-pool est | 1964 | SR | do | 7.7 | 78 | |
| GE Co | GETR | 1962 | ID | do | 80.7 | 85 | |
| Do | VBWR | 1961 | ID | SS cermets | 29.9 | 89 | |
| Do | VBWR | 1964 | ID | do | 6.8 | 91 | |
| Industrial Reactor Laboratory | Research-pool | 1964 | ID | U–Al alloy | 3.8 | 84 | |
| NASA | Plumbrook | 1964 | ID | do | 29.4 | 90 | |
| Do | do | 1964 | SR | do | 12.8 | 70 | |
| Naval Research Laboratory | Research-pool | 1963 | ID | do | 4.9 | 90 | |
| United Nuclear Corp | Belgium-R–2 | 1964 | ID | do | 0.3 | 93 | |
| Westinghouse Electric | WTR | 1962 | ID | do | 83.7 | 87 | |
| From domestic power reactors: | | | | | | | |
| Commonwealth Edison | Dresden | 1963 | SR | Zr clad $UO_2$ | 20,398 | 0.9 | 68.5 |
| Do | do | 1963 | SR | SS clad $UO_2$ | 625 | 2.1 | [3] 1.7 |
| Yankee Atomic Electric | Rowe, Mass | 1963 | SR | do | 20,089 | 2.6 | 95.6 |

[1] Idaho. [2] Savannah River. [3] Also some thorium rods containing 0.6 kilograms of $U^{233}$.

## NEW PRODUCTION REACTOR (NPR)

### *Operation*

During 1964, startup testing and power ascension programs have been conducted satisfactorily on the New Production Reactor at Hanford which achieved initial criticality on December 31, 1963. The large plant—which, beginning in 1965 will be used for production of electricity as well as production of nuclear materials—functioned well during the test programs. A number of relatively minor problems required correction, but no basic design or technical deficiencies have been identified. Total construction costs for the project are estimated at $199.7 million.



*Production-Power Complex.* At year's end, the AEC's New Production Reactor (NPR) was undergoing a series of test programs relative to operation for plutonium production. The Washington Public Power Supply System's (WPPSS) integrated 800,000 electrical kilowatt generating plant was well along in construction. The NPR is on *left* in photo, and the WPPSS plant on *right*. In this first-of-its-kind complex, steam generated by the plutonium production process in the NPR will be used by the WPPSS plant for production of electricity. Initial operation of the dual-purpose complex is expected in the fall of 1965.

### *Heat Exchanger Repair*

The major corrosion damage to the primary heat exchanger tubing [6] has been repaired. One unit required retubing; another required inserts at the tube sheet; and minor repairs, such as tube plugging, were required in the other damaged units. The precise cause of the corrosion damage has not yet been established. Operationally, the heat exchanger performance has been in accordance with design expectations.

### *Power Generation Project*

Construction of the 800,000 electrical kilowatt power plant by the Washington Public Power Supply System (WPPSS), which was begun in the fall of 1963, continued during 1964. At year's end, the $122-million project was 30 percent completed and on schedule. Power from the first 400,000 kilowatt generator is scheduled in September 1965. The second of the two 400,000 kilowatt generators is expected to be ready for operation in November 1965.

# MILITARY APPLICATION

The Commission, largely in consonance with guidance from the Department of Defense (DOD), conducts the research, development, testing, and production necessary to provide the United States with a strong nuclear defense capability.

## 1964 ACTIVITIES

During 1964, the Commission continued efforts toward meeting the Presidentially announced safeguards [7] of the limited nuclear Test Ban Treaty:

(*1*) The underground test program at the Nevada Test Site continued and 29 events were announced during the year; development of Pahute Mesa for higher-yield tests is essentially complete; and, new techniques for effects tests were proven out—Alva, an effects event conducted in August, was the most complex underground test to date.

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[6] See p. 47, Annual Report to Congress for 1963.

[7] Prior to ratification of the Test Ban Treaty in 1963, the late President Kennedy had announced as U.S. National Policy, four safeguards which would be maintained to provide the Nation with a national defense nuclear readiness posture. The four safeguards were: (1) continuation of an aggressive underground nuclear weapons test program; (2) maintenance of a progressive laboratory program; (3) a readiness capability to resume atmospheric tests if the treaty should be broken by other signatories; and (4) development of monitoring systems to detect violations of the treaty. The wording of each safeguard is shown in *italicized* type on the following pages although they are not listed in numerical sequence.

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(*2*) Active and aggressive research and development programs responsive to military needs were maintained at the AEC's weapons laboratories. Several authorized construction projects required for upgrading the laboratory facilities were initiated.

(*3*) Stockpiling of test material, construction at Johnston Island, and airborne diagnostic test capability progressed to the point that atmospheric testing can be resumed on short notice. An airborne non-nuclear test exercise to prove out the system was conducted in October.

(*4*) Development of test detection techniques has continued. A second underground nuclear event (Salmon) for detection purposes was successfully conducted on October 22, 1964. The second pair of AEC-instrumented satellites was placed in orbit in July 1964.

Weapons development activities encompassed work toward increasing hardness and penetration capabilities of missile warheads, relatively clean nuclear explosions, and modernization of the stockpile. The production activities had no major problems and the production objectives are being achieved.

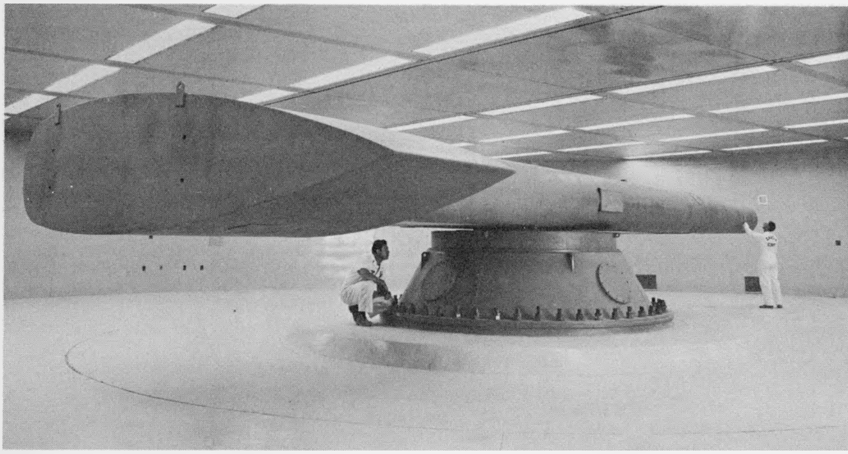
## WEAPONS DEVELOPMENT, TEST, AND PRODUCTION

### WEAPONS DEVELOPMENT

During 1964, the AEC (at its three weapons laboratories—Lawrence Radiation Laboratory-Livermore, Los Alamos Scientific Laboratory, and Sandia Laboratory-Albuquerque and Livermore) continued the aggressive effort necessary to meet the safeguards and continued development of weapons designed to meet Department of Defense requirements.

#### *Significant Progress*

Among significant weapon development objectives were a program to increase the hardness and penetration capability of missile warheads so that their vulnerability to enemy antiballistic missile countermeasures is decreased; and, the development of relatively "clean" (*i.e.*, less radioactive fallout) nuclear explosives for both strategic and tactical use, as well as for peaceful applications. Also, during the year, significant weapons tests in the areas of nuclear safety and nuclear efficiency were conducted; modernization of the stockpile through new production and modifications to existing weapons was achieved; and development continued toward the objective of providing improved devices for installation in nuclear weapons to prevent unauthorized employment.



*Weapons Tester.* A 25-foot radius centrifuge facility for study of the effects of high accelerations on weapon systems became operational in 1964 and greatly extends the linear acceleration capabilities for large systems at Sandia Corp. The centrifuge has a 1,600,000 g-lb capability for test specimens weighing up to 16,000 pounds. Smaller specimens may be taken to 200 g (a "g" is the acceleration force of gravity—32.174 feet per second per second). A vibration system is being added to the centrifuge to provide linear acceleration and vibration in combination. The vibration exciters will produce a gross force of 15,000 pounds at a frequency range of 20 to 3,000 cps in linear acceleration fields up to 100 g.

Included in the laboratory effort to achieve the above objectives was the design and fabrication of more sophisticated test devices which were utilized in the continuing underground test program at the Nevada Test Site, and preparation for a readiness capability to resume atmospheric testing in the event of an abrogation of the limited nuclear Test Ban Treaty. In addition, the AEC continued to participate with the DOD in development of test detection methods (Vela Program).

### *Progressive Laboratory Programs*

Laboratory effort and construction were continued for sustaining safeguard number 2:

"*The maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology which will attract, retain and insure the continued application of our human scientific resources to these programs on which continued progress in nuclear technology depends.*"

More than $25 million was authorized for improvements, modifications, and additions to the plant facilities at the weapons laboratories during the fiscal year ending June 30, 1964. Fourteen of the 17 projects authorized are already under construction; the remaining three projects will begin in early 1965. An additional $10 million in the current (fiscal year ending June 30, 1965) military applications budget authorizes five additional projects for the laboratories.

In addition, the current budget provides for continuing progressive laboratory programs in basic nuclear weapons technology, and nuclear and applied research and development directed toward stated military requirements. It also provides for continuation of programs to simulate various weapons phenomenology in a laboratory environment.

The improvement in facilities, the maintenance of challenging research and development programs, and the continuing underground test program have enabled the laboratories to retain and recruit the necessary staff to carry out the assigned programs.

## NUCLEAR TESTS

The AEC has successfully conducted its nuclear weapons test program under the limited nuclear Test Ban Treaty for more than a year. New techniques have been developed to conduct experiments—which were formerly not considered feasible—in underground tests and with use of conventional laboratory tools, particularly in the area of effects and weapons vulnerability studies. An aggressive development program supported by underground testing was continued.

### *Limited Nuclear Test Ban Treaty*

Under the limited nuclear Test Ban Treaty,[8] nuclear detonations in the atmosphere, outer space, and underwater are prohibited. Underground tests are permissible, however, so long as they do not cause radioactive debris to be present outside the territorial limits of the nation under whose jurisdiction or control the detonation was conducted. Prior to ratification of the treaty, the Senate was assured by the late President Kennedy that the national interest would be protected by four safeguards including one that calls for a U.S. readiness to resume full-scale testing on a planned time schedule should the treaty be broken by another signatory nation. (Over 100 nations have signed the treaty, although France and Communist China have not.) President Kennedy stated the readiness posture included in the four safeguards would be a national policy.

During mid-1964, the Commission and the Department of Defense developed a National Nuclear Test Plan in accord with the limited Test Ban Treaty. The plan encompasses the conduct and execution

[8] Signed on August 5, 1963, by representatives of the United States, United Kingdom, and Union of Soviet Socialist Republics; ratified for the U.S. by the late President Kennedy on October 7, 1963, after the Senate's approval on September 24, 1963. See pp. 13–15, 55, of Annual Report to Congress for 1963.

of the continuing underground test program and all phases of readiness preparations for testing in those environments prohibited by the treaty. The plan provides assurance that Safeguards 1 and 3, as stipulated by the President, are being implemented and maintained.

### *Safeguard 1*

*"The conduct of comprehensive, aggressive, and continuing underground nuclear test programs designed to add to our knowledge and improve our weapons in all areas of significance to our military posture for the future."*

By means of the continuing, active underground test program at the Nevada Test Site (NTS), increasingly important advanced data have been obtained on weapons designs and concepts as well as weapons effects. Engineering technology and diagnostic techniques have advanced so that more complex, highly-instrumented, underground tests are now possible. During 1964, 29 underground events were announced, including one joint United States-United Kingdom (U.K.) event.

#### OPERATION WHETSTONE

The unclassified name for the current underground series of weapons tests designed to meet the objectives of the research and development program, being conducted at the Nevada Test Site (beginning July 1, 1964, and ending June 30, 1965,) is Operation Whetstone. (Operation Niblick was the name of the preceding underground series which ended June 30, 1964.) The planned events for Whetstone fall into five broad categories: (*a*) Weapons and device development events, (*b*) Plowshare (peaceful uses of nuclear explosives) experiments, (*c*) Department of Defense effects events, (*d*) tests designed to increase the United States detection capability (Vela Program), and (*e*) joint United States/United Kingdom events for conduct under the U.S.-U.K. 1958 Agreement for Mutual Defense Purposes.

Fifteen events have been publicly announced as being conducted under Whetstone. Thirteen events were publicly announced as having been conducted in 1964 under Niblick. In addition, one off-site event was conducted for the Vela (detection) program—the Salmon event on October 22, 1964.

### *New Hole Excavation Techniques*

Techniques, new to the United States and others, originated or improvised to cope with the unique and unprecedented needs presented by underground tests, have enabled miners at NTS to excavate rooms, up to 900 cubic yards in size, at the bottom of drilled vertical shafts.

The use of mined "shot" chambers permits much more sophisticated diagnostic instrumentation and makes it possible to obtain more data from a single detonation by adding extra programs and projects. The use of mined shot chambers does encompass an element of risk, especially in construction, but all necessary precautions are observed in order to minimize the risk and performance has been exceptionally good. On September 19, 1964, four miners were trapped 4 days before rescue at the bottom of an 1,800-foot hole when cables broke at the surface and the down-hole cabling collapsed into the shaft. One contractor employee at the surface was killed by the whiplash of the cables.

Further advances in digging techniques have permitted the drilling and casing of holes to depths and diameters unheard of up to a few years ago (*e.g.* 4,700 feet deep and upwards of 72 inches uncased, or 48 inches in diameter when cased). Associated geological and hydrological conditions encountered have forced radical changes in techniques. The NTS-developed techniques have attracted drilling industry interest and shows a potential for making drilling more competitive (in cost, as well as time), for construction of large-diameter holes in many other media and uses.

### *Expanded Scope of Experiments*

As the underground test program has matured, increasing technical engineering and diagnostic knowledge has been gained which has expanded the scope of the experiments that can be conducted underground. An example of this expansion in scope was the Alva effects event conducted by Lawrence Radiation Laboratory-Livermore on August 19. The specific purpose was to record the effects from a nuclear detonation on various types of materials and components. Alva was one of the most important events conducted to date as well as the most costly and complex. If the test ban were not in being, the event would normally have been conducted in the atmosphere; however, with the current increase in engineering knowledge and experience methods were found to derive the desired data from the underground event.

The Alva event emplacement consisted of a deep-mined shaft at the bottom of which five horizontal tunnels were arranged asymmetrically, with the nuclear device at the hub. In each tunnel nuclear and nonnuclear components and materials were placed for exposure to the effects of a nuclear detonation. In addition to the specimens to be exposed, large amounts of instrumentation were included. Although technology is rapidly advancing, the cost to achieve these objectives has also risen—the construction for this event totaled more than $5.5 million.

### *Test Area Expanded*

The Pahute Mesa area expansion, adding about 166 square miles, to the NTS was completed during the year and will be ready for testing purposes in 1965. The expansion, north and west of NTS, into more remote, higher elevations will permit drilling of deeper holes for the conduct of higher-yield underground detonations. Studies have indicated that the underground geologic formations in the high Pahute Mesa area may not transmit earth shock to off-site communities as readily as would formations at the more accessible parts of NTS. Low-intermediate yield experiments are planned to confirm the studies before proceeding to high-intermediate yield events. The construction carried out to complete the Pahute Mesa expansion included more than 50 miles of road (both gravel and paved), an airstrip, electrical and water supply systems, and an austere control point complex fashioned from trailers.

Several emplacement holes ranging up to about 5,000 feet in depth and 72 inches in diameter (cased to 48 inches in diameter) along with a number of instrumentation, satellite, and exploratory holes—one to a depth of 13,670 feet—were in various stages of completion at year's end.

### *Test Event Summary*

A summary of continental U.S. nuclear testing is as follows: a total of 127 announced weapons related tests have been conducted at the Nevada Test Site (NTS) since the initiation of the current testing program on September 15, 1961, after the Soviet resumption of atmospheric testing. Included are three United States-United Kingdom tests of U.K. devices. Not included are 10 Plowshare (peaceful uses) experiments at NTS and three off-site events—a Plowshare experiment, Gnome, in 1961 near Carlsbad, N. Mex.; and two Vela (detection) experiments—Shoal in 1963 near Fallon, Nev., and Salmon on October 22, 1964, near Hattiesburg, Miss. Tests announced in 1964 include 21 U.S. weapons related tests, one U.S.-U.K. test of a U.K. device, six Plowshare experiments, and one Vela experiment.

The table below summarizes the announced 1964 events:

TABLE 5.—UNDERGROUND NUCLEAR DETONATIONS AT NEVADA TEST SITE

(January 1, 1964–December 31, 1964)

| Event name | Date | Type of event [1] |
|---|---|---|
| Fore | January 16 | Low intermediate yield. |
| Oconto | January 23 | Low yield. |
| Klickitat [2] | February 20 | Low intermediate yield. |
| Pike | March 13 | Low yield. |
| Hook | April 14 | Do. |
| Sturgeon | April 15 | Do. |
| Turf | April 24 | Low intermediate yield. |
| Pipefish | April 29 | Low yield. |
| Backswing | May 14 | Do. |
| Minnow | May 15 | Do. |
| Ace [2] | June 11 | Do. |
| Fade | June 25 | Do. |
| Dub [2] | June 30 | Do. |
| Bye | July 16 | Low intermediate yield. |
| Cormorant [3] | July 17 | Low yield. |
| Alva | August 19 | Do. |
| Canvasback | August 22 | Do. |
| Haddock | August 28 | Do. |
| Guanay | September 4 | Do. |
| Auk | October 2 | Low intermediate yield. |
| Par [2] | October 9 | Do. |
| Barbel | October 16 | Low yield. |
| Salmon [4] | October 22 | Do. |
| Forest | October 31 | Do. |
| Handcar [2] | November 5 | Do. |
| Crepe | December 5 | Low intermediate yield. |
| Parrot | December 16 | Low yield. |
| Mudpack [5] | December 16 | Do. |
| Sulky [2] | December 18 | Do. |

[1] Low yield, less than 20 kiloton (kt); low intermediate yield, 20 kt to 200 kt.
[2] Plowshare event (Peaceful Uses of Nuclear Explosives).
[3] Jointly with the United Kingdom.
[4] Vela (detection) event.
[5] Department of Defense event.

## ATMOSPHERIC TEST READINESS CAPABILITY

The AEC has completed the programmed construction, stockpiling, and airborne diagnostic capability preparation required prior to January 1, 1965, necessary to meet the objectives of test safeguard number 3:

"*The maintenance of the facilities and resources necessary to institute promptly nuclear tests in the atmosphere should they be* *deemed essential to our national security or should the treaty or any of its terms be abrogated by the Soviet Union.*"

For atmospheric test series conducted from 1948 to 1962 the main bases of operation were Christmas Island (Operation Dominic [9]) and Eniwetok Atoll (prior to Dominic). Johnston Island was used as a base for high altitude events and in support of the other areas. The success of the airborne diagnostic technique in the latter part of Dominic made the use of Christmas Island unnecessary. U.S.-owned Johnston Island was chosen as the land base to support any future atmospheric tests.

### *Johnston Island Construction*

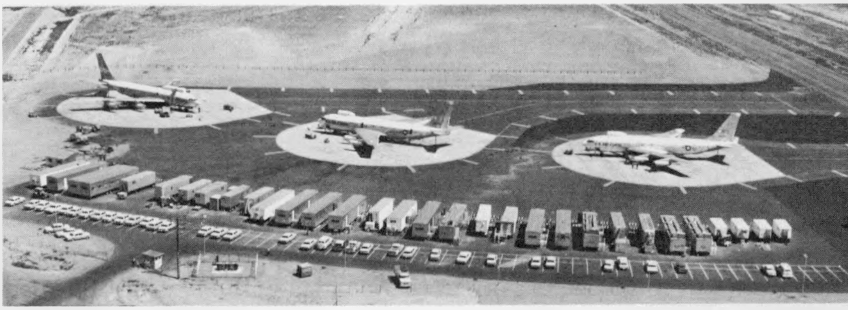
The upgrading program at Johnston Island has essentially been completed although there remain a number of facilities to be constructed in the reaction period after the scheduled readiness date of January 1, 1965, or to be completed shortly after that date. Support facilities such as extension of airstrips and aircraft parking areas, offices, shops, and warehouses are complete. Eight barracks have been completed. Mess hall facilities have been expanded, along with services such as electric, water, sewer, and communications. The usable land area of the Johnston Atoll has been increased, by dredging and filling, to about 640 acres from the original area of about 210 acres.

Those scientific facilities at Johnston Island and the Hawaiian Islands which were essential for the conduct of airborne exercise were completed. Other scientific construction has been constructed where the capabilities of the facilities will not deteriorate or become obsolete with the passage of time. Some scientific construction will be deferred to the scheduled reaction time (*i.e.* the time period between decision to resume atmospheric testing and the conduct of the initial test if, and when, it becomes necessary to resume atmospheric testing) in order that data gathering facilities will be in harmony with test event requirements at that time.

### *Airborne Test Exercise*

An airborne exercise was succesfully conducted in the Johnston Atoll area in October. The Air Force made available three high performance jet aircraft which were structurally modified and then instrumented for use by each of the weapons laboratory staffs as "flying laboratories." A number of other USAF aircraft were modified to function as sampler aircraft for any future atmospheric tests.

[9] See pp. 62–67, Annual Report to Congress for 1963.



"*Flying Laboratories.*" Photo shows the three NC–135 jet aircraft used in the October airborne test exercise as flying diagnostic laboratories parked at Kirtland Air Force Base, Albuquerque, N. Mex. In the foreground are the large number of instrumentation vans that supported the exercise which was held near Johnston Island. During the airborne exercise, the three planes were positioned around a B–52 "drop" aircraft to record electronic signals from a non-nuclear drop test vehicle.

For the exercise near Johnston Island, the three diagnostic aircraft (staged from Hickam Air Force Base in Hawaii) and the sampler aircraft were positioned around a "drop" aircraft. A complete check of the airdrop system was conducted by recording data through use of electronic signals transmitted by the non-nuclear device. The operation, called Crosscheck, fulfilled expectations. Analysis of the technical data acquired was still in progress at year's end. The exercise, principally a "de-bugging" exercise for the diagnostic aircraft, revealed some minor deficiencies. None would preclude an immediate operation.

### TEST MATERIAL READINESS

A series of special ballistic cases (or test vehicles) has been developed and flight-tested to establish drop trajectories. These cases would carry nuclear devices to be tested in any possible atmospheric series. Telemetry systems to be carried in the test vehicles have also been developed and procured. Rockets, to carry close-in and far-out instrumentation, have also been developed, tested, and are being stockpiled for any possible need.

## WEAPONS PRODUCTION

Under Presidential authorization, 1964 production of nuclear weapons continued to meet stated military requirements with no major production problems or shortages in meeting production requirements. In several instances, the system was ahead of schedule. New warheads and bombs allowing greater military flexibility of application entered the stockpile and the modernization of existing nuclear weapons continued.

### *Stockpile Improvement*

During the year, the AEC supported increased military operational capabilities with the delivery of new warheads for the Polaris, Subroc, and Minuteman missile systems and new nuclear artillery projectiles and atomic demolition munitions. In addition, weapons production incorporated the latest designs and technological concepts which provided improved reliability, efficiency, safety, and the prevention of unauthorized employment. Considerable effort continued in the production of nuclear bombs and warheads for strategic, tactical, antisubmarine warfare, and air defense employment.

A continuing effort to achieve production objectives at a minimum cost has been emphasized. This effort begins with the design and development of weapons and weapon components, including the use in new programs of previously developed nuclear and non-nuclear components. The weapon production activities have been conducted on an orderly basis to minimize the need for expensive "crash" efforts. In the retirement of obsolescent weapons, careful attention has been given to the recovery of reusable nuclear and non-nuclear components for use in current AEC weapons production, in research and development programs of both the AEC and DOD, and for DOD training requirements.

### *Consolidation of Facilities*

The Commission announced in April that weapon facilities at San Antonio, Tex., and Clarksville, Tenn., are scheduled to be closed by July 1966, and that their operations will be transferred to the AEC's facilities at Burlington, Iowa, and Amarillo (Pantex Plant), Tex. All four facilities are contractor-operated by Mason & Hanger-Silas Mason Co., Inc. The Burlington and Amarillo plants now operate as chemical explosive-component manufacturing and weapon assembly plants. The Burlington and Amarillo plants have considerable capability not available at San Antonio and Clarksville and can be expanded with minor modifications. The San Antonio and Clarksville facilities have operated as weapon modification and assembly plants for the replacement of limited-life components, conducting quality assurance, and also for the modification of weapons as the technology has advanced.

The action followed a 2½-year study of the future new weapons production workload assignable to Burlington and Amarillo, and of weapons workload assignable to San Antonio and Clarksville. The study of the future workload showed that the system would level off in 1965 and decrease somewhat in future years. It was determined that under these projections, the weapons work could be consolidated in the Burlington and Amarillo facilities with significant cost savings estimated at about $3 million annually. Of this, some $2 million will be in reduced personnel costs. The one-time costs of the transfer, including construction costs at Amarillo and Burlington, are estimated at about $4.5 million. The work now performed at the assembly plants could only have been transferred to San Antonio and Clarksville after major modifications and significant new construction.

When the consolidation is complete, the Clarksville facility will be returned to the DOD and the San Antonio facility will be declared excess to Commission needs.

## DETECTION OF NUCLEAR EXPLOSIONS

During 1964, the AEC continued to participate in studies on ways and means to improve detection techniques and systems (Vela program) for both underground and space nuclear explosions. The Vela program is supervised by the Advanced Research Projects Agency (ARPA) of the Department of Defense and is a research and development effort conducted to improve capabilities of detecting, locating, and identifying nuclear detonations. The ultimate objective is development of a system, or systems, capable of adequately monitoring a comprehensive nuclear test ban. The Vela program has three subprograms; (*a*) detection of underground detonations; (*b*) detection, by means of satellites, of nuclear explosions in space; and (*c*) detection of nuclear explosions in space through ground equipment.

The Vela program has progressed well toward meeting Safeguard number 4:

"*The improvement of our capability, within feasible and practical limits, to monitor the terms of the treaty, to detect violations, and to maintain our knowledge of Sino-Soviet nuclear activity, capabilities, and achievements.*"

### VELA UNIFORM PROGRAM

Development of techniques for improving the capability to detect, locate, and identify underground nuclear explosions is conducted under the Vela Uniform program. The DOD has the administrative, funding, and technical responsibility for the program, and the AEC is responsible, in connection with all nuclear events for: (*a*) construction and firing; (*b*) determination of yield and conducting post-shot drilling; (*c*) instrumenting for close-in measurements; and (*d*) public safety.

During 1964, measurement of ground shock accelerations and other effects, and operation of both short and long range seismic detection stations for Vela research and development purposes were conducted in conjunction with the weapons test series at the Nevada Test Site. Two nuclear detonations—Project Shoal in 1963, and the Salmon event of Project Dribble in 1964—have been conducted outside the Nevada Test Site especially for the program; both events were "open" with news media representatives present.

### *Project Shoal*

During 1964, analysis of data and information obtained from Project Shoal was analyzed and the site closed. Shoal was a nuclear detonation of about 12 kilotons fired on October 26, 1963, in the Sand Springs Mountains area of Nevada (about 28 miles southeast of Fallon).[10] The device was buried in granite about 1,200 feet underground in an active seismic area. The primary objective was to obtain seismic signals generated by a nuclear detonation for comparison with those of naturally occurring disturbances.

The site was partially secured during 1964 by placing a concrete stemming plug down the emplacement hole for about 20 feet and a security fence erected around the emplacement site.

### *Project Dribble*

The Dribble program, as planned, contemplated three underground nuclear detonations in the Tatum Salt Dome, about 20 miles southwest of Hattiesburg, Miss. The primary objectives of the project are:

(*1*) To obtain data which may be extrapolated to indicate the significance of decoupling at the 5-kiloton level of yield; and

(*2*) To study seismic wave propagation in the earth's mantle from nuclear explosions in the southeastern United States.

The three-event series include: (*a*) Salmon: a 5-kiloton "tamped"[11] nuclear detonation at a depth of 2,700 feet which was conducted in 1964; (*b*) Sand: a 100-ton (0.1 kiloton) "decoupled"[12] detonation in a 95-foot diameter cavity at a depth of 2,000 feet; and (*c*) Tar: a 100-ton (0.1 kiloton) "tamped" event at a depth of 2,000 feet. No schedule has been announced for the latter two events.

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[10] See pp. 69–70, Annual Report to Congress for 1963.

[11] "Tamped" is the placing of an explosive event underground in direct contact with the medium in which it will be fired so that the shock and earth movement generated by the explosion will be directly transferred by close physical coupling to the medium.

[12] "Decoupled" is the use of an underground cavity as an explosion site to reduce the transference of the explosive energy and hence the amount of shock and earth movement imparted to the surrounding medium, thus possibly concealing the true magnitude of the explosion or reducing the effects of the explosion below the detection capabilities of a detection system.

*Salmon event.* Salmon was detonated on October 22 and involved the detonation of a 5-kiloton nuclear device at the bottom of a 17.5-inch hole drilled to a depth of 2,700 feet. The bottom 500 feet of the shaft was uncased in order not to distort the seismic signals imparted to the surrounding salt medium. Salmon was a tamped event and was completely contained.

A significant achievement was the drilling of the Salmon emplacement hole. The type of hole, 2,700 feet deep in a salt mass and remaining essentially dry, had never been accomplished before. The peculiar geological factors associated with a salt mass usually include a number of aquifers (water sources) which heretofore had usually resulted in the infiltration of water into a salt emplaced hole.

### *Unmanned Seismological Observatory*

Early in 1964, Sandia Laboratory was authorized to design, build, and environmentally test one or more prototypes of an unmanned seismological observatory (USO) for the Advanced Research Projects Agency of the Department of Defense. Sandia plans to develop a compact, reliable USO capable of operating unattended for a minimum period of 90 days, and with a timing accuracy of about 0.1 second or better for the operational period. The USO is being designed to be immune to normal terrestrial environments, such as extremes of heat and cold, extremes of wetness and dryness, high winds, and lightning. The tentative goal is to begin field evaluation of two prototypes by early 1966.

### *Vela Satellite Detectors Program*

The AEC continues to participate in the Department of Defense Vela satellite program, a research and development effort aimed to develop satellite-based instruments and systems to detect nuclear explosions in space.

The program of developing instrumentation for the Atlas-Agena rocket launched satellites is a cooperative effort by the Los Alamos and Sandia laboratories. Satellite-borne radiation detectors for neutrons, gamma rays, and X-rays, and the associated electronic logics, have been developed and fabricated by the two laboratories. At the end of 1964, four such space probes were in orbit.

*1963–1964 launchings.* A second Atlas-Agena launch was successful in mid-July 1964, placing two more AEC-instrumented satellites in orbits similar to the first two. The two new spacecraft have essentially the same detection systems as the first two, plus new detectors for measuring "solar wind" proton fluxes, low energy solar X-ray fluxes, and the characteristics of plasma clouds occasionally observed by the first pair of spacecraft.

The first pair of AEC-instrumented Vela satellites were successfully placed in orbit by a single Atlas-Agena launch in mid-October 1963. Each satellite was injected into nearly circular orbits, with average altitudes of 68,000 statute miles, well beyond the Van Allen radiation belts. The AEC-developed instrumentation systems continue to perform as planned, and have demonstrated the feasibility of satellite-based detection systems. At year's end, after 14½ months in orbit, they have accumulated valuable operational and background radiation information. No unexpected backgrounds have been observed which would nullify the basic detection concepts.

*Future launches.* A third Vela satellite launch is scheduled for 1965 and will place two additional AEC-instrumented satellites in orbits. The detection systems for the third set of space probes are being modified on the basis of information obtained from the first four satellites, and some new detection concepts will be explored.

In addition to the currently authorized Atlas-Agena launchings, AEC-developed instrumentation systems are being included on other space launchings to measure background radiation at various levels above the earth.

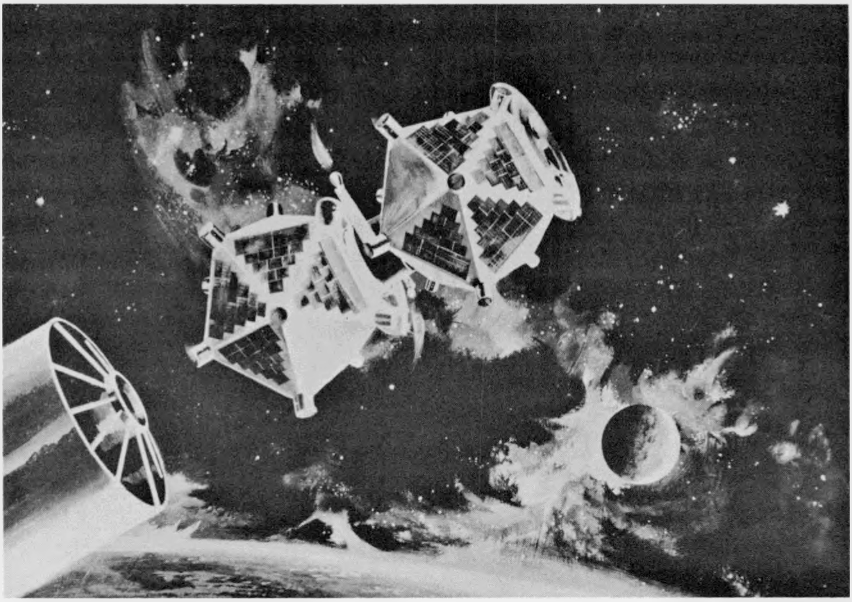
### *Vela Ground Detectors Program*

The Los Alamos Scientific Laboratory is participating also in the Vela program to develop ground instruments for detection of nuclear explosions in space. To date, the primary effort has been in two areas, air fluorescence and direct optical. The first method is based on the detection of fluorescent light produced when nitrogen is bombarded with X-rays. Significant results have been obtained from continued analysis of data obtained by equipment tested during the Dominic high altitude events in the Pacific in 1962.[13] Additionally, laboratory investigations of fluorescence efficiencies and other atomic-molecular physics problems are being conducted. The direct optical technique uses an optical system to measure the visible light produced by a nuclear explosion. Development efforts are being conducted on improved optics and optical systems.

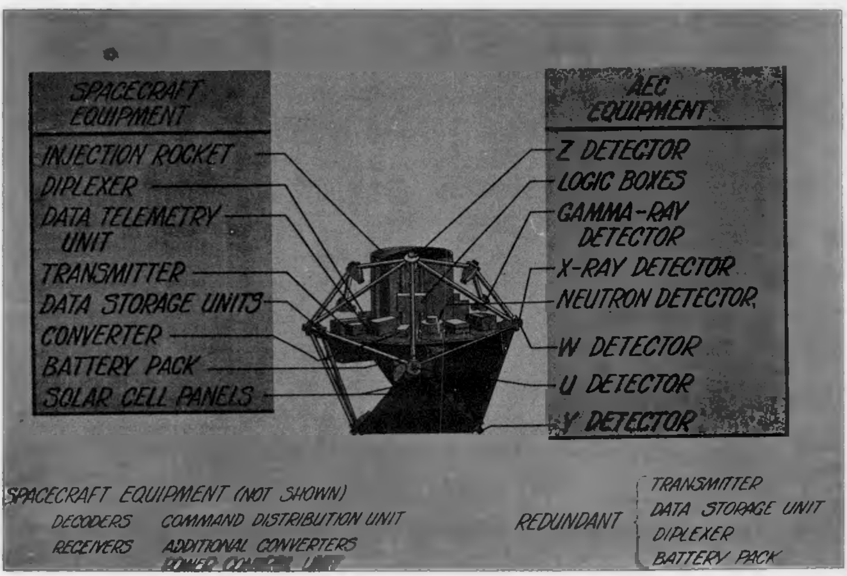
## MUTUAL DEFENSE AGREEMENTS

Under the provisions of the Atomic Energy Act of 1954, as amended, the President may authorize the United States to cooperate with another nation or regional defense organization to which the United

[13] See pp. 62–67, Annual Report to Congress for 1963.



*Vela Satellite.* At the end of 1964, four Vela nuclear detection satellites were in orbit about 68,000 miles from earth. Drawing is an artist's conception of how the Vela satellites looked after separation from the booster (*lower left*) and before they were put in orbit in deep space. These sentinel satellites, which were designed to detect nuclear explosions in space, carry X-ray, neutron, and gamma ray detectors plus associated data-processing electronics which transmit signals to ground stations. The AEC developed the detectors and logic systems for these satellites and data is recorded by a world-wide network of Air Force ground stations. The Vela program is supervised by the Advanced Research Projects Agency of the Department of Defense with the AEC participating in research and development of detection techniques and systems.



States is a party and to communicate certain classified data as is necessary for mutual defense purposes. During 1964, exchanges of information for mutual defense purposes continued under 11 such agreements for cooperation.

The United States has agreements for mutual defense purposes in effect with Australia, Canada, Belgium, France, the Federal Republic of Germany, Greece, The Netherlands, Turkey, Italy, the North Atlantic Treaty Organization (NATO), and the United Kingdom. A revision of the agreement with NATO was submitted to the Congress on June 30, 1964; and will become effective upon approval by all the member nations of NATO.

These mutual defense agreements provide for exchange of classified information for the purpose of development of mutual defense plans, the training of personnel in the employment of and defense against atomic weapons and other military applications of atomic energy, the evaluation of the capabilities of potential enemies in the employment of atomic weapons and other military applications of atomic energy, and the development of compatible delivery systems for atomic weapons.

An agreement with the United Kingdom—the only one of its kind—involves exchange of classified nuclear weapons information for the purpose of improving the atomic weapons design, development, and fabrication capabilities of each nation has been in existence between the United States and the United Kingdom since 1958. Under the provisions of this agreement, information concerning nuclear weapons matters is exchanged through the medium of joint working groups, individual visits of scientific personnel, and reports.

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# Part Three

# Nuclear Reactor Programs

The heat generated by atomic fission and from decaying radioisotopes is convertible into useful energy which can make an important, and eventually a vital, contribution toward meeting this Nation's long-term energy requirements; toward solving fuel logistics problems of our military services; and toward providing high-powered, extended-range propulsion plants and auxiliary power systems for surface, underwater, and space craft that cannot be matched by conventional power sources. The programs summarized in this part of the Annual Report represent approximately 20 percent of the Commission's 1964 fiscal year operating costs.

# NUCLEAR REACTOR DEVELOPMENT

The Commission's nuclear reactor development programs are concerned with the development, demonstration, improvement, and safe operation of nuclear reactors and nuclear devices which may be used to generate electricity in power plants; to produce heat for such process heat applications as desalting sea water; to heat living and working quarters; to propel submarines or surface vessels; to propel missiles or space vehicles; to furnish thermal and electrical power for unattended use in space, on the earth, and under the sea; and to provide energy for use on lunar or planetary bodies. These activities are labeled as the "Civilian Power," "Maritime," "Space," "Military," "Advanced Reactor Technology," and "Nuclear Safety" programs and are discussed in that order on the following pages.

In 1964, each of these nuclear reactor development programs continued to make steady strides toward its ultimate objectives, some achieved major milestones, and some were shifted in their direction.

## MAJOR 1964 DEVELOPMENTS

On June 10, President Johnson[1] noted that the United States is achieving great economic progress through the introduction of large-scale nuclear reactors for commercial power. Although no nuclear plants are presently producing power at competitive costs, the President's comment was predicated upon recent decisions by electric utilities to begin now to build large-scale central station nuclear power plants which they expect will produce competitive power upon completion. These decisions to select nuclear plants over conventional fuel plants on a competitive basis is a strong indication that the Nation is considerably ahead of its previously estimated time schedule for achieving economic nuclear power production. Today it seems possible that no fewer than seven million homes will be receiving nuclear power by 1980 as compared to the four-million-home estimate made in the AEC's 1962 "Report to the President on Civilian Nuclear Power."

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[1] In a commencement address at Holy Cross College, Worcester, Mass.

# CIVILIAN NUCLEAR POWER REACTORS PROGRAM

The objective of the civilian nuclear power reactors program is to constantly explore, develop, and advance the technology of central station nuclear power plants so the cost of power from nuclear sources will become economically competitive on an ever-widening basis with the cost of power from conventional sources, and fuller use will be made of the nuclear energy latent in the nuclear fuels, uranium and thorium. As of December 31, 1964, the net electrical generating capacity of central station-type nuclear power plants was 1,073,600 electrical kilowatts (ekw), and plants totaling 2,404,000 ekw were under construction or firmly committed for construction. In addition, power conversion equipment capable of generating 800,000 ekw from heat produced by the New Production Reactor near Richland, Wash., is being constructed by the Washington Public Power Supply System.

## ADVANCED CONVERTER PROPOSALS

On February 14, the AEC solicited proposals from the nuclear industry for the cooperative design, construction, and operation of a spectral shift control reactor nuclear power plant and, on February 22, requested proposals for the cooperative design, construction, and operation of prototype advanced converter reactor plants incorporating either (*a*) the heavy water-moderated, (*b*) high temperature gas-cooled, (*c*) thorium seed-blanket, or (*d*) sodium-cooled graphite-moderated concepts. The AEC considered each of these five advanced concepts desirable and ready from a technology standpoint for prototype construction.

### *Four Proposals Received*

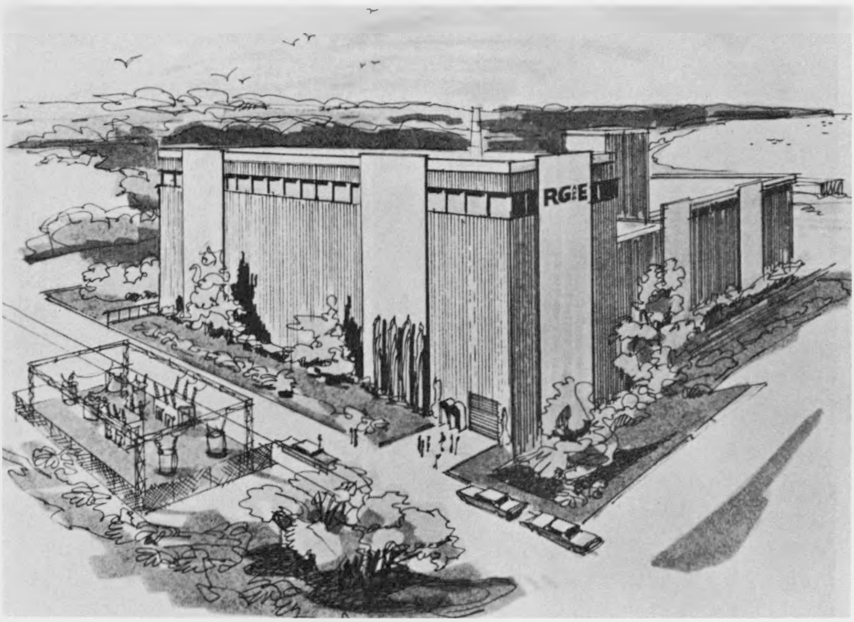
In response to these invitations, the AEC received the following four proposals:

(*1*) A 260,000-net-electrical-kilowatt high-temperature, gas-cooled reactor plant for location on a site 19 miles east of Rochester, N.Y. The proposal was submitted by the Rochester Gas & Electric Corp. and the General Atomic Division of General Dynamics Corp.

(*2*) A proposal, submitted by the State of California Department of Water Resources, for a thorium-fueled seed-blanket reactor plant to supply about 525,000 net electrical kilowatts to power the pumps of the California Water Project which involves transporting water from the northern to the southern part of the State. The site for the proposed plant has not yet been determined; the plant rating will depend on the site finally selected. If located on the coast, the plant may also include a sea-water desalting facility.

(*3*) A 150,000-net-electrical-kilowatt spectral shift control reactor plant to be located about 35 miles southeast of Carson City, Nev. The proposal was submitted by Sierra Pacific Power Co. and Babcock & Wilcox Co.

(*4*) A sodium-cooled, graphite-moderated reactor with a warranted design capacity of 200,000 net electrical kilowatts, to serve as a hook-on facility to the existing 137,500 net kilowatt Mt. Tom gen-



*Proposed Plant.* During February, the AEC sought proposals for the cooperative construction and operation of prototype power plants incorporating a spectral shift, heavy-water-moderated, high-temperature gas-cooled, thorium seed-blanket, or sodium-cooled graphite-moderated reactor. Four responses were received and in September the Commission announced the acceptance of two of the proposals, one proposed for New York and the other in California. The above is an artist's drawing of the advanced High Temperature Gas-cooled (HTGR) nuclear power station which Rochester Gas and Electric Corp. proposes to build on the shores of Lake Ontario, about 19 miles east of Rochester, N.Y. The plant would have an electrical generating capacity of 260,000 kilowatts. The AEC has accepted the proposal as a basis for negotiations with Rochester Gas and Electric and General Atomic Division of General Dynamics which developed the HTGR system and which will be prime contractor for the plant. General Atomic will furnish the entire power plant and its nuclear fuel. The other proposal accepted for negotiations was from the State of California for a thorium-fueled seed-blanket reactor plant to supply about 525,000 net electrical kilowatts for the California Water Project which will transport water from the northern to the southern part of the State.

erating station at Holyoke, Mass. The proposal was submitted by the Holyoke Water Power Co. and the Atomics International Division of North American Aviation, Inc.

### *Two Proposals Accepted*

On September 24, the Commission announced that, after further technical evaluation of the five advanced converter concepts and an evaluation of the four proposals submitted for prototype plants, it had accepted as bases for negotiation of "Memoranda of Understanding," the proposals for the high-temperature gas-cooled (Rochester) and the thorium seed-blanket (California) nuclear plants, and had decided not to accept the proposals for the spectral shift control (Sierra Pacific) and sodium-graphite (Holyoke) nuclear plants. In addition, the Commission redirected research and development on the heavy water-moderated reactor concept to the use of an organic coolant; the research and development work to be done jointly by Combustion Engineering and Atomics International, with assistance from the AEC's Savannah River Laboratory.

*Large Seed-Blanket Reactor* (*LSBR*). The research and development work conducted to date to determine the potential of the seed-blanket reactor concept for large central station application has identified two promising reactor concepts: a seed-blanket reactor, with uranium 235 in the seed and thorium in the blanket, that appears capable of operating for 9 or 10 years without refueling; and a seed-blanket reactor, fueled with uranium 233 in the seed and thorium in the blanket, which has high potential for breeding in a completely light water reactor system over core lifetimes as long as 2 to 4 years between refuelings. The initial nuclear core for the California seed-blanket reactor plant will demonstrate both core concepts; it will have a central breeding demonstration region with a life of 2 to 4 years, surrounded by fuel assemblies having a life of 9 or 10 years.

Successful completion of the LSBR project will constitute a major advance in reactor technology through demonstration of breeding in a light water system. The thorium seed-blanket concept is the only known approach for extending fuel utilization of light water thermal reactors significantly beyond today's value of 1 to 2 percent of the potential energy in the mined ore. The thorium seed-blanket concept is expected to provide a means for ultimately making available for power production about 50 percent the potential energy in the fertile thorium fuel reserves. The energy source that would thus be made available is many times larger than the energy available from known fossil fuel reserves.

*High-temperature gas-cooled reactor.* The design and development program on high-temperature gas-cooled reactors which General Atomic has been conducting for the AEC has indicated an ultimate potential of simultaneously achieving 1 million electrical kilowatts or more in a single plant, over 45 percent thermal efficiency, and breeding or near-breeding. The proposed Rochester Gas & Electric prototype project would demonstrate many of the required advanced plant features, would provide a large-scale demonstration of fuels, and would provide operating experience—all essential to the subsequent design and construction of a 1-million-electrical-kilowatt plant.

## REACTOR PROJECTS

### PRESSURIZED WATER REACTORS

#### *Shippingport Atomic Power Station*

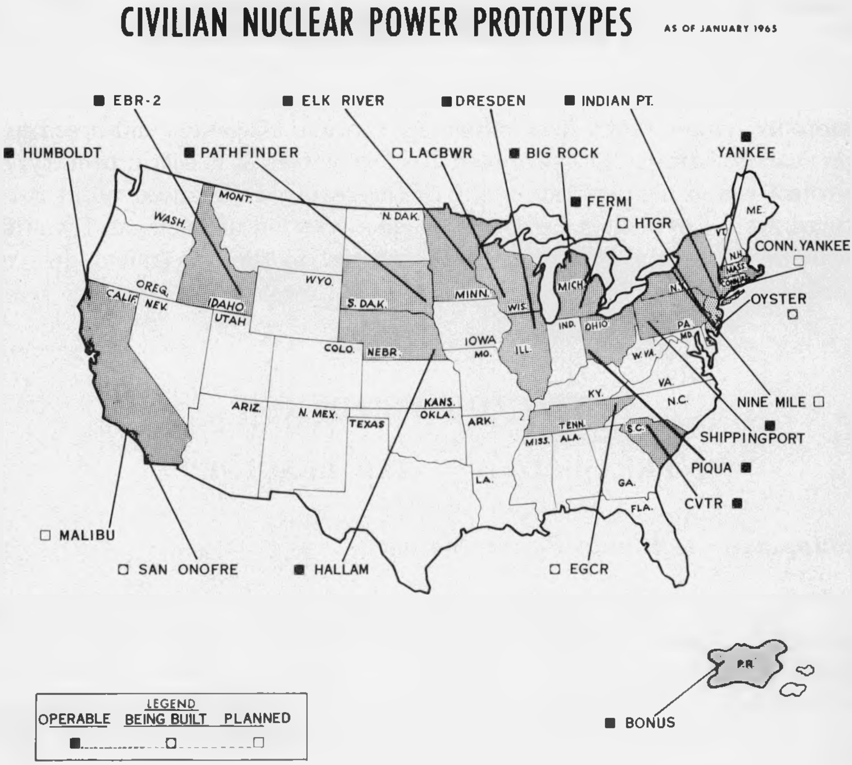
The fourth seed of the first seed and blanket core was depleted on February 9, and the Shippingport Atomic Power Station in Pennsylvania was shut down for refueling. The first core had operated for a total of 27,780 equivalent full power hours; the natural uranium blanket had achieved an average and peak depletion of 11,000 and 37,000 megawatt-days per metric ton of uranium respectively. Refueling and plant alterations necessary to permit higher power operation of the station were performed in the remainder of 1964.

#### *Yankee Nuclear Power Station*

The Yankee Atomic Electric Co.'s pressurized water reactor at Rowe, Mass., operated on its third core until August 2, 1964, and was then shut down for refueling. About one-half of Core III was removed and replaced with fresh 4.1 percent enriched uranium. The reactor was started up on its fourth core on September 6, and has continued to operate without difficulty at its rated capacity of 600 thermal megawatts, 175,000 electrical kilowatts.

In May, the Commission, after having received agreement from the Yankee Atomic Electric Co., approved placing the Yankee reactor under International Atomic Energy Agency safeguards for a 5-year period. (See International Activities section, Part Four.) The first IAEA inspection was completed in November.

Destructive examination of stainless steel-clad, uranium oxide fuel discharged from the Yankee reactor at average exposures up to ap-




proximately 21,000 megawatt days per metric ton of uranium (MWD/MTU) has revealed that the fuel is in excellent condition. In an attempt to obtain even higher exposures one of the two fuel assemblies discharged from Yankee Core I and re-inserted into the reactor with Core II for additional irradiation was again re-inserted in the reactor with the new Core IV. By mid-1965, when the fourth core is scheduled to be discharged from the reactor, this fuel assembly will have achieved an average exposure of approximately 27,000 MWD/MTU.

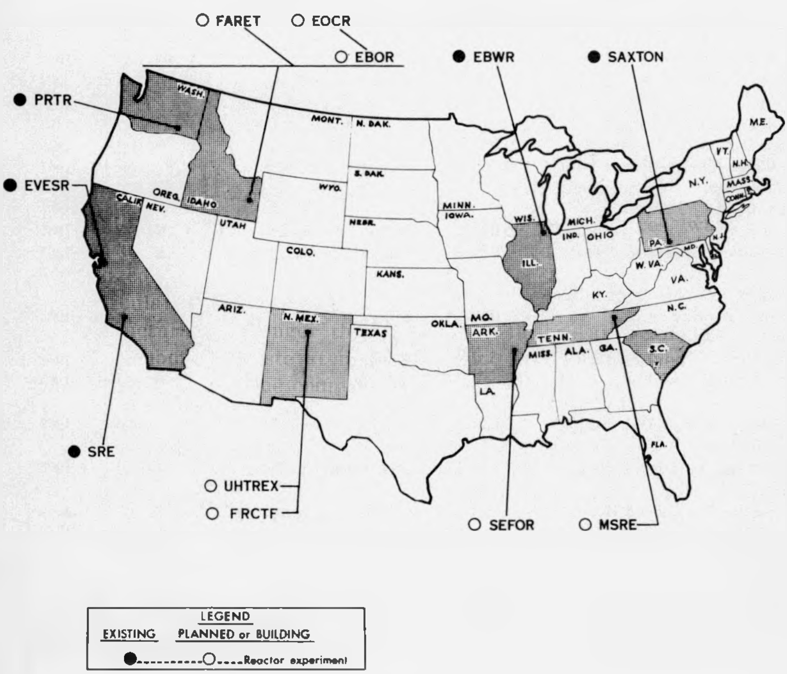
***Indian Point Unit No. 1***

On January 30, the Consolidated Edison Co.'s reactor at Indian Point, N.Y., was shut down for a required inspection of the uranium oxide-thorium oxide fuel elements. While down, repairs were made to the welds in the stainless steel lining around the reactor pit. The reactor again attained criticality (i.e., sustained a controlled chain fission reaction) on June 25, and full power operation resumed in mid-August.

### *Saxton Nuclear Experimental Reactor*

The Saxton Nuclear Experimental Corp.'s pressurized light water reactor near Altoona, Pa., was returned to power operation on January 30, after having been shut down since the previous November for modifications. The reactor, while producing small amounts of electric power, is primarily used for experiments to determine ways in which more heat energy can be obtained from specified amounts of fuel.

EXPERIMENTAL CIVILIAN NUCLEAR POWER PROJECTS AS OF JANUARY 1965




### *San Onofre Nuclear Generating Station*

In March, the AEC signed a contract with the Westinghouse Electric Corp. to perform research and development work on the San Onofre reactor project. A contract was also signed with the two utilities which share the project's cost—Southern California Edison Co. and San Diego Gas and Electric Co.—to provide waiver of fuel use charges. On May 12, the Department of the Navy signed a 60-year easement with the two utility companies permitting the construction of the power station on a portion of the Camp Pendleton Naval Reservation near San Clemente, Calif. Site preparation was initiated

TABLE 1.—CENTRAL STATION TYPE NUCLEAR POWER PLANTS*

| Reactor | Arrangement[1] | Location | Net Plant Capacity Electrical Kilowatts (ekw) | Initial Criticality |
|---|---|---|---|---|
| Pressurized Water Reactors: | | | | |
| Shippingport Atomic Power Station. | ([3]) | Shippingport, Pa | 60,000[3] | 1957 |
| Yankee Nuclear Power Station | PDRP-I | Rowe, Mass | 175,000 | 1960 |
| Indian Point Station[2] | Pvt | Indian Point, N.Y | 255,000 | 1962 |
| Saxton Nuclear Experimental Reactor. | Pvt | Saxton, Pa | 3,250 | 1962 |
| San Onofre Nuclear Generating Station. | PDRP-I | San Clemente, Calif | 375,000 | 1966 |
| Connecticut Yankee Atomic Power Station. | PDRP-I | Haddam Neck, Conn | 462,000 | 1967 |
| Malibu Nuclear Plant | PDRP-P | Corral Canyon, Calif | 462,000 | 1968 |
| Boiling Water Reactors: | | | | |
| Dresden Nuclear Power Station | Pvt | Morris, Ill | 200,000 | 1959 |
| Elk River Reactor[2] | PDRP-P | Elk River, Minn | 23,000 | 1962 |
| Big Rock Nuclear Power Plant | PDRP-I | Big Rock Point, Mich | 72,800 | 1962 |
| Humboldt Bay Power Plant | Pvt | Humboldt Bay, Calif | 50,200 | 1963 |
| LaCrosse Boiling Water Reactor | PDRP-P | Genoa, Wisc | 50,000 | 1965 |
| Oyster Creek Nuclear Power Plant | Pvt | Oyster Creek, N.J | 515,000 | 1967 |
| Nine Mile Point Nuclear Station | Pvt | Oswego, N.Y | 500,000 | 1968 |
| Nuclear Superheat Reactors: | | | | |
| Pathfinder Atomic Power Plant | PDRP-I | Sioux Falls, S. Dak | 58,500 | 1964 |
| Boiling Nuclear Superheat Reactor | PDRP-P | Punta Higuera, Puerto Rico. | 16,500 | 1964 |
| Organic Cooled Reactors: Piqua Nuclear Power Facility | PDRP-P | Piqua, Ohio | 11,400 | 1963 |
| Sodium Cooled Reactors: | | | | |
| Hallam Nuclear Power Facility | PDRP-P | Hallam, Nebr | 75,000 | 1962 |
| Experimental Breeder Reactor No. 2. | Gov't | NRTS, Idaho | 16,500 | 1963 |
| Enrico Fermi Atomic Power Plant | PDRP-I | Lagoona Beach, Mich | 60,900 | 1963 |
| Gas Cooled Reactors: | | | | |
| Peach Bottom Atomic Power Station. | PDRP-I | Peach Bottom, Pa | 40,000 | 1965 |
| Experimental Gas Cooled Reactor | Gov't | Oak Ridge, Tenn | 21,900 | 1965 |
| Heavy Water Reactors: Carolinas-Virginia Tube Reactor[2] | PDRP-I | Parr, S.C | 17,000 | 1963 |
| Under Negotiation: | | | | |
| Rochester Gas & Electric Corp (High Temperature Gas Cooled) | PDRP-I | Rochester, N.Y | 260,000 | |
| State of California Department of Water Resources (Thorium Seed-Blanket). | PDRP-P | Undetermined | ([4]) | |

[1] Gov't = Government owned.
Pvt. = Privately owned.
PDRP = Project is under the cooperative Power Demonstration Reactor Program.
PDRP-I = Participation with Investor-owned utility.
PDRP-P = Participation with Publicly-owned utility.

[2] Some of the energy is derived from conventional superheat.

[3] A cooperative project involving participation with a privately owned utility, entered into prior to the PDRP. Turbogenerator rated at 100,000 ekw; reactor plant modifications will permit operation at 135,000 ekw net equivalent.

[4] About 500,000, although plant rating will depend on site finally selected.

*Condensed from "Nuclear Reactors Built, Being Built, or Planned in the United States" (TID-8200) available from Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va., for $0.50. Single copies may be obtained free of charge from the Division of Technical Information Extension, U.S. Atomic Energy Commission, P.O. Box 62, Oak Ridge, Tenn., 37831.

on May 13, and actual construction work was started during July. The plant is scheduled for 1966 operation. The signed original contracts specify a 395,000 gross electrical kilowatt reactor plant; the utilities, however, are installing a 450,000 electrical kilowatt turbogenerator set because of their confidence that the pressurized water reactor can attain this higher output, probably during second core operation.

### *Connecticut Yankee Atomic Power Station*

On February 14, site clearing work was started for the 490,000 gross electrical kilowatt pressurized water reactor project of the Connecticut Yankee Atomic Power Co. at Haddam Neck, Conn. Actual construction started with the pouring of the first concrete on August 3. All long-lead time items are on order and the project, which is scheduled for completion in 1967, is progressing smoothly.

### *Malibu Nuclear Plant*

On March 4, a contract was signed by the AEC and the City of Los Angeles providing for design assistance and waiver of fuel use charges for a 490,000 gross electrical kilowatt pressurized water plant scheduled for 1968 completion on a Corral Canyon site near Malibu. The contract between Westinghouse Electric Corp. and the City of Los Angeles to construct the plant is awaiting issuance of an AEC construction permit.

## BOILING WATER REACTORS

### *Experimental Boiling Water Reactor*

Throughout 1964, the Experimental Boiling Water Reactor (EBWR) at Argonne National Laboratory was modified and improved to permit operation with plutonium fuel in about one-fourth of its core. The plutonium fuel was fabricated by the Hanford Laboratories and, following a series of critical experiments, was shipped to Argonne beginning in September. Assembly of the plutonium and uranium fuel elements for the entire core was completed at Argonne during December. Core loading was begun during December, and physics testing is currently in progress.

### *Humboldt Bay Power Plant*

The boiling water reactor in the Humboldt Bay Power Plant of Pacific Gas & Electric Co., near Eureka, Calif., was available for electrical generation about 88 percent of the time during its first year of commercial operation which ended in August 1964. During this period the reactor produced nearly 385 million kilowatt-hours of electricity, and by the end of 1964 the nuclear plant's total production of electricity surpassed one-half billion kilowatt-hours.

### *LaCrosse Boiling Water Reactor*

In October, the AEC was notified by Allis-Chalmers, the LaCrosse, Wis. reactor's designer-builder, that there would be an approximate 3- to 5-month delay in completing construction on the project. A number of difficulties combined to cause the delay—welding and rolling problems during the fabrication of the reactor pressure vessel, pitting defects which caused rejection of about 40 percent of the containment shell steel plate, delays in fabricating the prototype control rod and control rod drive mechanism, etc. Construction had previously been scheduled to be complete by June 28, 1965; the delay moves the completion date to October 1965. The LaCrosse Boiling Water Reactor is expected to provide firm power to the Dairyland Power Cooperative by September 1966, as scheduled.

### *Elk River Reactor*

During its preliminary test program, the AEC-Rural Cooperative Power Association's boiling water reactor at Elk River, Minn., attained its design full 58.2 thermal megawatt, 23,000 electrical kilowatt (ekw), power level, and a full power, 28-day warranty run was completed March 21. This was followed by a 60-day transition run to prepare the reactor operators for plant operation after transfer from Allis-Chalmers to RCPA. In November the reactor was shut down for visual inspection of the control rods. They were found to be serviceable, and the plant was returned to power operation.

### *Big Rock Nuclear Power Plant*

The boiling water reactor in the nuclear power plant of Consumers Power Co. at Big Rock Point, Mich., was shut down on March 29, after successfully completing a series of research and development tests at its initial-rated power level of 50,000 ekw. During the shutdown, the core loading was increased from 56 to 84 fuel assemblies to permit reactor operation at a maximum power level of 75,000 ekw. The reactor resumed power operation on May 21 and achieved its new full-power level on June 5. During an inspection of the reactor in September, several bolts which attached the thermal shield to the reactor vessel were found in the core. Corrective action is being taken, and the reactor is scheduled for startup again in early 1965. The AEC's development, testing, and fuel irradiation program in progress at the Big Rock Point plant is aimed at obtaining a high-power-density, long-lifetime fuel with low fabrication cost.

### *Dresden Nuclear Power Station*

On April 12, the Commonwealth Edison Co. shut down its Dresden boiling water reactor plant at Morris, Ill., for a scheduled refueling. At the time of its shutdown, the reactor had produced 1,327,000,000 kilowatt-hours of electricity since its previous refueling in March 1963. Replacement of 96 (about 20 percent) of its fuel assemblies was completed on May 12. Following a successful testing period, the reactor again began producing power on June 9. At the end of the year, the reactor was continuing to operate in a completely satisfactory manner.

### *Other Boiling Water Reactors*

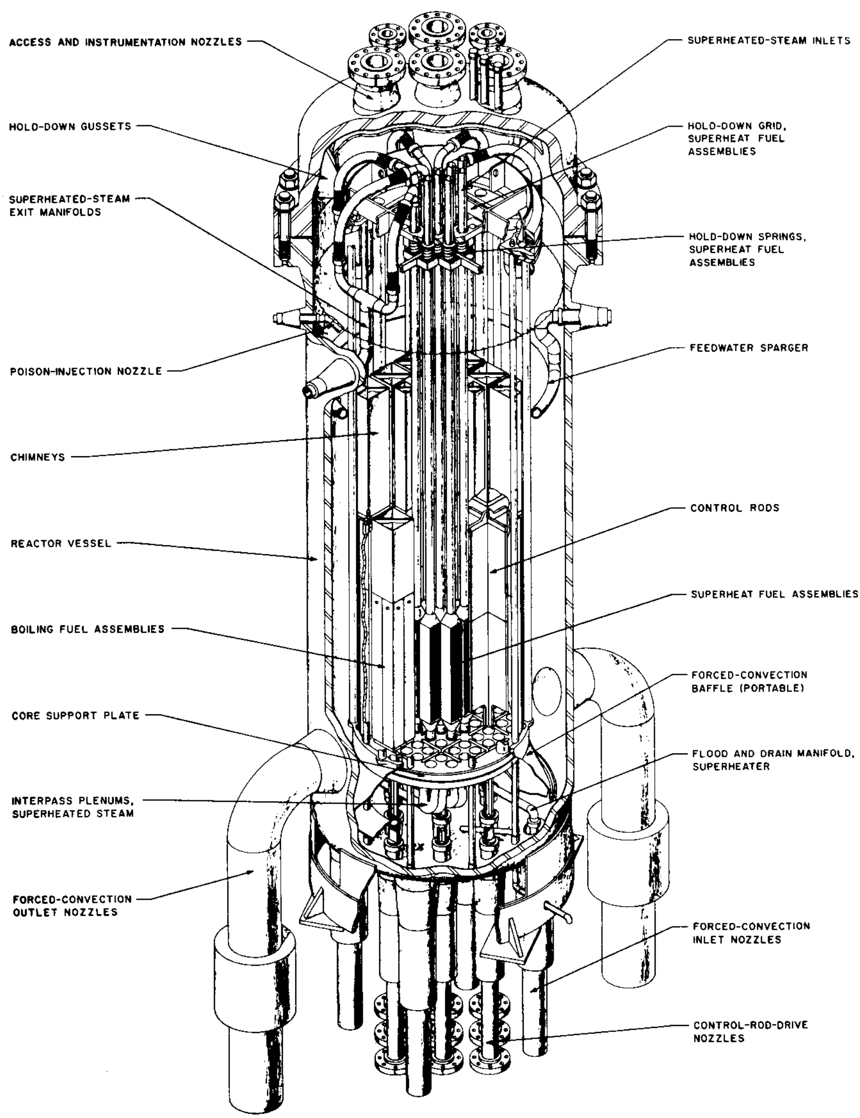
The 1964 activities on the Nine Mile Point (Niagara Mohawk Power Corp.) and Oyster Creek (Jersey Central Power & Light Co.) reactor projects were primarily licensing and regulatory matters and are reported in the Regulatory Activities section, Part Six. In October, the Pacific Gas & Electric Co. announced withdrawal of its application to construct a 313,000 ekw boiling water reactor power plant at Bodega Bay, Calif. (See also Regulatory Activities, Part Six)

## NUCLEAR SUPERHEAT REACTORS

### *Boiling Reactor Experiment No. 5*

Zero-power critical experiments were continued through January on the Boiling Reactor Experiment No. 5 (BORAX–5) at the National Reactor Testing Station (NRTS), Idaho. The central superheater core structure was then removed from the reactor vessel and stored. A peripheral superheating core was subsequently installed which initially produced steam on May 18. (In the "central superheating" core, water is boiled as it passes up through the outer region of the core and the steam is then superheated as it is forced back down through the center of the core; in the "peripheral superheating" core the water is boiled in the central zone of the core and the steam is superheated in the outer region.) Full power was achieved on May 25 with steam at 489° F. in the boiler section, which was superheated to

895° F. at 600 pounds per square inch. Experimental runs continued in a completely satisfactory manner until August 14, when the current experiments were completed and BORAX–5 was shut down. There are no present plans for further BORAX–5 experimental operation.




*Central Superheater.* Drawing shows major components of the BORAX–5 reactor's central superheater system experiment, one of the last two experiments conducted with the reactor at the National Reactor Testing Station before it was shut down during 1964. The Argonne National Laboratory-built reactor had been in operation since 1962 for conducting boiling water reactor experiments.

### *ESADA Vallecitos Eperimental Superheat Reactor*

The ESADA[2] Vallecitos Experimental Superheat Reactor (EVESR) at Pleasanton, Calif., produced its first nuclear superheated steam on March 17, and attained its full rated power of 12.5 thermal megawatts on May 13. Saturated steam of 1,000 psi is supplied from an adjacent oil-fired burner and is superheated in the EVESR core to 950° F. Superheat fuel tests conducted to date in the reactor have been entirely satisfactory.

### *Pathfinder Atomic Power Plant*

On March 24, the Pathfinder reactor of the Northern States Power Co. at Sioux Falls, S. Dak., achieved criticality in the boiler region with a loading of 15 fuel assemblies. The boiler core loading was completed in September, and the fully loaded boiler core went critical on September 17. Mechanical checkout of the plant, low-power testing, and operator training was then completed. During November, the superheater fuel was loaded and the first critical test of the reactor with a full loading of boiler and superheat fuel was conducted. Results were in complete accord with predictions.

### *Boiling Nuclear Superheat Reactor*

The Boiling Nuclear Superheat (BONUS) Reactor at Punta Higuera, Puerto Rico, achieved initial criticality in the boiler region on April 13. Continued operation of the reactor was restricted to "boiler-only" until modifications could be made to the nuclear instrumentation and off-gas system. On August 8, BONUS initially fed electricity into the Puerto Rico Water Resources Authority system during a power test which lasted 1 hour and 22 minutes. Modifications to the instrumentation and off-gas system were completed by October 6, 1964, and integrated boiler-superheat test operation began in October. On November 11, a superheater fuel assembly failed, apparently as a result of an operating error. A valve in the line through which steam was being dumped was partially closed, thus essentially stopping the flow of steam through the superheater assemblies. The failed assembly was replaced and test operation resumed within two weeks. The failed fuel assembly is currently undergoing destructive examination at Oak Ridge National Laboratory.

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[2] Empire State Atomic Development Associates, Inc., a group of seven New York utilities.

### *Privately-sponsored Nuclear Superheat Work*

In August, the East Central Nuclear Group, an organization of 14 electric utilities serving the Ohio Valley and surrounding areas, announced that it had initiated the preliminary phase of a joint program with the Babcock & Wilcox Co., Lynchburg, Va., for the development of a supercritical-pressure, steam-cooled fast breeder reactor. The cooperating utilities believe this reactor concept possesses the potential of very low capital costs, high efficiencies, and low fuel cycle costs, and will thus result in generating costs which could be competitive with conventional fuels in the low-fuel-cost areas which they serve.

## ORGANIC-COOLED REACTORS

### *Piqua Nuclear Power Facility*

On January 27, the Piqua Nuclear Power Facility initially achieved full 11,500 net electrical kilowatt power operation. All formal testing of the reactor by Atomics International (AI) was completed on February 10, and the City of Piqua, Ohio, began operating the reactor for the AEC on February 13 under AI supervision. On May 21, the reactor was shut down for its first scheduled fuel shuffling, maintenance, and containment building leak test. At the time of its shutdown, the reactor had operated for 59 days without interruption, had generated more than 21 million gross kilowatt-hours of electricity, and had furnished about 40 percent of the energy requirements of the City of Piqua. The city assumed full operating responsibility for the nuclear power facility on August 12.

To date, the Piqua reactor—the only operating organic-cooled and-moderated reactor in the United States—has demonstrated excellent load-following characteristics. The heat transfer and coolant purification systems have performed very well. There has been no fuel element surface fouling, and fuel swelling has been less than anticipated and well within acceptable limits.

Operating experience gained by the end of 1964 indicates that the 45.5 thermal megawatt nominal design Piqua plant may have an operating capability of as much as 60 thermal megawatts with practically no modifications, and of up to 80 thermal megawatts with an aluminum powder metallurgy (APM)-clad uranium oxide core with only minor modifications.

## SODIUM-COOLED REACTORS

### *Sodium Reactor Experiment*

The Sodium Reactor Experiment at Santa Susana, Calif., operated successfully at a power level of 20 thermal megawatts until February 15, and was then shut down for modification. The modifications, scheduled to be completed in the spring of 1965, will permit the reactor to operate at higher power (30 thermal megawatts) and at sodium outlet temperatures up to 1,200° F. with uranium carbide fuel.

### *Hallam Nuclear Power Facility*

Initial testing and operation of the sodium-cooled Hallam, Nebr., reactor was performed for the AEC by Atomics International, Hallam's designer-builder. The plant operated very well during January and by February 4 had achieved 30 days of uninterrupted operation. Full operating responsibility for the facility was assumed by Consumers Public Power District of Nebraska on February 6.

Beginning in February, there were indications that several failures had occured in the moderator cans. The stainless steel liners in which the graphite logs are encased developed leaks and the space between the steel and graphite filled with sodium. This caused a slight loss of reactivity (a measure of the departure of a nuclear reactor from criticality), but since no safety hazard existed, the reactor operation was continued. Equipment to remove the failed moderator cans was designed and procured, and removal procedures were established.

By September 27, other moderator cans had failed, and the reactor was shut down for their removal and replacement. This operation is expected to be completed and the reactor operating again some time after February 1, 1965. The removed cans will be disassembled and examined to determine the cause of failure.

### *Experimental Breeder Reactor No. 1*

The small, history-making Experimental Breeder Reactor No. 1 (EBR–1) at the National Reactor Testing Station (NRTS), in Idaho, was decommissioned during the year as other facilities became available for the breeder[3] program. The EBR–1 was the first nuclear reactor to: (*a*) produce usable amounts of electricity (December 20–21, 1951); (*b*) demonstrate the feasibility of breeding (1953); (*c*) achieve a self-sustaining reaction with plutonium instead of uranium as fuel (November 27, 1962); (*d*) produce usable amounts of elec-

[3] A nuclear reactor that produces more fissionable material than it consumes.

tricity using plutonium as the major component in the fuel (July 1963); and (*e*) demonstrate the feasibility of using liquid-metal (sodium-potassium) at high temperatures as a reactor coolant. The reactor had been shut down on December 31, 1963, at the conclusion of its experimental program.

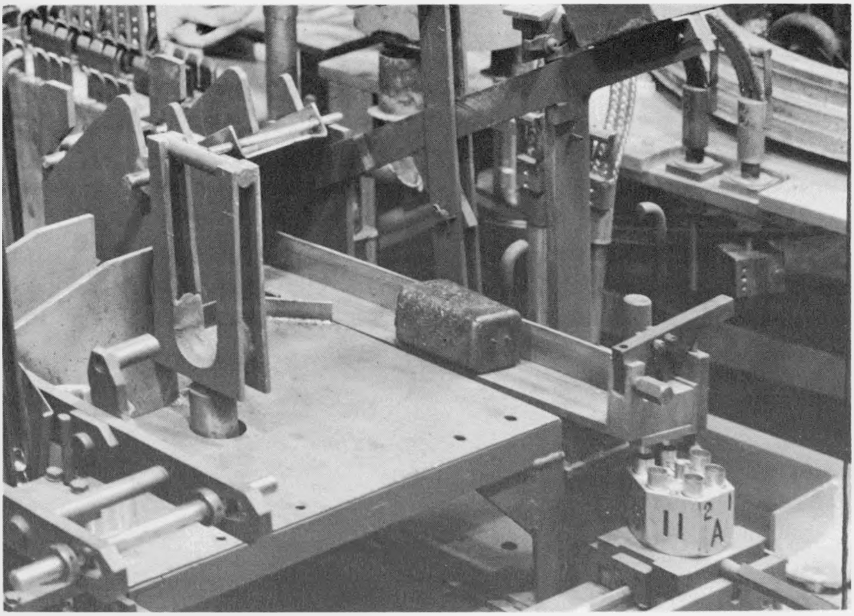
### *Experimental Breeder Reactor No. 2*

After the Experimental Breeder Reactor No. 2 (EBR–2) had achieved initial wet criticality in November 1963, it was operated at low power while preparations were made to remove and repair the primary and secondary sodium pumps which had failed during the plant pre-operational testing program. The low-power test data were obtained, and the pumps were repaired, reinstalled, and tested. The reactor and systems were then prepared for the approach to higher power, which began July 16. Reactor power was increased incrementally, and the reactor's stability was confirmed by transfer function measurements at each power level. Eight thousand (8,000) kilowatts of electric power was generated when the reactor reached half-power (30 thermal megawatts) level on August 13. In October, the power was increased to 37.5 thermal megawatts with 11,400 kilowatts of electric power generation. Operation has been very satisfactory and very stable. When EBR–2 reaches full power of 62.5 thermal megawatts in 1965, it will be operating at the highest power density achieved in a fast power reactor.

The adjacent Fuel Cycle Facility—which purifies partially-spent EBR–2 fuel through pyrometallurgical processes, re-enriches this fuel, and refabricates it into new fuel elements for return to the reactor, all by means of remotely operated equipment—successfully processed and refabricated the first irradiated EBR–2 fuel subassembly in September.

### *Enrico Fermi Atomic Power Plant*

During the first 4 months of 1964, the fast breeder reactor in the Power Reactor Development Co.'s (PRDC) nuclear power plant at Lagoona Beach, Mich., was subjected to low power physics tests. In April, the reactor was shut down to carry out a steam generator test program and to perform maintenance work, including replacement of the check valves on the main heat transfer pumps. On July 19, 1964, the reactor again attained criticality. Low power (less than 1 thermal megawatt) physics tests, including extensive foil irradiations in the core and in the blanket, and oscillator rod tests, were performed during the remainder of the year.



*EBR–2 Fuel.* The AEC's Experimental Breeder Reactor No. 2 (EBR–2) at the National Reactor Testing Station in Idaho began producing electric power in August, and during September the first irradiated fuel elements were started through the recycling process in the integrated fuel reprocessing system. The EBR–2 is the first such fully integrated plant. Photo, taken through a 5-foot-thick radiation-proof window in the Fuel Cycle Facility, shows the first uranium ingot (*center of photo*) ever produced from irradiated fuel by the Argonne National Laboratory-developed pyrometallurgical reprocessing method. The EBR–2 fuel subassembly from which the ingot was reprocessed had reached an estimated 0.1 atom percent (a/o) burnup and was allowed to cool 30 days before reprocessing. Such ingots are refabricated into fuel elements and returned to the reactor for further use by remote-control equipment.

The AEC and PRDC are exploring means whereby the reactor might be used to irradiate fuel pins and subassemblies for the AEC.

### *Fast Reactor Test Facility*

Site work for the AEC's 50-thermal-megawatt Fast Reactor Test Facility (FARET) experimental project is expected to start at a location near the EBR–2 at the National Reactor Testing Station in 1965 with completion set for 1968. FARET would be used to measure *Doppler*[4] coefficients, reaction rates, and the behavior of high performance cores at accelerated burnup rates. Outstanding among the

[4] In a reactor, vibration of the uranium atoms in a fuel element due to the increased operating temperature leads to the *Doppler* effect. This *Doppler* effect can vary the reactivity of the reactor.

features of FARET would be its use of fully instrumented test subassemblies, its ability to operate at sodium temperatures up to 1,200° F., and its flexible design which would accommodate cores varying in size from 50 to 2,000 liters.

### *Southwest Experimental Fast Oxide Reactor*

A contract between the AEC and Southwest Atomic Energy Associates for research and development support for the 20-thermal-megawatt Southwest Experimental Fast Oxide Reactor (SEFOR) project was signed on May 15, 1964. The reactor is designed to measure *Doppler* coefficients under transient test conditions. Preliminary site work is in progress at Fayetteville, Ark., with major construction scheduled to start early in 1965 and completion expected in 1967. West Germany and Euratom have an interest in the project.

### *Critical Experiment Facilities*

In November, a contract for architect-engineering services for design of the Zero Power Plutonium Reactor (ZPPR) was awarded to Mason & Hanger-Silas Mason Co., Lexington, Ky. This critical facility, construction of which is planned to start in late 1965 at the NRTS, will be used for studying the neutronic characteristics of large dilute plutonium fueled reactors.

The Zero Power Reactor No. 6 (ZPR–VI) critical assembly at Argonne National Laboratory was started up in 1964. This fast reactor facility is engaged in measuring *Doppler* coefficients, sodium void coefficients, and reaction rates of fertile and fissile materials on various core configurations using simulated uranium carbide fuel.

The ZPR–III experiments on a mock-up of the French Rapsodie reactor core were completed at NRTS. The facility was used to perform *Doppler* measurements with plutonium-carbide zoned cores and is currently employed for physics measurements on an engineering mock-up of the first core for the Fast Reactor Test Facility (FARET).

### *Large Fast Breeder Reactor Design Studies*

Four large fast breeder reactors conceptual design studies were completed for the AEC[5] in 1964 by Allis-Chalmers, Combustion Engineering, General Electric, and Westinghouse. In each study, a reactor suitable for use in a 1-million-electrical kilowatt plant was designed to produce at least 20 percent more fissionable material than it consumed in generating heat. Other common features were the use of sodium

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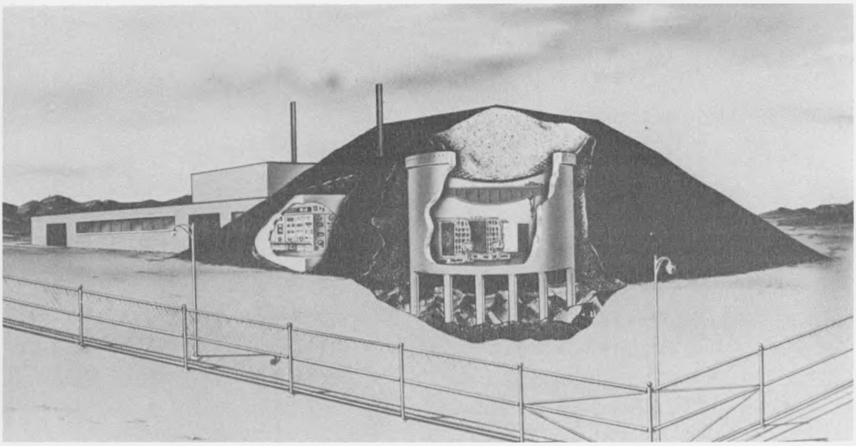
[5] See p. 105, Annual Report to Congress for 1963.



*ZPPR "Bunker."* Cutaway drawing shows the main components of the Zero Power Plutonium Reactor (ZPPR) and how it will appear when built. The reactor is still in the design stage with construction scheduled to start in late 1965 at the National Reactor Testing Station. As shown by the drawing, the reactor building will be covered by several feet of earth which will serve as additional shielding against the radioactivity emanating from the plutonium experiments.

coolant, stainless steel structural and fuel cladding material in the reactor, and the production of turbine inlet steam at a minimum temperature of 1,000° F.

The primary objectives of the studies were to determine the feasibility of safe operation with large sodium cooled fast breeder reactors and the potential for reducing electrical generating costs.

The four designs are being used by the AEC as basis for planning further studies and experiments in the areas of fuel development, fast reactor physics and safety, sodium components, and fast breeder reactor systems.

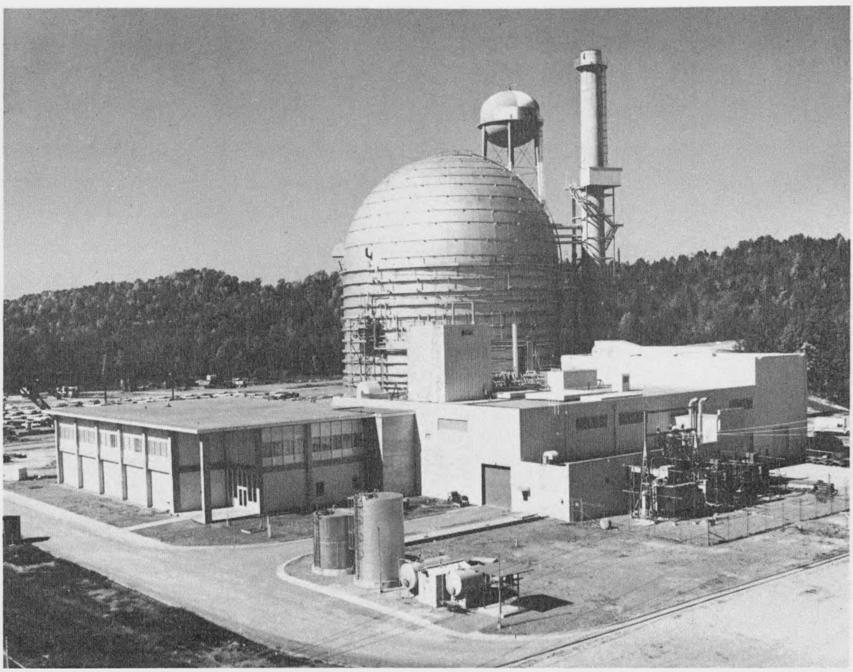
## GAS-COOLED REACTORS

### *Peach Bottom Atomic Power Station*

Construction of the Philadelphia Electric Co.'s prototype high-temperature gas-cooled reactor at Peach Bottom, Pa., was completed late in 1964, and reactor startup is scheduled for early 1965. The Peach Bottom reactor, with an outlet helium temperature of approximately 1,300° F., will operate at a higher temperature than any other U.S. civilian power reactor, and is also the first to use graphite-clad fuel elements instead of metal-clad fuel. A graphite-clad fuel element has been tested in the General Atomic In-pile Loop in the General Electric Test Reactor at Vallecitos with an average burnup of approximately 50,000 megawatt-days per ton.

### *Experimental Gas-Cooled Reactor*

Due to success in the difficult feats of fabricating and testing unique reactor components such as the pressure vessel, control rod drives, service and charge machines, and helium blowers, the construction of the AEC's Experimental Gas Cooled Reactor (EGCR) at Oak Ridge, Tenn., progressed steadily in 1964. The project is now more than 85 percent complete and the present estimated date for completion of construction is July 1965. Component fabrication and testing difficulties caused construction of the plant to fall 2 years behind the original schedule.



*Nearly Completed.* The AEC's Experimental Gas-Cooled Reactor (EGCR), currently under construction in Oak Ridge, Tenn., will produce some 22,000 kilowatts of electrical power when completed in 1965. The reactor core is fueled with uranium dioxide pellets, enriched to about 2.5 percent in uranium 235. The coolant gas is helium. Extensive research facilities are provided in the reactor to advance the nation's knowledge of the gas-cooled reactor concept. The EGCR will be operated for the AEC by the Tennessee Valley Authority.

## HEAVY WATER REACTORS

### *Carolinas-Virginia Tube Reactor*

Until May, power operation of the Carolinas-Virginia Nuclear Power Associates, Inc., reactor at Parr, S.C., was infrequent because of interruptions by test programs and various repairs. Since then, the heavy water-moderated and cooled pressure-tube reactor has operated satisfactorily up to its present licensed power level of 44.3 thermal megawatts (equivalent of about 12,200 electrical kilowatts).

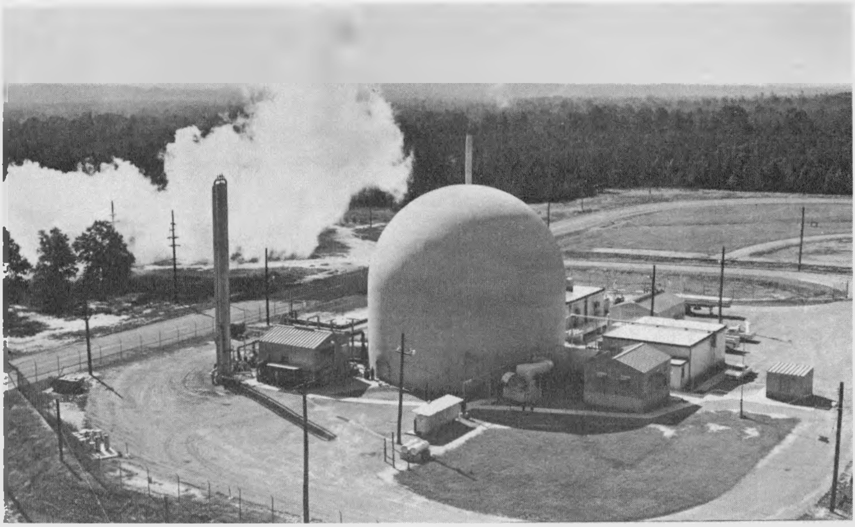
### *Plutonium Recycle Test Reactor*

The AEC's Plutonium Recycle Test Reactor at Hanford continued operation throughout 1964 in support of the plutonium utilization program. Design and engineering work was undertaken to increase the power level of the reactor from 70 to about 100 thermal megawatts. This increase will permit irradiation of plutonium-enriched fuel elements at conditions more typical of power reactors and result in more rapid accumulation of irradiation exposure on these elements than is presently possible.

### *Redirection of Heavy Water Reactor Program*

On July 23, the Commission approved the redirection of the heavy water-moderated reactor program toward an organic-cooled rather than a heavy water-cooled system. In early September, negotiations were started with Atomics International, Canoga Park, Calif., and Combustion Engineering, Inc., Windsor, Conn., on a contract to conduct a research and development program for heavy water-moderated, organic-cooled reactor systems. The research and development work to be covered by the contract is aimed primarily at developing the concept to a point which will permit the construction of demonstration plants.

*HWCTR closed.* The Heavy Water Components Test Reactor (HWCTR) at the Savannah River Plant near Aiken, S.C., has been operating since 1962 testing fuel elements and components for pressurized heavy water-cooled, heavy water-moderated reactor systems. Since the HWCTR cannot effectively contribute to the development of the organic-cooled heavy water system without major modifications, it was shut down on December 1 and will be placed in a standby condition by the end of February 1965. Atomic Energy of Canada Limited offered the use of half of their Whiteshell Reactor Facility (WR–1) at Whiteshell, Manitoba, a facility which can be used without major modifications, for the organic-heavy water program. Negotiations have been successfully completed for use of the facility.



*HWCTR Shut Down.* The AEC's Heavy Water Components Test Reactor (HWCTR) at the Savannah River Plant, near Aiken, S.C., was shut down on December 1 and is being placed in standby condition as a result of a re-direction in the heavy water reactor program. Photo shows the HWCTR in operation with product steam from the test reactor being vented to the atmosphere since the facility was not used to produce electricity. The reactor had been used to test candidate components for pressurized heavy water-cooled and -moderated reactor systems. Future heavy water work will be directed toward organic-cooled heavy water systems.

## DESALINATION STUDIES

Results of an Interagency Task Group investigation of using large nuclear reactor plants for sea water distillation and electricity production were released in March 1964.[6] The report estimated that if an appropriate research and development program were actively pursued, large-scale dual-purpose installations could be envisioned by about 1975 which would produce 1,000,000 to 1,500,000 kilowatts of electricity at a cost of 2.3 to 2.5 mills per kilowatt-hour and 500- to 800-million gallons of water per day at a cost of 20 to 25 cents per thousand gallons at the plant site.

[6] "An Assessment of Large Nuclear Powered Sea Water Distillation Plants," March 1964. Office of Science and Technology, Executive Office of the President. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $0.35. Appendices to this report are also for sale by the Superintendent of Documents for $3.25.

### *Key West Study*

In April, the report[7] on the joint AEC-Department of Interior study of a dual-purpose plant, producing approximately 50,000 electrical kilowatts and 10 million gallons of potable water per day for the Florida Keys indicated that a combination nuclear plant would, with electricity valued at 7.9 mills per kilowatt-hour, produce water initially at 84 cents per thousand gallons and later, as plant utilization increased, at 55 cents per thousand gallons. Although these costs are in line with existing costs at Key West and are comparable with those estimated for a similar-sized fossil fuel plant, the Key West Utility Board, in mid-September, decided that further consideration of a nuclear fueled dual-purpose power and water desalting installation such as that studied was not justified. The primary reasons for this decision were (*a*) insufficient demand for the amount of power and water which would be produced by such an installation, and (*b*) difficulty in obtaining financing.

### *Intermediate-Size Plant Study*

A joint AEC-Department of Interior study of intermediate-size reactors and related water desalting plants investigated 200 to 1,500 thermal megawatt steam plants, both nuclear and fossil fueled, with related water plant capacities of 15 million to 150 million gallons per day. The final report on this study was published in September.[8] It concluded that water costs in the range of 30 to 33 cents per thousand gallons (about $100 per acre foot) could be expected from a dual-purpose installation using the upper range of reactor sizes studied even with power credits of about 3.65 mills per kilowatt-hour and 7 percent fixed charged rates. Under these same conditions, nuclear reactors of 600-thermal-megawatt size appear to be competitive with fossil-fired installations using 35-cents-per-million BTU fossil fuel. At this and larger sizes, reactors appear to be more economical than the fossil-fueled plants based on the assumed ground rules for the study.

### *Desalting Program Study*

On July 15, President Johnson instructed the Department of Interior, in close collaboration with the AEC and in consultation with

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[7] NYO–10719, "Feasibility Study of the Dual-Purpose Nuclear Power Plant for the Florida Keys," March 1964, available through the Division of Technical Information Extension, Oak Ridge, Tenn., for $3.00.

[8] "A Study of Desalting Plants (15 to 150 mgd) and Nuclear Power Plants (200 to 1,500 MWt) for Combined Water and Power Production," Report # NYO–3316–1. Available from Clearinghouse of Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va., for $3.50.

the Office of Science and Technology, to give priority to the development of a detailed program plan for the early achievement of economic large-scale sea water desalting, using nuclear heat sources. This joint proposed program plan, which was released [9] by the White House on October 25, calls for the continued study, evaluation, and development of reactor concepts which will meet future combination plant requirements. Initial efforts of the proposed program include detailed analysis of dual purpose system characteristics in order to knowledgeably optimize system designs, and reactor system evaluations necessary to the planning and guidance of reactor development programs. The AEC program contemplates the construction and operation of two reactor prototypes. The first of these developmental prototypes would have a capacity of about 1,000 thermal megawatts (300,000 electrical kilowatts) and would be scheduled for operation by 1970 as a power-only installation. The second would be a 3,500 thermal megawatt power-desalting prototype reactor plant for operation by 1975. The heavy water moderated, organic-cooled reactor has been chosen for the present as the reference reactor concept.

### *Southern California Study*

On August 18, the AEC and the Department of Interior contracted with the Metropolitan Water District of Southern California (MWD) to share the cost of a 12–15 month study to determine the engineering and economic feasibility and preliminary design of large nuclear power and water desalting plants appropriate for the MWD system and the area it serves. The study will be conducted by the Bechtel Corp. under contract to MWD. The plants to be studied would be located in southern California, have a capacity of between 50 and 150 million gallons of water a day, and produce 150,000 to 750,000 kilowatts of electric power. The study is to be conducted in three phases. The first two phases, to be completed in 6 months, are to provide sufficient information to establish the economic desirability of constructing such a power generation and water desalting facility. The third phase is to provide a preliminary design, functional specifications, and a construction cost estimate of the preferred system at a selected site. (See International Activities section, Part Four, for summary of foreign interest in desalination programs.)

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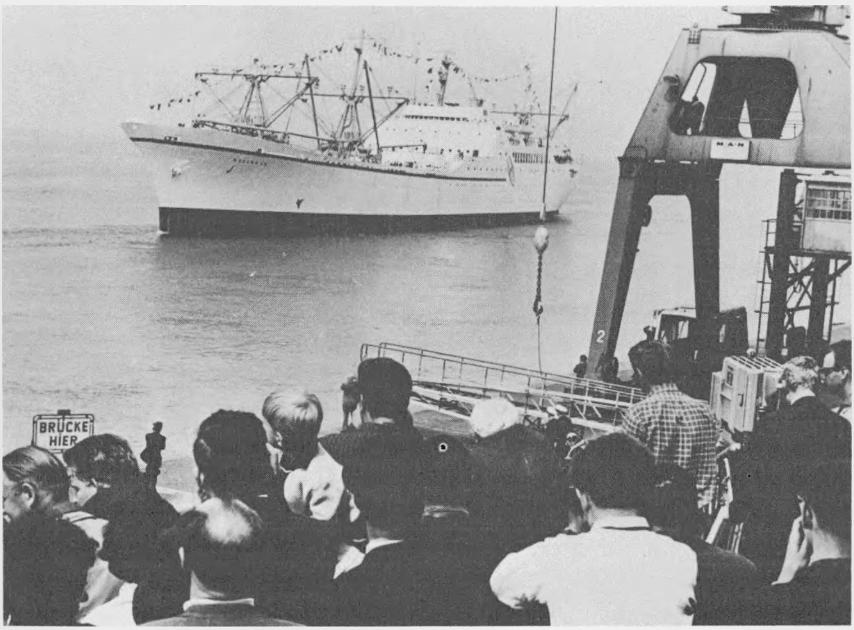
[9] The AEC portion was made public in AEC press release No. G–249, October 26, 1964, which is available from Division of Public Information, U.S. AEC, Washington, D.C., 20545; a limited number of copies of the complete "Report to the President—Program for Advancing Desalting Technology," are available from the Desalination Branch, Division of Reactor Development and Technology, U.S. AEC, Washington, D.C., 20545.

## MARITIME PROGRAM

The Atomic Energy Commission, in cooperation with the Maritime Administration of the Department of Commerce, conducts a maritime reactors program with the objective of developing an economically acceptable nuclear power plant for marine applications.

### *NS Savannah*

On May 5, 1964, the NS *Savannah*, the world's first nuclear-powered cargo-passenger ship, entered the port of Houston, Tex., thus resuming the port visit operations which labor contract difficulties had interrupted nearly a year earlier.[10] Subsequent operations proceeded without incident, and the ship completed her maiden trans-Atlantic voyage, to four northern European ports, on July 20.




*First Foreign Visit.* Crossing the Atlantic Ocean for the first time, the NS *Savannah*, arrived at Bremerhaven, Germany, first European port of call, on June 18. The craft's 1964 European schedule also included visits to Ireland, England, Belgium, France, Portugal, Spain, Italy, and the Scandinavian countries. Greece and Turkey will be visited in early 1965. The *Savannah* is the world's first nuclear-powered passenger-cargo ship and is operated for the U.S. Government by American Export-Isbrandtsen Lines.

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[10] See pp. 107–108, 317–318, Annual Report to Congress for 1963.

The sleek 595-foot white-hulled vessel's second European voyage, to Scandinavia, was successfully completed in September and was quickly followed by two more voyages which included stops in The Netherlands, Belgium, France, Portugal, Spain, and Italy.

As of December 31, the *Savannah* had traveled more than 75,000 miles under nuclear power, used less than 3 percent of its initial fuel loading, visited 24 domestic and 14 foreign ports, and had been visited by nearly 1,250,000 persons. Her reception in all ports has been uniformly enthusiastic.

### *Proposed New Prototype Reactors*

Concurrent with operation of the NS *Savannah*, studies and development work have continued to evaluate the potential role of nuclear power for maritime applications. These efforts have resulted in increased interest in the use of nuclear power for marine propulsion for they have shown that nuclear power has potential for improving the economic position of the U.S. Merchant Marine through leadership in developing higher speed ships offering improved service.

As evidence of this increased interest in nuclear power for marine applications, the AEC in 1964 received unsolicited proposals for the construction of land-based prototype maritime nuclear propulsion plants from the General Electric Co., and the United Nuclear Corp. Also, an informal solicitation of other manufacturers was made in response to which the Babcock & Wilcox Co. submitted a proposal. Each proposal involves a cooperative arrangement with substantial financial participation by the proposing organization and with limitations on the funds which would be required of the Government. The United Nuclear proposal involves the construction of a water-moderated and cooled prototype known as the M1U. Babcock & Wilcox's proposal is for an advanced pressurized water reactor known as the Consolidated Nuclear Steam Generator (CNSG).[11] General Electric proposed the construction of a gas-cooled, water-moderated land-based prototype reactor known as the 630–A. However, extensive evaluations of the 630–A program by the AEC and GE has disclosed general agreement that the proposed reactor system is not sufficiently attractive economically to warrant further development, and the cooperative program based on the 630–A was terminated as of December 31, 1964.

[11] See pp. 108–109, Annual Report to Congress for 1963.

### *Four-Ship Proposal*

In October, American Export-Isbrandtsen Lines informed the AEC Chairman and the Maritime Administrator of its interest in participating in a joint venture for the construction of four nuclear-powered merchant ships to be used in the New York-to-Far East trade route. Early in November, the AEC informed the steamship line of its readiness to discuss their proposal in more detail. American Export-Isbrandtsen Lines is the present contract-operator of the NS *Savannah.*

## SPACE APPLICATIONS

Two of the Commission's nuclear reactor development programs are engaged in developing nuclear reactors, nuclear devices, and related nuclear technology, for space applications. One of the programs, the joint AEC-National Aeronautics and Space Administration (NASA) program designated Rover, is developing the technology for using nuclear rocket propulsion for space missions. The other program, SNAP [12] (Systems for Nuclear Auxiliary Power), is developing a family of compact nuclear generators and nuclear reactors to provide power for spacecraft and satellites—and also for terrestrial and marine applications. Some SNAP units presently being developed use the heat from the decay of radioisotopes as the energy source; others use the heat generated by the fission of uranium in a reactor.

## ROVER PROGRAM

The objective of the Rover program is to develop the technology for using nuclear rocket propulsion for space missions. During the year the initial Kiwi series of reactor experiments was concluded, and the NERVA (Nuclear Engine for Rocket Vehicle Application) series of experiments began. The experiments are conducted at the Nuclear Rocket Development Station in Nevada.

### *Kiwi Project*

A major milestone in the Rover program was achieved on May 13 when the nuclear-fueled Kiwi-B4D reactor was successfully tested at power levels and temperatures which met or exceeded all planned test conditions except the duration of operating time at the power

[12] Reports on a special AEC study and evaluation of the SNAP program are on sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, as TID–20079, "Systems for Nuclear Auxiliary Power . . . an Evaluation—January 1964" for $0.30, and TID–20103, "Systems for Nuclear Auxiliary Power . . . a Report by the Commission—1964" for $0.25.


*Last Kiwi Test.* The Kiwi-B4E experimental nuclear rocket reactor was successfully tested at the Nuclear Rocket Development Station, Nevada, on August 28, and then, on September 10, became the first Rover program reactor to be restarted to near design power. The B4E was the eighth and last experimental reactor to be tested in the Kiwi-phase of the Rover program, as the work moved into the more advanced NRX phase during 1964. In the photo, the Kiwi reactor sits atop the control chamber which, during power tests, was operated by remote means. Atop the reactor is the nozzle, pointing skyward, as in all tests so far. The curved pipe at left, during a test, carries the liquid hydrogen propellant gas to the reactor, where it is heated and expanded. As the heated hydrogen leaves the nozzle, the thrust is produced which, when harnessed in an engine, is capable of propelling a spacecraft. The first Kiwi reactor, Kiwi-A, was tested July 1, 1959.

plateau. The test had been scheduled to run for several minutes but was stopped after slightly more than one minute because of a hydrogen leak which developed in the jet nozzle. However, sufficient time at the power plateau was achieved to provide a significant proof-test of the structural integrity of the reactor, as well as many other reactor features.

On August 28, the Kiwi-B4E reactor, the eighth and final reactor to be fabricated and tested in the Kiwi phase of the Rover program, was power tested. The test ran at planned reactor power and temperature for more than eight minutes, the maximum time possible with the available propellant supply. On September 10, the B4E reactor was re-started and operated smoothly for approximately 2.5 minutes near design power. The capability to re-start a reactor as demonstrated by this test came much earlier than anticipated. Reactor performance was smooth and uneventful. Los Alamos now will concentrate on the development of Phoebus high-powered graphite reactor technology. Much of this work is directed toward advancing what has been learned under the Kiwi/NERVA effort.

### *NERVA Project*

The first experiments with NRX (NERVA Reactor Experiment) reactors were conducted during the year as the Rover program moved into the NERVA phase. The NRX reactors are adaptations of the Kiwi reactor technology by the industrial team of Aerojet-General Corp. (Sacramento, Calif.) and Westinghouse Astronuclear Laboratory (Large, Pa.) for future application to the NERVA nuclear rocket engine. The first series of tests, on a cold-flow reactor termed NRX–A1, were successfully conducted during March and April and all test objectives were met. The reactor design also successfully avoided the damaging vibrations experienced in the 1962 KIWI–B4A reactor hot test.

On September 24, the NRX–A2 reactor—the first power reactor fabricated under the experimental engine program—was operated, as planned, for more than 6 minutes. This run was limited in duration by the available gaseous hydrogen supply. The test was successfully completed as planned and without incident.

On October 15, the NRX–A2 reactor was re-started to explore the behavior of the reactor system in the low-power, low-flow region. The reactor operated in a stable and reliable manner for 20 minutes and provided much data and information toward gaining a full understanding of early reactor startup and low-power control. The detailed data from both experiments is now being analyzed to determine what improvements should be made to future NRX reactor designs.

Throughout 1964, emphasis also was given to developing major non-

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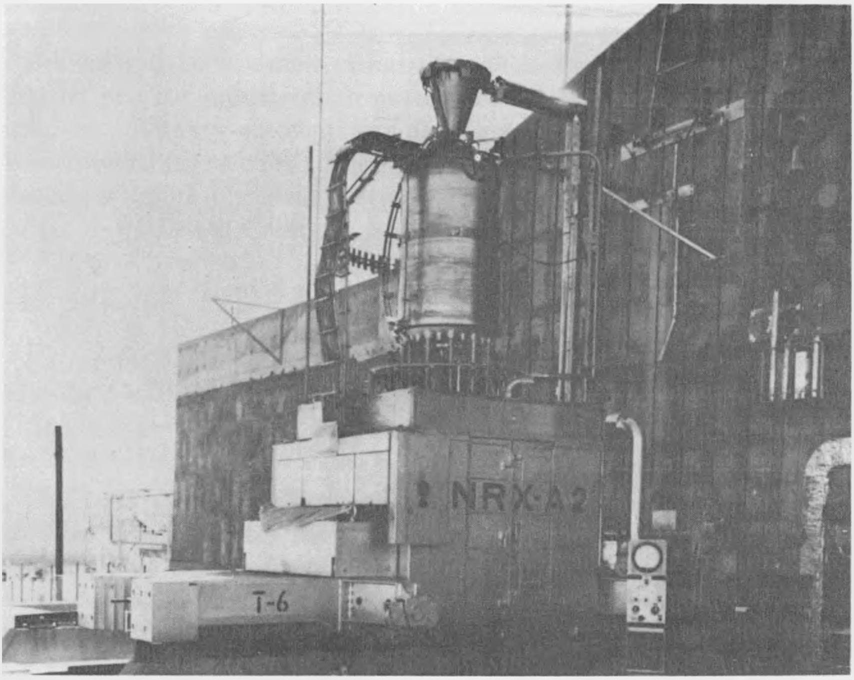
nuclear components for the experimental, liquid-hydrogen nuclear-rocket engine, to evaluating how these components will function in the heat and radiation environment of the reactor, and to designing a detailed NERVA engine concept.

*Kiwi Power Run.* Long-range photo shows the Kiwi B4E nuclear rocket reactor at the peak of its power test on August 28, 1964. The test was regarded as a significant milestone in the effort to develop technology which can provide nuclear rockets for long and difficult space missions beyond the moon. The reactor ran for 8 minutes, limited only by the supply of liquid hydrogen, which is stored in the ball-shaped "dewar" tanks at *left* which are, in effect, giant thermos bottles. The temperature of the liquid hydrogen is about —428° F. On the other hand, the reactor temperature is more than 3,000°. Close to the plume may be seen a cluster of 12 gas bottles, containing various gases which are pumped through the reactor after the test to cool it down. The picture was made with infrared film, to make visible the colorless hot hydrogen rushing from the nozzle atop the reactor. The plume which appears in the picture could not be seen with the naked eye.




*NRX-series Reactor.* Photo shows the NRX–2 reactor, the first NERVA reactor to be power tested in the Rover program. (NERVA stands for Nuclear Engine for Rocket Vehicle Application; NRX stands for NERVA Reactor Experiment.) Here the NRX–A2 is shown at the Nuclear Rocket Development Station, Nevada, before the September 24, 1964 test. Liquid hydrogen (at —428° F.) is fed through the large pipe at right, leading to the nozzle atop the reactor. On the left, also leading toward the nozzle, is a bundle of leads to instruments for measuring pressures, temperatures, vibrations and other test manifestations. The NRX–A2 was restarted October 15 and run at low power for about 20 minutes to obtain information on the behavior of the reactor system at low-power, low-flow conditions. The Rover program is the Nation's effort to develop nuclear propulsion for use in lunar-base logistical support, and particularly for deep space probes and exploration of the planets. In a nuclear rocket, hydrogen—carried in liquid form—is the propellant-coolant. It is heated and greatly expanded, then ejected through the nozzle to provide thrust. The reactor provides the heat. The program is directed by the Space Nuclear Propulsion Office, a joint office of the AEC and the National Aeronautics and Space Administration. The contractor for the NERVA phase of the development is the Aerojet-General Corporation; the principal subcontractor for the reactor work is the Westinghouse Astronuclear Laboratory. The NRX reactor is similar in design to the Kiwi-B4 reactors tested by Los Alamos Scientific Laboratory and is an adaptation of the Kiwi technology.

### *Advanced Research and Technology*

The work on Kiwi and NERVA reactors is supplemented by an advanced reactor research technology effort which includes work on advanced graphite reactors as well as investigation of alternate reactor concepts, particularly tungsten. Los Alamos Scientific Laboratory (LASL) is the principal contributor to the graphite program. With the Kiwi project completed, LASL will concentrate on a graphite reactor technology project (designated Phoebus) which is aimed at providing higher power levels as well as the technology for improving specific impulse and duration. Work also has continued at various AEC and NASA laboratories and industrial contractors to develop the components—turbopumps, valves, control systems, etc.—necessary in conducting large reactor tests and furthering the development of advanced nuclear rocket propulsion system technology.

### *Facilities*

Construction of an Administration and Engineering Building was completed during 1964 at the Nuclear Rocket Development Station located in Nevada, as were hot cells for the post-test examination of reactors in the Reactor Maintenance, Assembly and Disassembly (R–MAD) Building.

## SNAP PROGRAM

### *SNAP Reactor Units*

Compact, lightweight, nuclear reactor power systems are being developed by the AEC to produce electrical energy for such space applications as electric propulsion, lunar stations, orbiting space platforms, and interplanetary communications.

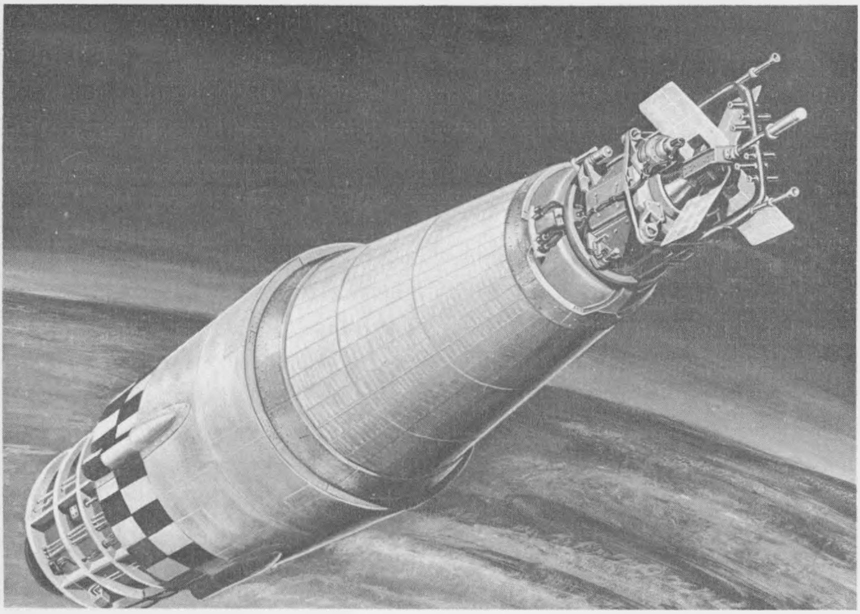
*SNAP–8.* The first power reactor of the SNAP–8 series—the SNAP–8 Experimental Reactor—successfully completed a 60-day performance test on April 28, 1964, at operating conditions at or above 450 thermal kilowatts with a core outlet temperature of 1,300° F. By early November, the reactor had accumulated more than 5,000 hours of operation at, or above, the SNAP–8 reference design power level of 450 thermal kilowatts, and 1,300° F., including more than 2,000 hours of continuous operation at 600 thermal kilowatts and 1,300° F. The reactor continued to operate for the remainder of the year under various test conditions. All tests conducted to date have confirmed the adequacy of the SNAP–8 reactor design to meet or exceed the specified system requirements.

Also in April, testing began on the SNAP–8 Developmental Reactor mockup. The purpose of this test system, which is a flight-design reactor and shield assembly containing "dummy" fuel elements, is to assure compatibility of the SNAP–8 reactor system with the space and launch environment. Shock and vibration and startup testing of the system was completed during 1964, and long-term operation at high temperature and vacuum was started.

*SNAP–10A.* The SNAP–10A program during 1964 was directed toward completing the various test systems to be used in verifying the power unit for its scheduled flight test in the spring of 1965.

Two ground test systems FSM–4 (electrical heat) and FS–3 (nuclear heat) were readied for operation. FSM–4 was started on endurance test in late December. FS–3 is scheduled for test commencing the first week of 1965. Flight units FS–4 and FS–5 have been assembled, and testing and delivery are on schedule for a planned March 1965 flight test.

The completion of the development program through a space flight demonstration was made possible by Congressional funding authorizations to the AEC. Existing management arrangements were extended with the AEC providing flight support funds to the USAF for the vehicle buildup and launch phase of the test.



*First Flight Reactor.* The SNAP–10A is the first AEC-developed nuclear reactor unit to be scheduled for an actual flight test. Drawing is an artist's concept of how the SNAP–10A device, which is scheduled to be orbited in the spring of 1965, will appear in flight. The SNAP–10A is on the forward end (*right*) followed in descending order by the thermoelectric radiator generator and the Agena rocket stage. The SNAP–10A is designed to provide 500 watts of electric energy to power equipment in a space satellite. The heat produced by fissioning uranium-zirconium hydride fuel in the reactor is transported by a sodium-potassium coolant loop to the thermoelectric converter.

The combination of ground and space tests is designed to prove the reactor-thermoelectric system for a minimum 90-day life at 500 watts electrical power output. A one year system life is the design objective. The SNAP–10A test systems are fundamental units to the total SNAP reactor development program. These tests will complete the SNAP–10A development and will provide confidence in SNAP–8 and succeeding system designs.

*SNAP Systems Improvement (SNAPSI) Program.* Following deferment of the SNAP–2 flight test in 1963 [13] the sub-system technology of SNAP–2 was incorporated into a broadly based program, called SNAPSI, which is designed to provide improved space nuclear power technology. The program includes efforts to advance the technology of SNAP hydride reactors and the mercury turboelectric components, plus high temperature thermoelectric converter work previously conducted under the SNAP–10A program.

The power generator package developed for the SNAP–2 mercury turboelectric system is unique in that it is hermetically sealed and all rotating components—mercury pump, alternator rotor, and turbine wheels—are combined on a single shaft which is supported by journal and thrust bearings which are lubricated by the mercury cycle working fluid. Operational capability of the flight design SNAP–2 combined rotating unit (CRU)—Model V—was demonstrated: over 9,000 hours of operation was attained on CRU–V machines, including a 98-day continuous operation test in early 1964 at power levels in excess of three electrical kilowatts. One of the earlier flight design power generators (Model IV M) attained more than 6,000 hours of operation.

Thermoelectric converter development effort in 1964 included the qualification testing of SNAP–10A type modules designed to operate at 1,300° F. instead of the 1,000° F. SNAP–10A temperature. Design work was also initiated to provide a technical specification for a compact, two-loop thermoelectric converter. Such a system will allow flexibility in component location, and will reduce system volume and weight.

*SNAP–50/SPUR.* The SNAP–50/SPUR [14] development program, established by joint AEC–NASA–DOD agreement, is directed toward the development and testing of an advanced Rankine [15] cycle nuclear power plant capable of operating in space and producing electrical power in the range of 300 to 1,000 kilowatts at an unshielded specific weight of about 20 pounds per electrical kilowatt.

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[13] See p. 121, Annual Report to Congress for 1963.
[14] SPUR stands for Space Power Unit Reactor.
[15] See p. 123, Annual Report to Congress for 1963.

During 1964, extensive development and performance testing of reactor fuels, both in- and out-of-pile (in and out of reactors), was accomplished. Fabrication and assembly of test stands for reactor pump and control drive components was carried out and testing initiated. Considerable power plant design was accomplished and is continuing to guide the component development efforts. A significant achievement was the completion, on October 11, of a 14-month (10,000-hour) test of an engineering sized lithium-columbium heat exchange system. This five megawatt system was operated at a maximum temperature of 2,000° F., and thus contributes a great deal toward verifying some of the technology upon which the SNAP–50/SPUR power plant design objectives are predicated.

Several large liquid metal loops were fabricated for testing power conversion components. Tests were initiated on stainless steel models of a multi-tube boiler and a liquid-metal cooled generator.

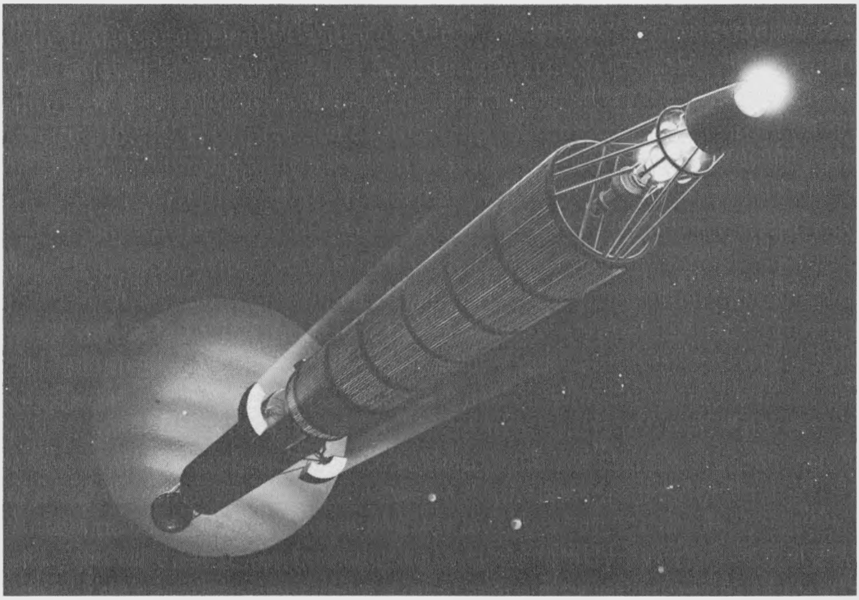
Based on the expected satisfactory performance of components now under development, a space configured reactor test and a power conversion sub-system test can be reasonably projected during 1970.

### *SNAP Isotope Units*

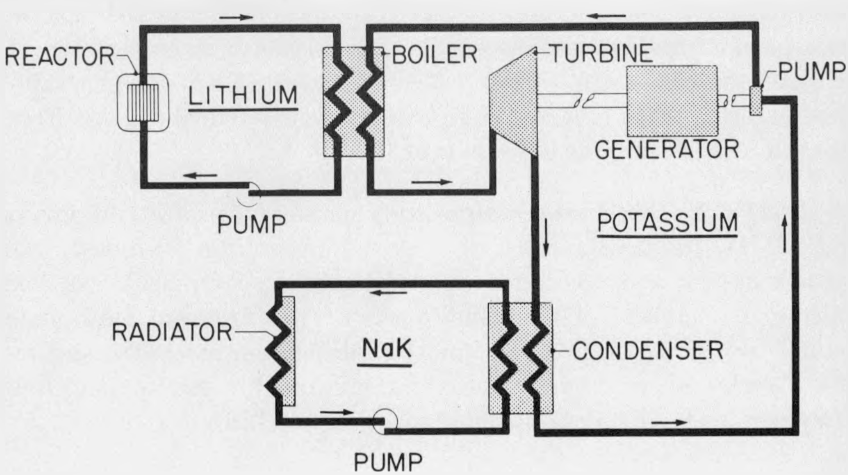
The heat produced by the spontaneous decay of selected radioactive isotopes can be used as the energy source for the generation of electricity to meet relatively low-power space requirements.

*SNAP–9A.* In April 1964, the third SNAP–9A 25-watt, plutonium 238-fueled generator to be launched aboard a Department of Defense satellite failed to achieve orbit because of failure of the launch vehicle. All available evidence indicates that the generator burned up at high altitude upon re-entry into the earth's atmosphere and that its fuel was harmlessly dispersed in very fine particles over an extremely wide area on top of the atmosphere. Two identical SNAP–9A generators had been successfully launched into orbit from Vandenburg Air Force Base, Calif., during the latter part of 1963.

*SNAP–17.* The initial design study phase of a project, designated SNAP–17, for development of a 25-watt strontium 90-fueled space power system and associated ground handling equipment was completed in October. The second phase of the program, now under study by the AEC, provides for the fabrication, assembly, and test of a series of prototype generators suitable for use on long-lived (5 years) meteorological or communications satellites.



*SNAP 50/SPUR.* Above is an artist's concept of an electrically-propelled interplanetary spacecraft which shows a SNAP 50/SPUR-type electric power plant integrated into a space vehicle to provide energy for the electric propulsion devices used to propel the spacecraft on an exploratory mission deep within the solar system. (SPUR stands for Space Power Unit Reactor.) Drawing *below* is the schematic flow for the SNAP 50/SPUR system. The reactor coolant, lithium, is heated in the reactor and circulated through a boiler where it transfers its heat to liquid potassium which, in turn, is vaporized. The potassium vapor then turns a turbine which drives an electric generator. The potassium vapor passes through a condenser which is cooled by a radiator loop, where the potassium vapor condenses to a liquid and is returned to the boiler by a pump. The joint AEC–NASA–DOD project is aimed at developing a nuclear power unit capable of delivering 300 to 1,000 kilowatts at a power-plant weight (unshielded) of about 20 pounds per electrical kilowatt.



## SNAP TERRESTRIAL AND MARINE APPLICATIONS

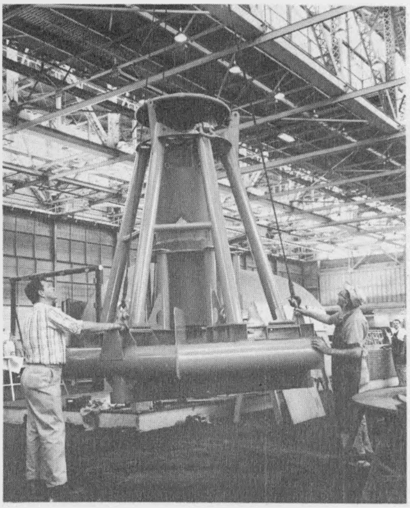
SNAP isotopic power is useful not only in space; it is equally useful in any application requiring long-term unattended operation under extreme conditions.

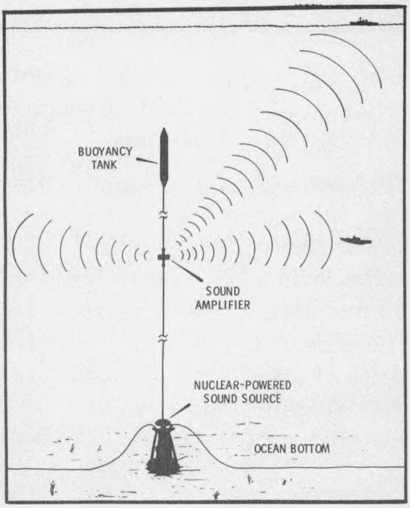
### *Navigational and Weather Aids*

*Lighthouse power.* On May 20, after several months of test use as a power source for beacons and foghorns, a 60-watt strontium 90-fueled SNAP–7B generator—designed to operate continuously for 10 years—was installed in a U.S. Coast Guard lighthouse in Chesapeake Bay, Md. In November, the SNAP–7B had successfully completed its first year of operation. The Coast Guard plans to move the unit to a remote, unattended operational lighthouse during 1965.

*Floating weather station.* The SNAP–7D 60-watt strontium 90-fueled generator provides the total power requirements of the U.S. Navy NOMAD (Navy Oceanographic Meteorological Automatic Device) Weather Station which was re-moored in the Gulf of Mexico on June 4. The SNAP–7D/NOMAD system was originally placed in operation in January 1964, but subsequently was returned to the Coast Guard Base in Mobile, Ala., for repair to the electronics package. At no time has the nuclear power supply experienced difficulty. During October, the SNAP–7D-powered NOMAD successfully rode out Hurricane Hilda and provided useful weather data to the Gulf Coast clearly and accurately every 3 hours. This prototype system is designed to be the forerunner of a world-wide network of remotely located, deep-sea moored floating weather stations.

*Deep-sea sounder.* On July 13, the first deep-sea isotopic power supply, designated SNAP–7E, was successfully lowered to the floor of the Atlantic Ocean about 750 miles east of Jacksonville, Fla. An attempt had been made in September 1962 to lower the SNAP–7E, but its outer pressure vessel leaked and shorted out the electronics equipment. The pressure vessel was completely redesigned and rebuilt, and the 7-watt strontium 90-fueled generator is now supplying power to a U.S. Navy-developed sound transducer used for underwater navigational experiments.






*Underwater Navigational Aid.* The SNAP–7E strontium 90 isotopic generator, shown *above left*, was implanted in July on the ocean bottom approximately 750 miles east of Jacksonville, Fla., at a depth of 15,000 feet. There it will provide seven watts of continuous electrical power to an experimental U.S. Navy underwater navigational aid for a minimum of two years, far in excess of the lifetime of existing power systems. The SNAP–7E radioisotope thermoelectric generator is 9½ inches in diameter by 14¾ inches high and is contained within a heavy biological shield of cast iron and depleted uranium. The fully shielded device is, in turn, placed within a two-inch forged steel pressure vessel capable of withstanding the extremely high water pressures encountered at these depths. The complete nuclear power system and associated electronic payload are supported by a six-sided superstructure required both to facilitate handling during the implantment operation and also to support the sound amplifier and buoyancy tank which are located 3,000 feet above the power supply. Artist's concept, *above right*, illustrates the complete implanted system. The lines to the left and right of the power system are grappling cables about four miles long which can be used to recover the unit. The SNAP–7E generator was designed by the Martin Co.

*Oil rig beacon.* SNAP–7F is a 60-watt, strontium 90-fueled generator which was assembled for display at the Third United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland, from August 31 through September 9. The SNAP–7F is scheduled to be installed in the Gulf of Mexico on an offshore oil-drilling platform to power navigational aids early in 1965. The Offshore Oil Operations Committee, an independent organization representing all offshore oil operators, is working with the AEC on this project to determine potential commercial applications of long-lived SNAP generators for the oil industry.

***Strontium 90 Studies***

Two major research and development projects were initiated in 1964 to develop a family of low-power (from 10 to 200 watts) strontium 90-fueled generators that are: (*a*) capable of achieving operating lifetimes in excess of 5 years, (*b*) inherently reliable and lightweight, and (*c*) economically competitive in many instances with existing power sources. One of these projects, designated SNAP–21, is directed to the development of a 10-watt strontium 90 nuclear electric generator for underseas navigation beacons and deep-sea oceanographic research. The other, the SNAP–23 project, provides for the development of a series of advanced radioisotope-fueled generators for a variety of terrestrial applications.

TABLE 2.—STATUS—SNAP RADIOISOTOPE UNITS

| SNAP No. | Power Electrical (watts) | Life (years) | Application | Fuel | Status |
|---|---|---|---|---|---|
| 3 | 2.7 | 5 | TRANSIT 4A and 4B | Pu-238 | Launched 6/61 and 11/61. |
| 7A | 10 | 10 | Light Bouy (CG) | Sr-90 | Installed Curtis Bay, Md. 1/64. |
| 7B | 60 | 10 | Land Light (CG) | Sr-90 | Installed Baltimore Light 4/64. |
| 7C | 10 | 10 | Weather Station (Navy) | Sr-90 | Installed 2/62. |
| 7D | 60 | 10 | Boat Weather Station (Navy). | Sr-90 | Installed 1/64, Gulf of Mexico. |
| 7E | 7 | 10 | Deep-sea (Navy) | Sr-90 | Installed 7/64 off Bermuda Coast. |
| 7F | 60 | 10 | Navigation Aid | Sr-90 | Delivered to AEC 7/64. |
| 9A | 25 | 5 | Navigational Satellite (DOD). | Pu-238 | 2 units launched 1963; 4/64 unit failed to orbit. |
| 11 | 25 | ⅓ | SURVEYOR (NASA) | Cm-242 | Scheduled delivery 1966. |
| 13 | 12.5 | ⅓ | Demonstration Unit | Cm-242 | Del. to fueling site 12/64. |
| Sentry | 5 | 2 | Weather Station (Weather Bureau). | Sr-90 | Inst. in Arctic 8/61. |
| 15A & B | 0.001 | 5 | DOD devices | Pu-238 | (A) Delivered 5/64; (B) Terminated 7/64. |
| 17A & B | 30 | 3–5 | Communication Satellite | Sr-90 | Phase I dev. init. in Jan., compl. 10/64 (2 contracts). |
| 19 | 30 | 5 | Nimbus B | Pu-238 | Prototype generator under development. |
| 21A & B | 10 | 5 | Advanced Undersea Generator. | Sr-90 | Phase I development initiated 3/64 (2 contracts). |
| 23 | 60 | 5 | Advanced Terrestrial Generator. | Sr-90 | Phase I development initiated 6/64. |

# MILITARY REACTOR PROGRAMS

## ARMY REACTORS

The objective of the AEC-Army nuclear reactors program is to develop reliable nuclear power plants which will reduce the dependence of the military services on petroleum supplies and thus substantially alleviate the logistic burden required for support of military operations.

### *Status of Projects*

As a result of a joint AEC-Department of Defense review of the Army reactors program which was completed in February 1964, the Military Compact Reactor project was reoriented from the development of a prototype 3,000 electrical kilowatt (ekw) reactor to a program which, for the next 2 years, will emphasize component technological development. The completed preliminary design of the 3,000 ekw plant will be used as the base point to determine the maximum power which can be obtained from this concept for possible application with the Energy Depot System currently under study by the Army.

During February, the Commission decided not to proceed with the design study and subsequent development of any of the plant concepts proposed for the second generation portable nuclear power plant.[16] The prime reason for the decision was that the most optimistic 1,000 ekw nuclear plant that could be developed on the basis of existing technology could not compete economically with conventional power plants except in remote areas having very high conventional fuel costs. However, plants based on more advanced technology will be studied to eventually provide a low-cost nuclear reactor unit which can meet economic criteria and permit greater use of field plants for various Department of Defense requirements.

The research and development effort to develop a long life, higher power tubular core for portable medium-power (PM) plants was terminated in June primarily for economic reasons. A plant systems development program was initiated during 1964 to improve the performance and reliability of control rod drive, nuclear instrumentation, hydrogen control, and radioactive waste disposal systems of the PM plants.

### *Status of Reactor Plants*

*McMurdo Station Antarctica.* On March 12, the Portable Medium Power Plant No. 3A (PM-3A) at McMurdo Station, Antarctica, was

[16] See p. 127, Annual Report to Congress for 1963.

accepted by the Government from the contractor, Martin-Marietta Corp., and transferred to the Navy. The PM–3A assumed the entire McMurdo Base electrical load in June, and continued to supply power to the site until mid-November when a 2-month shutdown was scheduled to conduct annual maintenance and incorporate modifications into the plant.

*Sundance, Wyo.* In April, the Portable Medium Power Plant No. 1 at the Air Defense Command radar station at Sundance, Wyo., was shut down for scheduled semiannual maintenance after 2,630 hours of continuous operation. During the shutdown, the control rod thimbles were found to be corroded to a point which required their replacement. The plant returned to operation in September and is again supplying the Sundance site with electrical power.

*ML–1 at NRTS.* The Mobile Low Power Plant No. 1 (ML–1) located at the National Reactor Testing Station (NRTS) in Idaho, was operational during a significant part of 1964. Modifications to ML–1 equipment to repair a pressure vessel gas leak, improve fuel elements, and replace turbine bearings were completed, and the reactor returned to power in mid-April. A highly successful limited-endurance and full-power test was subsequently conducted during which the plant accumulated more than 664 hours of operation. A number of additional tests were conducted on the ML–1 during the year and more than 2,000 hours of operating time had been accumulated by the ML–1 by the end of the year. The Gas-Cooled Reactor Experiment (GCRE) facility was modified to provide a capability to test ML–1 type reactor units independent of power conversion equipment.

*Fort Greely, Alaska.* The Stationary Medium Power Plant No. 1A (SM–1A) at Fort Greely, Alaska, returned to operation on April 21 after a lengthy shutdown for scheduled maintenance and refueling. By mid-August, the SM–1A had operated at power continuously for more than 2,750 hours, or 114 days, thereby achieving a new record run for an Army nuclear power plant. After a two-month shutdown for maintenance and the removal of flux wires that were causing the control rods to stick, the plant is continuing to supply power.

*Fort Belvoir, Va.* In July, the now outmoded nuclear instrumentation system of the Stationary Medium Power Plant No. 1 (SM–1) at Fort Belvoir, Va., was replaced with a new transisterized nuclear instrumentation system. The new system provides increased reliability—thus contributing to safer reactor operation, and greater ease of maintenance—thus reducing reactor down time.

*Camp Century, Greenland.* After nearly 3 years, of operation, the Portable Medium Power Plant No. 2A (PM–2A) [17] was returned to the continental United States from Camp Century, Greenland, in August 1964. This was the first reactor move of its type ever attempted.

After the dismantling and removal of the PM–2A reactor, the AEC received a letter from the Government of Denmark regarding the results of a radiological survey they made of the reactor site which showed radioactivity levels to be relatively insignificant, well below the requirements of the U.S. agreement with Denmark for operation of this plant in Greenland.

The plant's secondary system was stored in an eastern Army Depot pending a determination as to its future use. The primary system, minus the reactor core and demineralizers, was shipped to NRTS in Idaho. The PM–2A pressure vessel is undergoing tests at NRTS to determine stress properties of the primary system materials as a result of long-term irradiation. The core, demineralizers, and containment vessel are stored at the AEC's Savannah River, S.C., plant.

## NAVAL REACTORS

The joint Navy-AEC naval reactors program has as its objective the design and development of a group of nuclear propulsion plants in a wide range of power ratings for installation in naval ships, ranging from small submarines to large aircraft carriers.

### *Attack Carrier*

In response to a request from the Secretary of Defense, the AEC in August announced its decision to proceed with a development of a very high-powered, long-fuel-life reactor for application to a two-reactor nuclear-powered attack aircraft carrier on a schedule which will permit its installation in the next aircraft carrier planned for construction. The carrier would require refueling only once in its lifetime.

### *Core Research*

Throughout 1964, the naval reactors research and development program continued the development of advanced cores of longer life and simpler reactivity control, as well as the development of reactor plants of lower cost, higher performance, quieter operation, and greater reliability, simplicity, and maintainability. During the latter part of the year, the first of a new type of longer-lived cores was installed

[17] See p. 139, Annual Report to Congress for 1961.

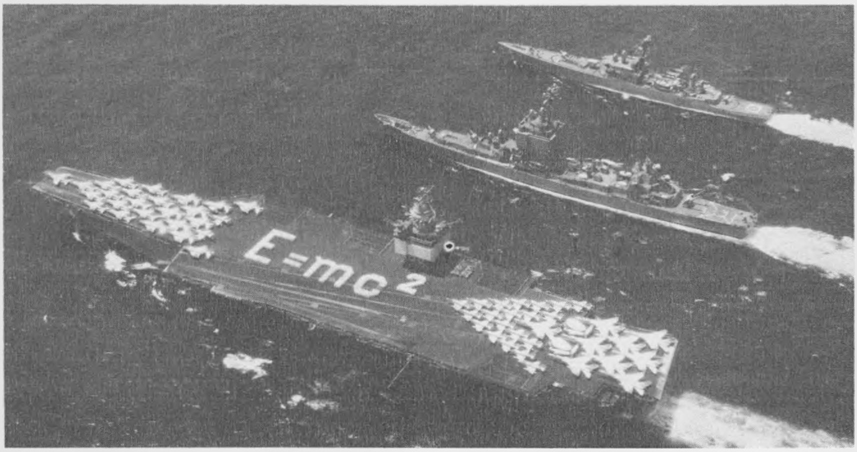
in the Submarine Advanced Reactor (S3G) land prototype plant at West Milton, N.Y., for test operations.

### *New Facility*

A new land-based prototype, the Natural Circulation Reactor (S5G) plant for submarine propulsion continued under construction at the National Reactor Testing Station. The concept of this plant is to cool the reactor by natural circulation, thus eliminating the need for large reactor coolant pumps and associated electrical and control equipment. Major emphasis in the design of this plant is being placed on reliability, simplicity, and noise reduction.

### *Nuclear Fleet*

As of December 31, 1964, Congress had authorized 92 nuclear-powered submarines, of which 51, including 29 of the Polaris missile-launching type, were in operation. The aircraft carrier *Enterprise*, the guided missile cruiser *Long Beach*, and the guided missile destroyer leader *Bainbridge* were operational, and a second guided missile destroyer leader, *Truxton*, was launched at Camden, N.J. Nuclear-powered naval ships had cruised a total of more than 4,300,000 miles.




*Nuclear Task Force.* The world's first all-nuclear surface task force was formed May 13, 1964, by the aircraft carrier *Enterprise*, the guided missile cruiser *Long Beach*, and the guided missile destroyer leader *Bainbridge* in the Mediterranean, where it was deployed with the Sixth Fleet. On July 31, the three-ship task force embarked from the Mediterranean and steamed over 30,500 miles on a 2-month around-the-world cruise ("Operation Sea Orbit") which demonstrated the U.S. Navy's ability to send these high-speed ships anywhere in the world without logistic support. In photo, the crew of the *Enterprise* spells Einstein's equation for the equivalent of energy and mass: $E=mc^2$ (Energy=mass times the square of the speed of light).

## PLUTO PROGRAM

The objective of the AEC's Pluto program has been the development of a reactor to serve as the heat source in a nuclear ramjet propulsion system having a potential application in a supersonic low altitude missile. Experimental reactors used in the program were developed by the Lawrence Radiation Laboratory (LRL), Livermore, Calif.

### *Tory IIC Tests*

Subsequent to the completion of repairs to correct deficiencies in the Tory IIC test facility at the Nevada Test Site, LRL resumed prenuclear blowdowns and tests of the facility in January 1964. After shipment of the assembled Tory IIC reactor to NTS from LRL in mid-February, criticality tests were begun on March 25 with the reactor assembled in the test vehicle.

On May 12, the reactor was operated at an intermediate power level which simulated flight at a 10,000-foot altitude and a Mach 2.8 speed. The initial full power ground test of the Tory IIC was conducted on May 20 at test conditions which simulated flight at sea level and design speed of Mach 2.8. Both tests were unqualifiedly successful.

### *Program Phased-Out*

The Department of Defense advised the AEC in a July 1, 1964, letter of the decision against pursuing a flight test objective with the Pluto program. Consequently, additional planned tests of the reactor were cancelled and the Tory IIC program was phased out. Pluto test facilities at NTS were mothballed. Investigations of possible alternate applications of the very high temperature gas-cooled Pluto reactor technology are currently in progress.

## ADVANCED REACTOR TECHNOLOGY

The objective of the Commission's advanced reactor technology program is the development of a broadly-based technology which will lead to improvements in existing reactors and the development of new reactor concepts and processes.

Activities carried out to advance the technology of nuclear reactors are reported more fully in the publications, "Fundamental Nuclear Energy Research—1964" [18] and "Nuclear Fuels and Materials Development." [19]

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[18] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $0.00.

[19] TID–11295 (3d ed.) July 1964. Available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va., for $7.00.

### *Development of Research and Test Reactors*

Development work continued during 1964 on several specialized reactor facilities for advanced research and test irradiation applications. These facilities include the 100-thermal-megawatt High Flux Isotope Reactor (HFIR) at Oak Ridge which is expected to be operational by early 1966; the Argonne Advanced Research Reactor (AARR) to be constructed at Argonne National Laboratory beginning in late 1965; the 250-thermal-megawatt Advanced Test Reactor (ATR) for which the basic reactor is scheduled to be completed by the summer of 1965 with overall project completion, including construction of the gas loop, scheduled for mid-1967 at the National Reactor Testing Station at Idaho; and the High Temperature Lattice Test Reactor (HTLTR) to be constructed at Hanford.

*AARR.* Heat transfer and fluid flow studies now underway are expected to lead to ultimate operation of the AARR at a power level of 240 megawatts and a maximum flux of 10 quadrillion ($10^{16}$) neutrons per square centimeter per second (n/cm$^2$/sec). The AARR concept is based on an initial design rating of 100 megawatts with a maximum flux of 3 to 5 quadrillon ($3 \times 10^{15}$ to $5 \times 10^{15}$) neutrons/cm$^2$/sec. The design and construction of the facility may provide for the increased power of 240 megawatts. Further research and development is planned in several key areas. A $10^{16}$ steady-state thermal flux would be a substantial advance over that provided by any other reactor operating or planned in the United States—and possibly, in the world.

*HTLTR.* Development work progressed in 1964 on the HTLTR which will be a versatile, low-power research reactor to provide nuclear data for reactor systems at temperatures of at least 1,000° C. provided through electrical heaters. When completed in 1966, the reactor will consist of an insulated stack of graphite ten feet on an edge containing nuclear fuel to sustain the chain reaction, and electrical heaters to achieve and maintain the high temperatures of interest. A central section of variable size up to 5×5 feet square by 10 feet long is provided to contain the experimental test section. The test section may be of any composition or arrangement within the above volume limitation except that the moderator must be a solid, although not necessarily graphite. The fission power of the HTLTR required for the measurements is small, with a maximum requirement of a few kilowatts only for certain measurements. The HTLTR will be the only facility in the United States for investigating the physics of reactor lattices at very high temperatures, and will exceed in temperature the ability of any other similar facility now known or planned.

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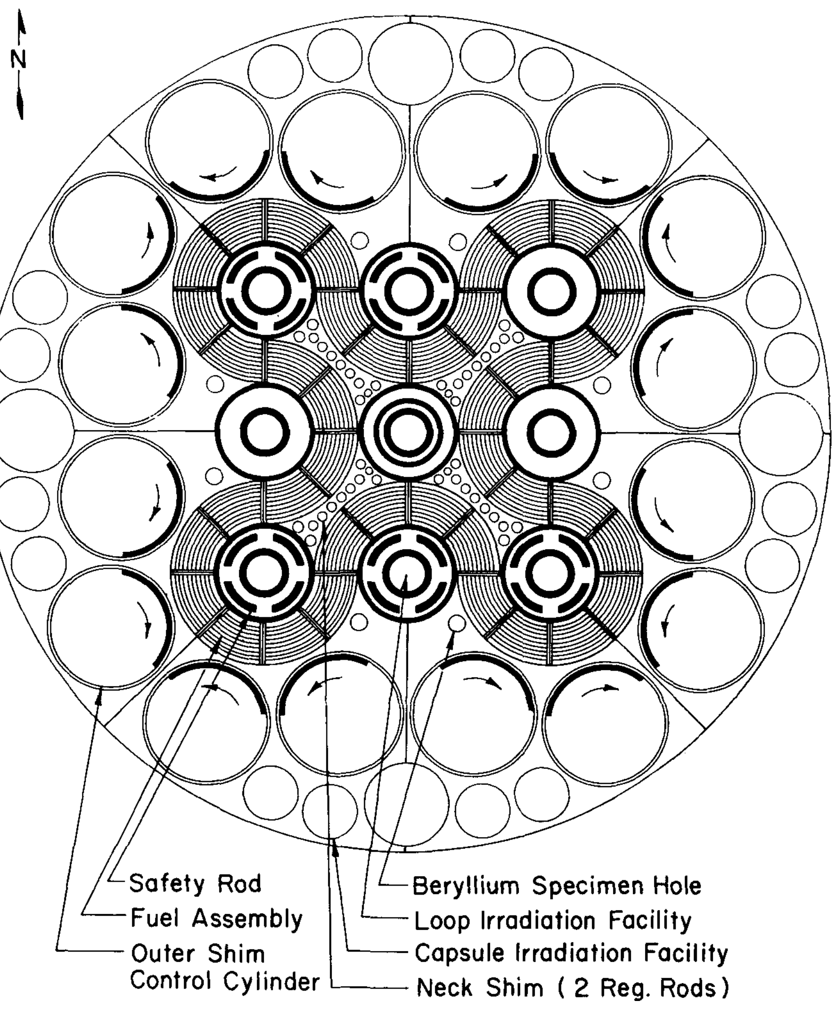
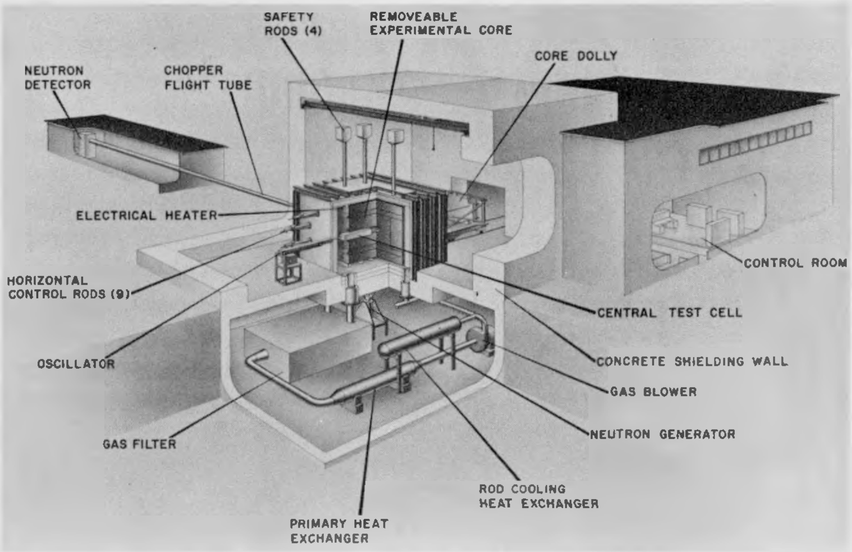



*ATR Core.* The Advanced Test Reactor (ATR) will provide nine 5-inch-diameter regions 4 feet long, in which unperturbed thermal flux can reach $2.5 \times 10^{15}$ neutrons per square centimeter per second under optimum conditions, at 250 megawatts. Spectrum and flux will essentially be adjustable independently for five regions and will be capable of being kept nearly constant throughout a 17-day operation cycle. The ATR critical facility (ATRC), a nuclear duplicate of the ATR, went into operation in May. It is being used to provide experimental data for calculations for the safety analysis on the ATR. It will also provide experiment sponsors with nuclear data they will need for the design of their experiments to be inserted in the ATR. Phillips Petroleum Co. operates the ATRC for the AEC and will operate the ATR when it is completed in 1965.




*Versatile Research Facility.* Schematic drawing of the High Temperature Lattice Test Reactor (HTLTR) which, when completed at Hanford in 1966, will be the only facility in the United States which can be used to determine nuclear physics data of reactor lattices in the range of 1,000° C. (1,832° F.). The experimental central test cell can be used in varying arrangements, configurations, and sizes. The high heat levels will be maintained by electrical heaters.

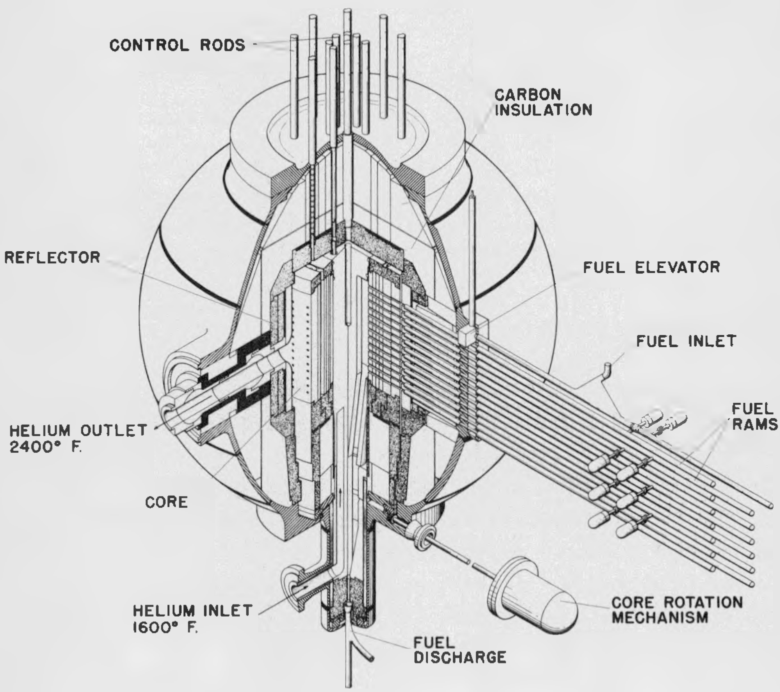
## *Advanced Reactor Experiments*

Investigative work continued throughout 1964 on several advanced reactor experiments which show promise of contributing valuable technical information to the advancement of reactor technology: the Molten Salt Reactor Experiment (MSRE), which is aimed at thorium breeding; the Experimental Beryllium Oxide Reactor (EBOR), for studying beryllium oxide as a moderator in a gas-cooled reactor system; and the Ultra High Temperature Reactor Experiment (UHTREX), which is being built to learn about the technology of highly contaminated high temperature gas systems.

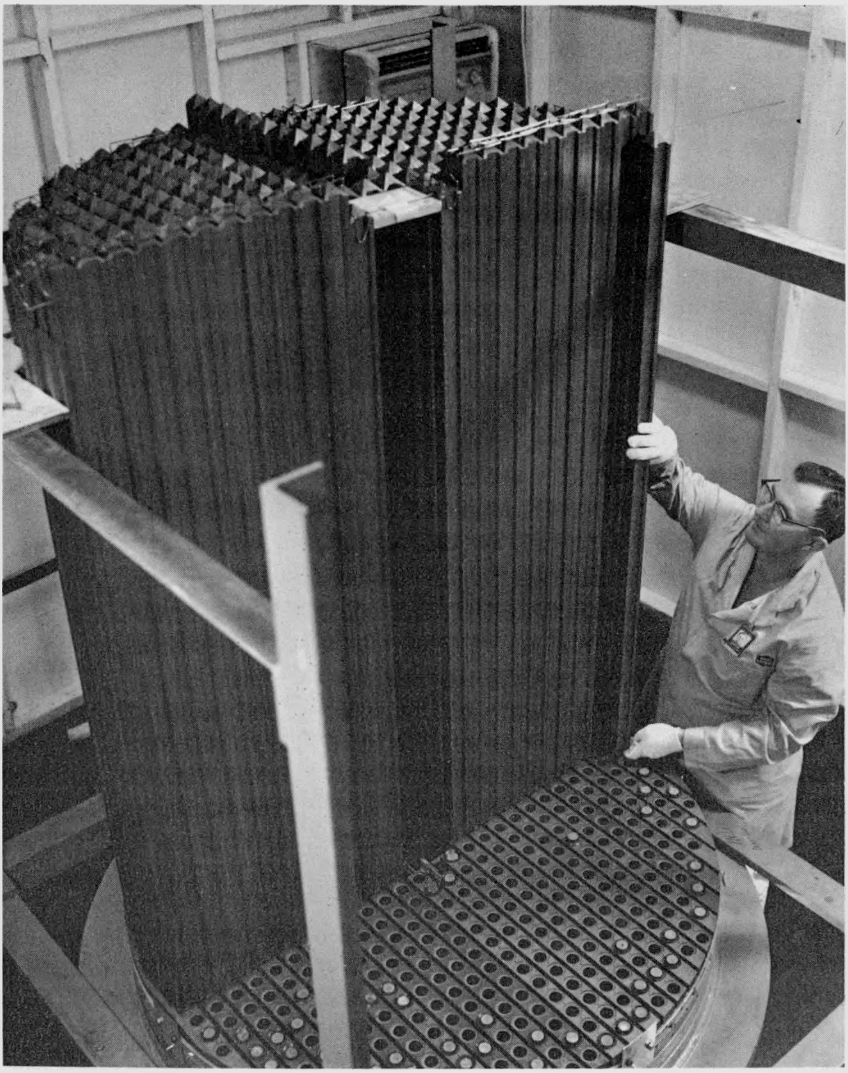
In October, flush salt was added to the MSRE and its non-nuclear testing is proceeding on schedule at the Oak Ridge National Laboratory. Initial criticality is expected early in 1965. Completion of both the EBOR at the National Reactor Testing Station in Idaho and the UHTREX at Los Alamos have been re-scheduled for completion in 1965 and 1966, respectively, primarily because of delays in the delivery of major components.

In February, after determining that the overall molton plutonium program would best be served by concentrating on the more versatile 20 thermal megawatt Fast Reactor Core Test Facility under construction at Los Alamos, operation of the one thermal megawatt plutonium-iron fueled Los Alamos Molten Plutonium Reactor Experiment (LAMPRE) was terminated.

Current emphasis in the Advanced High Temperature Gas Reactor (710) project (General Electric—Nuclear Materials and Propulsion Operation, Cincinnati, Ohio) is on the development and performance testing of the fuel element. Significant progress was made during 1964 in the demonstration of the Medium Power Reactor Experiment (MPRE) concept feasibility through the operation of boiling potassium test rigs at the Oak Ridge National Laboratory.




*UHTREX.* Cutaway drawing of the Ultra High Temperature Reactor Experiment (UHTREX) now under construction at Los Alamos Scientific Laboratory. The objective of this project is to obtain data on an advanced high temperature gas cooled reactor system through the operation of a 3 thermal megawatt experimental reactor employing graphite fuel elements of various types, at temperatures up to 2,400° F., in order to evaluate problems associated with the operation and maintenance of a highly contaminated reactor system using inexpensive fuel. Data from this experiment are expected to be applicable to advanced type reactor systems for the generation of electrical power such as magneto hydrodynamic (MHD) generators or for process heat.



*Graphite Core.* The Molten Salt Reactor Experiment (MSRE) at Oak Ridge National Laboratory is moderated by a graphite core which is about 55 inches in diameter and 64 inches high made of long graphite stringers, each about 2 inches square. A spindle, 1 inch in diameter and 4 inches long, is machined on the bottom end. The top ends of the stringers are pointed in order to prevent particulate matter from settling out and remaining there. A channel is machined in each face of the stringer to provide flow channels for the salt when the stringers are assembled. The channels are 1.2 inches wide and 0.2 of an inch deep, making the flow channels, when assembled, 1.2 inches wide and 0.4 of an inch deep. The partly assembled core shown in the photo is on its INOR–8 grid structure, which is topped by two horizontal layers of graphite bars drilled to accept the spindles. The stringers are held down by INOR–8 rods that pass through holes in the grid structure and through holes drilled into the spindles. The MSRE is expected to go into operation in 1965.

Analytical and experimental evaluation of the Paste Blanket Reactor concept (Atomic Products Research Associates, Detroit, Mich.) continued, as did work on the Settled Bed Reactor (Brookhaven National Laboratory) and the chemonuclear program (Brookhaven).

### *Chemical Separations and Development*

Continued progress on the development program in fluoride volatility reprocessing technology at the Argonne, Oak Ridge, and Brookhaven National Laboratories led the Commission to invite selected industrial firms to participate with it in the evaluation of the potential of such methods. The Commission's ultimate intent is to further the application of this technology to the processing of low-enrichment power reactor fuels due to its potential superiority to present aqueous methods.

### *Direct Conversion*

During the early part of 1964, experimental fission-heated thermionic single cells were tested within a reactor (in-pile) for more than 500 hours at electric power outputs of interest to nuclear space power system applications. These tests were conducted in the General Electric Reactor at Vallecitos by both the General Electric Co. and the General Atomic Div. of the General Dynamics Corp. A three-cell test converter was also operated in-pile near the end of 1964 by the General Electric Co. (The AEC sponsored work in the area of direct conversion is summarized in the supplemental report, "Fundamental Nuclear Energy Research—1964.")

### *Thorium Utilization*

In March, 1964, a 9-month production program was successfully completed at Oak Ridge National Laboratory's "kilorod" facility during which 1,100 fuel elements containing 3 percent uranium 233 and 97 percent thorium were fabricated for use in critical experiments at Brookhaven National Laboratory. This fabrication work at ORNL was the first engineering-scale demonstration of semi-remote fabrication of thorium-uranium oxide fuel elements. The technique used was the "sol-gel" process [20] and vibratory compaction of Zircaloy-clad fuel elements. The radiation data from the kilorod program indicate that uranium 233 can be fabricated without undue radiation hazards to personnel and on a reasonable schedule in fully shielded facilities when the uranium 232 (U–232) content is greater than 400 parts per million

[20] See pp. 262–263, "Fundamental Nuclear Energy Research—1962."

(ppm), in unshielded facilities when the U–232 content is less than 50 ppm, and in facilities employing shadow shielding when the U–232 content is between 50 and 400 ppm.

The adaption of the sol-gel process for making microspheres of uranium-thorium oxide and thorium-uranium dicarbide was successfully demonstrated at ORNL on a small scale. These very small spheres of fuel are of interest in the manufacture of fuel elements for reactors which will use recycle U–233 thorium fuel. The process will be demonstrated on a larger scale early in 1965 in the Cold Microsphere Development Facility, recently completed in Oak Ridge. Related fuel development by General Atomic is being accomplished for the Peach Bottom, Pa., High Temperature Gas Cooled Reactor using a mixture of highly enriched uranium dicarbide and thorium dicarbide particles dispersed in a graphite matrix.

The final design for the Thorium-Uranium Fuel Cycle Development Facility, to be built at Oak Ridge for use in developing processes for the remote reclaiming and fabrication of thorium-uranium 233 fuel assemblies, was initiated in April and is scheduled for completion early in 1965.

## NUCLEAR SAFETY RESEARCH

The objective of the Commission's nuclear safety research and development program is to generate and apply information which will insure the safe development, design, construction, and operation of nuclear reactors and nuclear devices in environments ranging from the ocean depths to outer space. The outstanding safety record attained in the operation of an ever-increasing number of nuclear facilities and nuclear devices over a period of more than 20 years attests to the effectiveness of the emphasis placed on the protection of the public and persons engaged in nuclear energy activities. The activities of this program are more fully reported in the publication, "Summary Report, Nuclear Safety Research and Development Program".[21] Specific examples are also included in the "Fundamental Nuclear Energy Research—1964" report.

The major areas covered by the nuclear safety research and development program are: (*a*) Reactor Safety Research and Development, (*b*) Engineering Field Tests, (*c*) Effluent Control Research and Development, and (*d*) Analysis and Evaluation.

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[21] WASH–1052 prepared by the Division of Reactor Development, U.S. Atomic Energy Commission, November 1964. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $0.50.

## REACTOR SAFETY RESEARCH AND DEVELOPMENT

The reactor safety research and development program involves both fundamental and applied research in nuclear reactor safety, including studies in reactor kinetics, fuel meltdown phenomena and fuel-coolant interactions (chemical reactions), reactor containment, and fast reactor safety studies. The data obtained are applicable to the design and safety evaluation of thermal and fast reactors as well as to the safety analysis of non-reactor situations. These include criticality assessment in chemical processing plants, safety in fuel handling and storage, and ignition characteristics of plutonium and other reactor materials.

### REACTOR KINETICS

#### *SPERT Program*

The study of reactor excursion phenomena is centered around the Special Power Excursion Reactor Test (SPERT) program at the National Reactor Testing Station, Idaho, carried out for the AEC by the Phillips Petroleum Co.

To provide insight into the possible consequences of violent, uncontrolled nuclear excursions, three deliberate potentially destructive tests have been conducted in the SPERT–1 facility (an open tank-type reactor), including one test of a metallic plate, aluminum-clad core, and two tests of a uranium oxide fuel, stainless steel-clad core of the type used in U.S. power reactors. The last of these tests was carried out in April 1964; the excursion reached a peak power of 35,000 megawatts on a period of 1.55 milliseconds and resulted in an energy release of 165 megawatt seconds. The maximum observed pressure was 135 psi. After the test, all control rods and most of the instrumentation were still operable. Damage to the core consisted of rupture of two, and discoloration and/or bowing of about 175, of the 599 fuel rods in the core. The results of the oxide core destructive tests indicate that, under the conditions encountered, fuel rod rupture may cause steam to form which helps to shut down the reactor and thus limit the potential energy release of an excursion; and, that failure of a fuel rod and the consequent release of high-temperature uranium oxide powder into the water does not necessarily result in explosive pressure pulses. These results further demonstrate the inherent safety features of low-enrichment uranium-oxide-fueled, water-cooled reactors.

#### *Power Burst Facility*

The Power Burst Facility (PBF) is a planned transient test facility designed to generate power bursts with initial asymptotic periods as short as one millisecond, producing energy releases large enough to destroy entire fuel subassemblies placed in a capsule or flow loop within the reactor, without damage to the reactor itself. It will be used to evaluate the consequences and hazards of very rapid destructive excursions in power reactors as well as to carry out detailed studies of nondestructive reactivity feedback mechanisms in the short period domain. Construction of the PBF at the National Reactor Testing Station (NRTS) is scheduled to start during the summer of 1965 and take about 2 years to complete.

## CHEMICAL REACTIONS

### *Fuel-Coolant Reactions*

Metal-water reactions would occur as a result of a major reactor accident in which molten reactor core metals were dispersed into the cooling water. The energy released by such reactions could exceed that released by the fission process during a nuclear excursion. Work being carried out by the Argonne National Laboratory is seeking to provide a practical means for estimating both the rate and extent of those reactions. Included in the program are experiments in the Argonne Transient Reactor Test (TREAT) facility at the NRTS which are yielding information on the nature and degree of fragmentation of fuel under excursion accident conditions. It is noteworthy that the results of this program have been successfully correlated with the extent of aluminum-water reaction which occurred in both the SPERT-ID destructive test and the SL–1 accident.[22]

### *Fission Product Behavior Studies*

The principal work on fission-product behavior is conducted at the Oak Ridge National Laboratory, Brookhaven National Laboratory, and Atomics International, Canoga Park, Calif. At Oak Ridge fission-product transport and deposition are being investigated in a 1,350 cubic foot containment-shell simulator called the Nuclear Safety Pilot Plant. In early 1965, irradiated fuel specimens will be melted under various "accident" conditions so the realistic ranges of fission products produced can be studied for their transport characteristics.

Variations of such parameters as fuel type, cladding, atmosphere, pressure, peak temperature, time at temperature, and burnup are being varied in fission product release experiments. These studies have shown that three release mechanisms (for $UO_2$ fuels) could operate as the result of an accident: diffusion, fuel oxidation, and fuel melting.

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[22] See pp. 35–39, Annual Report to Congress for 1961; pp. 190, and 518–523, Annual Report to Congress for 1962.

Results indicate that release via diffusion from $UO_2$ is rapid above 1,700° C., while that caused by air-oxidation of $UO_2$ is significant only at temperatures below 1,500° C. The most rapid release is found on fuel melting, when large fractional releases of many fission products occur within a few seconds' time. Fortunately, many of these plate-out (particulates which precipitate and are deposited on the vessel wall) even on surfaces above 1,000° C. The data indicate that less than one percent of the strontium, zirconium, cerium, barium, and uranium oxide are released from the "high-temperature zone" (1,000° C.) to cooler portions of the experimental assembly.

## REACTOR CONTAINMENT

### *Containment Systems Experiment*

In 1964, the large hardware items were procured for the Containment Systems Experiment (CSE) facility being built at the AEC's Hanford Plant, Wash. This facility will study the effect of simulated loss-of-coolant accidents of various intensities on different containment systems. The facility will also be used for experiments on pressure rise and decay, the transport of fission products, and leakage rate determination over a broad range of system conditions. The efficiency of engineered safeguards such as containment sprays and filter-trains will be assessed for a wide range of simulated accident conditions. Experiments are expected to begin upon completion of the facility, scheduled for early 1965.

### *Pipe Rupture Studies*

In 1964, the first phase of a study of pipe rupture was completed by the General Electric Co., San Jose, Calif. These investigations assessed the possible modes and likelihood of cracks and ruptures in the reactor primary coolant piping as a cause of a major reactor accident involving a loss of coolant and potential release of fission product aerosols to the reactor containment. The second phase of this study, initiated in late 1964, will include studies and tests to better understand the pipe failure process. An increased understanding of how defects grow to cracks and then to failures, the maximum size of rupture, and the probability of failure, should lead to a better technical basis for assessing this facet of the nuclear safety problem, and to improved design measures, inspection of materials, and fabrication techniques to prevent such occurrences.

***Reactor Containment***

A study of the leakage of low-pressure containment buildings was completed by Atomics International during 1964. Building components of ordinary construction—such as metal and concrete panels, doors, joints, and piping penetrations—were tested for leakage and investigated for means of reducing leakage. It was found that such construction generally leaks more than ordinary containment shells and can only be subjected to low pressures. However, if a reactor can be designed so that under all foreseeable accident conditions only low pressures would be produced in the containment and only small amounts of fission products released to the containment, conventional construction techniques which have been improved to minimize leakage appear to offer some economic advantages over ordinary containment shells.

### FAST REACTOR SAFETY STUDIES

The major emphasis of fast reactor safety studies is on fuel meltdown investigations since fast reactors typically contain much more fuel than is required for a minimum critical mass. This characteristic, in conjunction with the short prompt neutron lifetime of fast reactors, can conceivably produce a severe accident if a meltdown is followed by rapid reassembly into a more compact configuration. The Transient Reactor Test (TREAT) facility at NRTS is being used for the experimental investigation of the complex factors influencing fuel failure and movement. The TREAT experiments in which fast reactor fuel elements are subjected to transient nuclear heating are conducted by Argonne National Laboratory and are supplemented by an intensive theoretical effort.

A number of studies are in progress to investigate sodium boiling and the dynamics of the expulsion of sodium from reactor coolant channels. Knowledge of void distributions under abnormal operating conditions is necessary for the assessment of fuel failure as well as for the prediction of the magnitude of the reactivity effect associated with sodium voids. With the increasing importance of the fast breeder reactors, safety work in this area can be expected to increase.

## ENGINEERING FIELD TESTS

Engineering field tests extend laboratory-scale test results into full-engineering-scale field tests results.

### TERRESTRIAL SYSTEMS

Preliminary design of the facility for a Loss of Fluid Test (LOFT) engineering scale test was completed in May by Kaiser Engineers of

Oakland, Calif. Construction was initiated in October at the National Reactor Testing Station, and is expected to be completed in the fall of 1967. LOFT will simulate the loss-of-coolant accident on a 50 thermal megawatt pressurized water reactor.

Throughout 1964, the LOFT test program was developed and refined. As presently constituted, it will include: (*a*) extensive leak testing of the containment facility; (*b*) rapid loss-of-coolant tests with the reactor system, using a non-fueled core, to determine mechanical effects on the reactor and containment systems; (*c*) nuclear operation at rated power for from 400 to 1,600 hours; (*d*) loss of coolant with fueled core, leading to core meltdown and escape of fission products into reactor vessel and containment, and (*e*) post-test examination. Present scheduling calls for non-nuclear operations to be complete by the fall of 1968, and the initial loss-of-coolant test to be completed by the spring of 1969.

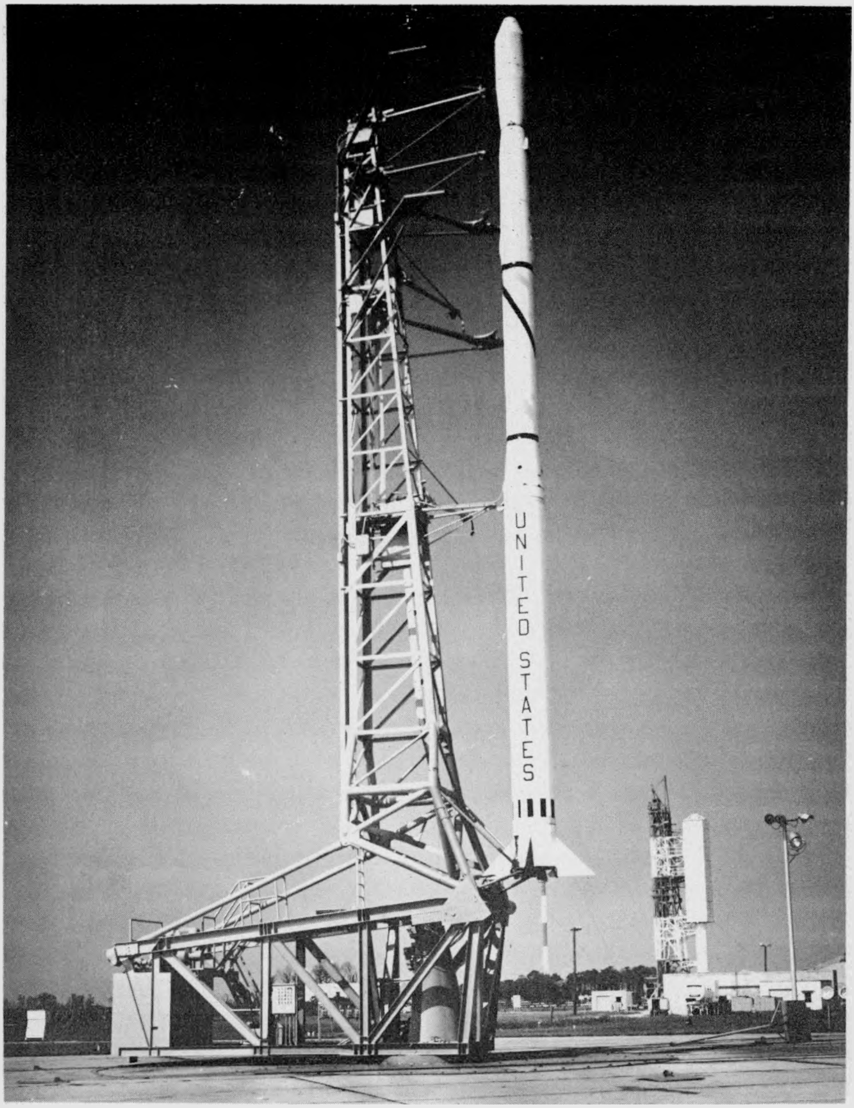
## AEROSPACE SYSTEMS

Engineering-scale safety tests of aerospace nuclear systems have been accelerated and expanded to meet the needs of a variety of applications. Solving the technological problems involved in the design, construction, and operation of compact, reliable systems, which also incorporate adequate safety features under launch, controlled flight, and re-entry conditions, requires a major effort. During 1964, this program was directed primarily toward the development programs of the Systems for Nuclear Auxiliary Power (SNAP). Emphasis was placed on the more imminent operational flights of each category—the SNAP–10A for reactor systems, and the SNAP–19 (the plutonium 238-fueled thermoelectric generator designed to supply electric power to the NIMBUS B satellite) for isotopic systems.

### *RFD–2 Test*

The basic safety approach for the SNAP–19 is predicated on achieving an orbit of sufficient lifetime to allow the radioactive fuel to decay to nonhazardous levels by the time it re-enters the atmosphere. However, in the case where a less-than-nominal orbit is achieved, the generator is designed to (*a*) disassemble early in the re-entry regime, and (*b*) expose the fuel capsules to a sufficient amount of the heat of re-entry to allow for (*c*) burnup of the radioactive materials. It has been postulated from theoretical analysis that, in the process, any hazardous materials would be ablated [23] into a fine particulate which would become suspended and dispersed safely in the upper atmosphere.

[23] Ablation: Sublimation, vaporization, or melting of a surface material due to aerodynamic heating.




*RFD–2 Test.* During October, the AEC conducted a second re-entry flight demonstration of a SNAP isotopic generator to prove out the safety design features that would cause the generator to disassemble so that the fuel material would burn during re-entry into the earth's atmosphere from orbit. The flight, which covered a trajectory from Wallops Island, Va., to near Bermuda, was a success. Photo shows the encased re-entry vehicle and isotopic generator atop the Scout rocket launch vehicle. The first (RFD–1) flight test had been conducted in 1963.

*Objectives.* To prove the safety design features of the SNAP–19 generator, a re-entry flight demonstration (RFD–2) was conducted on an inert isotopic generator similar in design to the SNAP–19 on October 9, 1964, by the Sandia Corp., the principal AEC contractor for aerospace nuclear safety. This was done in collaboration with the developer of the SNAP–19, the Martin Co. of Baltimore.

The objectives of the RFD–2 flight test were to:

(*1*) Investigate the disassembly of an inert isotopic generator during re-entry;
(*2*) Determine the time history of fuel capsules exposure to re-entry heating;
(*3*) Study aerodynamic heat input to the generator during re-entry;
(*4*) Correlate the results of the test with analytical predictions and with experimentally measured heating rates; and
(*5*) Study thermal-battery activation by the re-entry heat pulse to test, in a space environment, a device which can automatically initiate a satellite destruct charge during re-entry.

*Disassembly achieved.* RFD–2 was composed of the isotopic generator mounted on the front of a re-entry vehicle, all of which was launched from the NASA Wallops Island, Va., Range on a Scout vehicle. The re-entry vehicle, which contained the telemetering equipment used to transmit data on the events as they occurred during the re-entry regime, was designed to survive burnup. The payload design included movement switches which would indicate generator disassembly during re-entry (thus releasing the inert fuel capsules). Preliminary data from the flight indicates that the generator disassembled as predicted.

Fuel capsules containing flare materials, instead of the plutonium 238 which will be used in the orbital generator, were included as part of the payload in order to determine the time required to burn through the fuel encapsulating material. This phase of the test was important because the plutonium cannot ablate until the encapsulating material burns off. Some flare colors from the burning capsules were visible with the naked eye from Bermuda; thus, it is expected that the yet-to-be-evaluated data obtained with spectral cameras at Bermuda and on downrange aircraft will give positive identification of burn-through altitudes and provide gross ablation rates.

*Playback obtained.* During one portion of re-entry, it is impossible to transmit radio signals from the re-entry vehicle because of formation of an ion plasma around the vehicle which causes telemetry blackout. A tape recorder was included in the re-entry vehicle for recording events during the blackout and for playback of the information after blackout but prior to impact into the ocean. Playback was successful on RFD–2, probably due to the use of a newly designed re-entry vehicle. (Playback was not obtained after blackout on RFD–1, discussed below.)

*Vehicle not recovered.* In the event of playback failure, it is advantageous to recover the re-entry vehicle so that the tape recorder can be retrieved. Also, of importance, an actual examination can then be made of the re-entry vehicle. To achieve recovery, flotation gear was incorporated into the re-entry vehicle along with a radio transmitter for locating it as it floated on the ocean. Although the parachute and its flotation gear and transmitter were recovered, the parachute shrouds parted and the re-entry vehicle was never found. However, since playback was achieved, no significant test data were lost.

It appears that the flight was highly successful, based upon the excellent preliminary results described above; however, it will take several months to analyze the hundreds of photographs that were taken and to translate the telemetry tapes into actual temperatures and events that occurred on the generator during re-entry burnup.

### *RFD–1 Test*

A similar re-entry flight demonstration (RFD–1)[24] had been carried out in conjunction with Atomics International on May 22, 1963, on a prototype of a SNAP–10A reactor system. It was determined from this aerospace safety test that a nuclear reactor could be designed to disassemble. This is the necessary first step in the re-entry burnup phenomena associated with the ultimate disposal mechanism for any residual radioactive fission products. Ablation of cladded uranium-zirconium hydride fuel elements were studied using the flare technique described for RFD–2.

### *Burn-up Studies*

Ground tests are continuing to measure the hypersonic heat transfer rates to the complex aerodynamic shapes of SNAP systems. Data from these experiments are being used to correlate the RFD–1 and RFD–2 data to ground facilities, and thus provide lower cost tools for evaluating the burnup characteristics of SNAP systems. These experimental data are being coupled with detailed theoretical analyses to predict the failure mode for space nuclear devices and the resulting altitude of exposure for nuclear fuel materials to aerodynamic heating.

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[24] See pp. 20, 142–145, Annual Report to Congress for 1963.

While flight tests have provided relatively gross data on the heating and melting of encapsulating materials used in SNAP isotopic systems and for the fuel elements used in SNAP reactors, it is necessary to obtain data of a more fundamental nature in order to completely understand the re-entry burnup phenomenon itself. This greater understanding is a prerequisite to determining the attendant dispersion pattern of the re-entry debris—an important consideration in evaluating any biological hazard associated with radioactive material from the airborne reactor or isotopic systems.

*Oxidation rates.* To achieve this objective, Sandia Laboratory is conducting theoretical and experimental studies of the burnup (ablation phenomena) associated with high-speed re-entry of a body into the earth's atmosphere. Tests have been undertaken on oxidation rates of specific reactor fuels as a function of their shearing stresses. For example, heat was supplied to small wire specimens by electrical resistance heating. Re-entry flow conditions were simulated by extending the wires across a small wind tunnel. Test results confirmed that the oxidation rate of zirconium, for instance, varies as a function of the aerodynamic shearing force on the body. A separate theoretical study is continuing of the thermal effects of metallic oxidation to establish the possible contribution of oxidation to the ablative destruction of SNAP reactor and isotopic fuel materials. Further, wave superheater tests have been run on various combinations of materials such as zirconium, zirconium hydride, stainless steel, and molybdenum as a part of a study of the reaction of metals in a simulated re-entry environment.

*Fuel disintegration.* Atomics International is conducting tests on reactor fuel material in hyperthermal arc jet facilities. In these experiments, high-speed, arc-heated air is driven through nozzles to simulate the environment to which a re-entry fuel element would be subjected. More than 50 samples of SNAP reactor fuel have been tested in this manner. It was observed that the fuel was heated rapidly, went through a period of soak heating, then disintegrated. Tests will be conducted to evaluate the effects of oxidation, catalytic efficiency, and emissivity on the ablation of SNAP fuel rods. Data from these tests will be compared with theoretical analysis to formulate an analytical model for describing the complex phenomena associated with fuel ablation.

*Tantalum study.* A series of arc jet tests has been conducted to study the oxidation characteristics of tantalum under high-enthalpy, low-pressure flow simulating orbital decay re-entry conditions. No tantalum specimen could be made to melt, decompose, or lose weight in pure nitrogen flow; other specimens, when exposed to the same enthalpy and pressure condition as in the nitrogen tests but with a nitrogen-oxygen mixture, did attain a melting condition. The length of time to attain surface melting increased with decreasing oxygen flow rate. The surface temperature of the specimens, at melting, was observed to be as much as 1,000° C. below the melting temperature of pure tantalum. Oxidation rates, based on measured length changes, in these tests appear to be faster than those predicted for given oxygen flow rates. These preliminary studies have provided valuable insight toward understanding the thermochemical behavior of re-entering tantalum. Similar work is now underway to resolve discrepancies between theory and experiment.

*Flash-heating technique.* To further study re-entry burnup, a novel flash heating technique has been developed for studying the combustion of freely falling droplets of metal. The method involves melting and igniting carefully-cut squares of metal foil with an intense pulse of heat from a capacitor discharge lamp. With this device, droplets of zirconium and plutonium have been burned in air containing various amounts of water vapor and in a gas consisting of a 20 percent oxygen-80 percent argon mixture. A violent explosion of the molten droplets was observed under most test conditions. These studies are expected to result in an understanding of the mechanisms responsible for the explosive behavior of molten droplets. This is of interest to the aerospace safety program because it is postulated that molten droplets will be formed by the intense re-entry heat pulse. These droplets could explode and contribute to formation of burnup debris.

### *SNAPTRAN Experiments*

In addition to a need to understand re-entry burnup phenomena, it is necessary to examine preflight incidents involving both reactors and isotopic systems. Prior to orbital flight of a SNAP system it is possible for accidents to occur, such as vehicle aborts at the launch pad, in which the entire system is destroyed by fire or explosion. For this reason, tests have been conducted to determine the behavior of a SNAP system in an environment simulating a launch abort fire and/or explosion. In addition, the nuclear device may, in a launch pad abort, fall from the top of the vehicle to the launch pad; or in case of an improper launch, the SNAP system might impact on land or in the ocean immediately off the coast. The various systems have been subjected to impact tests at selected velocities simulating land and ocean impacts in order to determine the destruction mode and related information.

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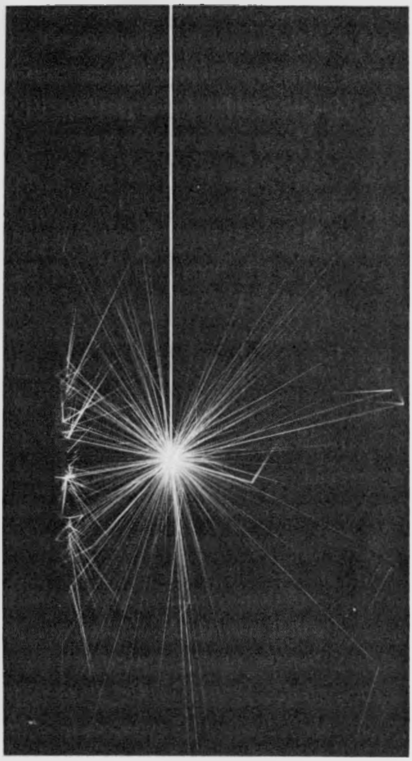
Part of the emphasis during 1964 on the SNAP–10A reactor system consisted of a test to determine the consequences of an accidental nuclear excursion. Such an accident could be induced by the inadvertent water immersion of a SNAP–10A reactor. This could take place if a SNAP–10A mission should abort on launch in such a way that the reactor were thrown into the water off-shore of the range or into the deluge water flume or catch basin. An experiment, designated SNAPTRAN 2/10A–3 [25] was performed at the National Reactor Testing Station by Phillips Petroleum Co., in conjunction with Atomics International and Edgerton, Germeshausen & Grier, Inc., to model the postulated accident.

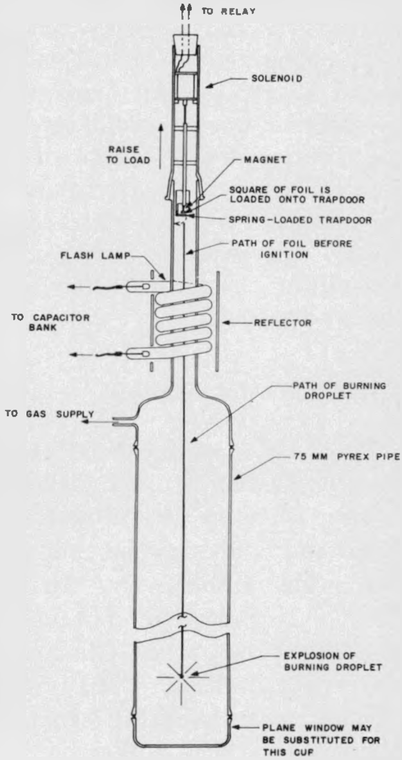
*First destructive test.* Previous tests had shown that components external to the reactor core become disengaged upon rapid entry into water. A test configuration was therefore chosen in which a SNAP–10A/2 reactor vessel and core were mounted in a large tank of water. The reactor was maintained subcritical by a boron-containing sleeve which was subsequently removed very rapidly through use of an explosive charge. Removal of the sleeve injected the maximum reactivity available, with the result that the reactor power rose on an exponential period of approximately 640 microseconds (640 millionths of a second). The power rise was terminated by the inherent prompt negative temperature coefficient when the fuel-moderated material reached approximately 1,900° F. The reactor subsequently disassembled violently due to the hydrogen pressure developed by the high temperatures. The nuclear energy release was approximately 40 megawatt-seconds which resulted in a mechanical energy release of about two megawatt-seconds, or the equivalent of one pound of TNT. The fuel lattice retained at least 99 percent of the available fission products. The halogens that escaped from the fuel were retained in the water and, as a result, no airborne iodine was detected. The only fission products detected in the radioactive cloud were noble gases and their daughters. It has been determined that less than 1 percent of the noble gases that were generated during the excursion were released. The radioactivity in the cloud was small and decreased to background about 12 miles downwind.

It can be concluded from this experiment that no significant radiological hazards result from the rapid water immersion of a SNAP–10A/2 reactor.

*Second series underway.* Another series of tests, designated SNAPTRAN 2/10A–1, using a modified SNAP–10A/2 reactor complete with

[25] SNAPTRAN stands for SNAP Transient.






*Explosion of Zirconium Droplet.* Nuclear reactors are efficient sources of power for satellites but have the disadvantage of containing toxic materials that could be hazardous upon return to earth from orbit. The photographs illustrate research on metal burnup being done at Sandia Corp. In the *left* photo, a zirconium droplet, formed by melting a piece of foil by an intense heat pulse, falls through a combustion chamber and explodes into numerous tiny particles that in an actual re-entry would remain suspended in the atmosphere high above the earth or settle slowly and safely over a wide area. Drawing on *right* is a diagram of the flash heating laboratory apparatus.

beryllium reflectors and control drums is presently in progress. The objectives of these tests are to determine the kinetic behavior of the reactor when subjected to large reactivity insertions and to determine the consequences of power excursions approaching the maximum possible. The series includes transients initiated by step and impulse reactivity insertions and will encompass tests in which no reactor damage will occur, tests in which a limited amount of fuel damage will occur, and a test involving complete destruction of the reactor.

## EFFLUENT CONTROL RESEARCH AND DEVELOPMENT

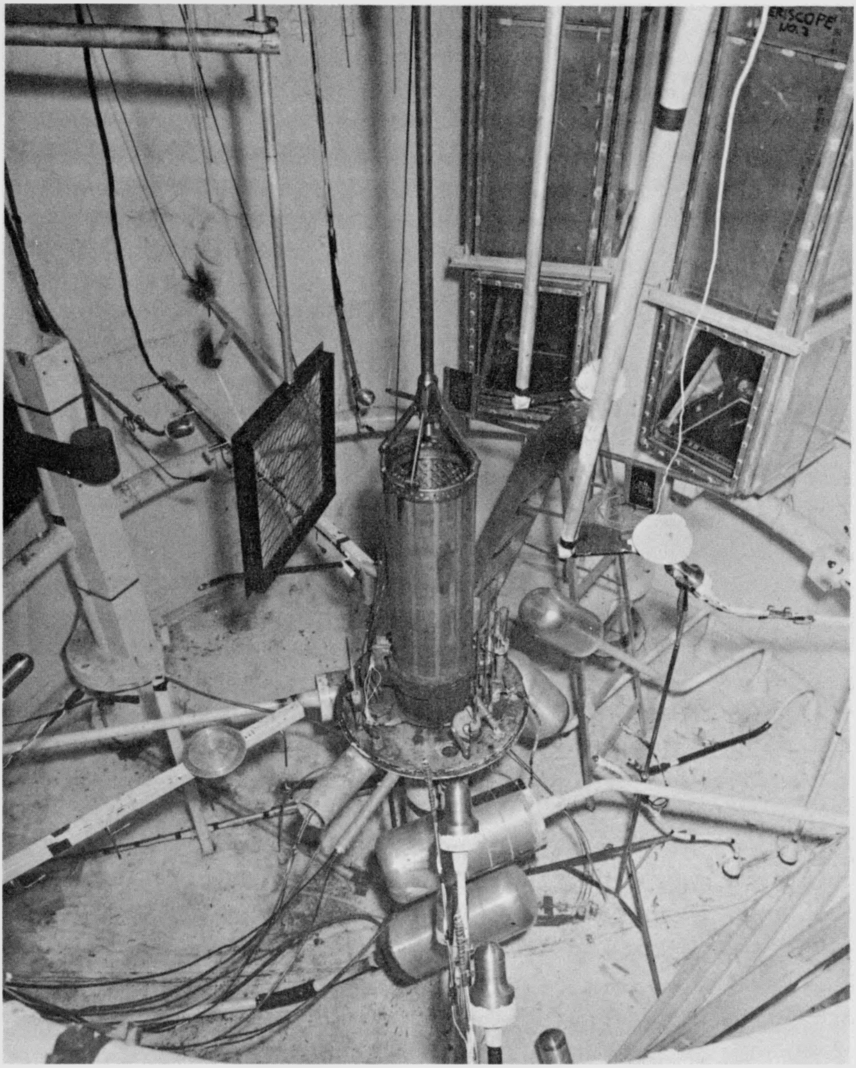
The programs in effluent control research and development are directed toward the safe management and disposal of various types of radioactive wastes resulting from nuclear reactor operations, the quantitative determination of the behavior of these residual radioactive effluents in the environment, and the development of engineering criteria associated with the environmental aspects of nuclear technology operations. This work provides a basis for defining and controlling the ultimate fate and possible effects of radioactivity in the environment.

### *Environmental Studies*

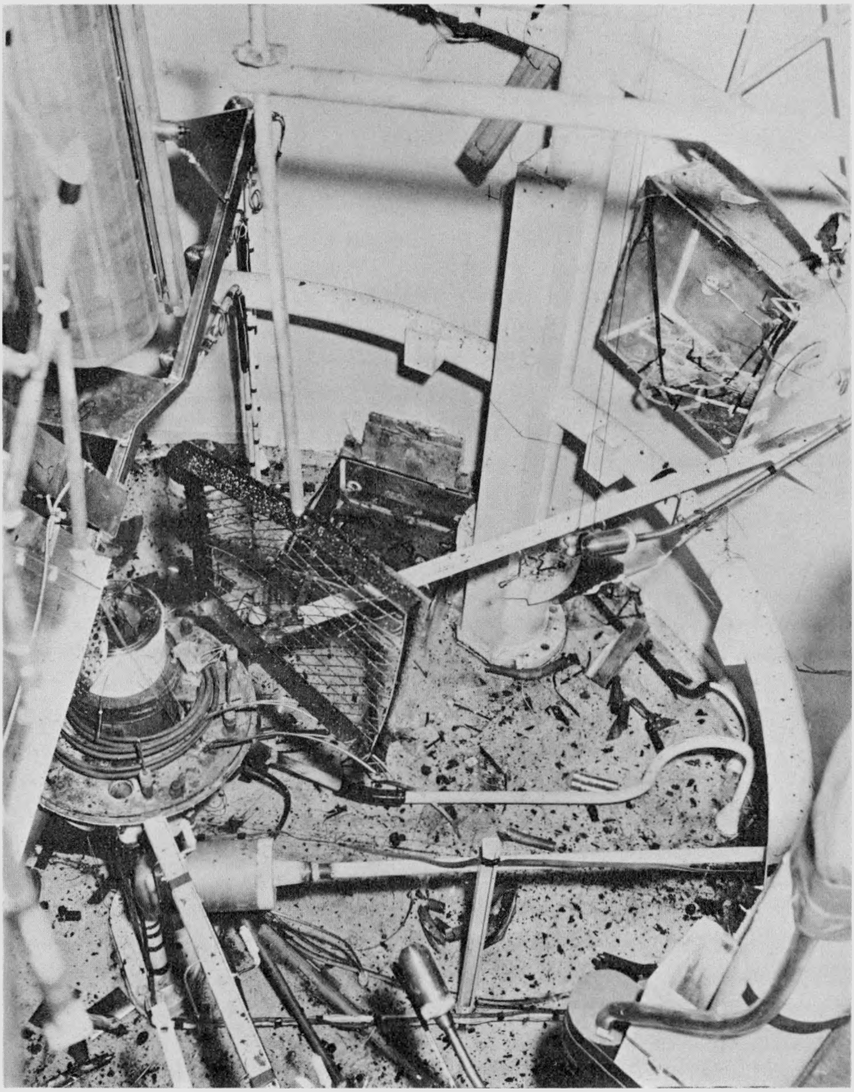
The AEC's operations at Hanford, Savannah River, the National Reactor Testing Station, Oak Ridge, and other installations, conduct investigations to determine the ultimate fate of specific isotopes in water and land environments, and the safe capacity of these environments for radioactivity. In cooperation with the AEC, the U.S. Geological Survey undertakes studies on hydrogeological aspects of waste disposal; the Chesapeake Bay Institute of Johns Hopkins University, Baltimore, Md., and the Scripps Oceanographic Institute of the University of California, La Jolla, make oceanographic investigations; and the U.S. Weather Bureau conducts meteorological studies concerned with the fate and behavior of radioactive materials in the atmosphere. This work is supplemented by specific studies by scientists at universities and research institutions.

*Flume experiments.* In April, the first release of radionuclides in the University of Texas "research flume" at Austin marked the start of a study to determine the effect of various factors on the fate of radionuclides in streams. The 200-foot-long flume, connected to two large reservoir tanks, can be biologically, chemically, and hydraulicly controlled to observe the effect of the variation of one factor while the others are maintained constant. Definition of these relationships will allow qualitative prediction of the expected ability for the assimilation of low-level radioactive waste for several broad classes of streams.

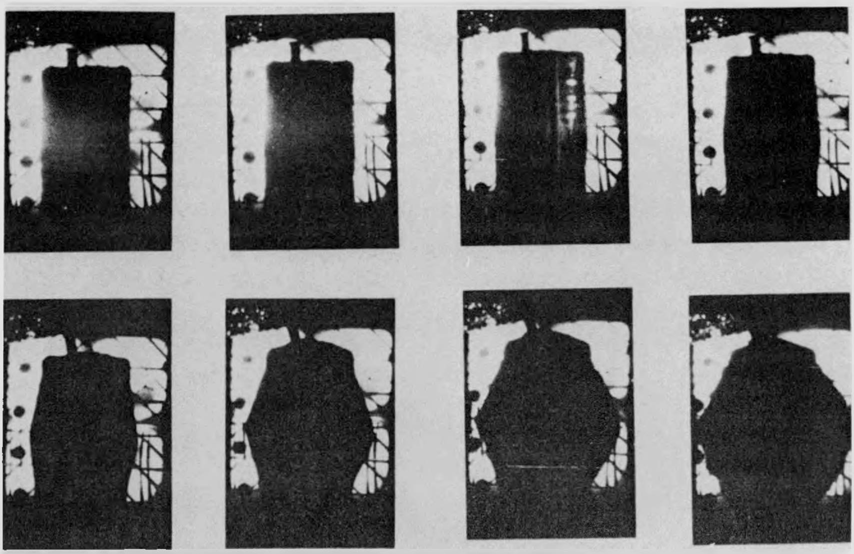
*Field studies.* Preliminary analysis of all the data from the Clinch River Study conducted by Oak Ridge National Laboratory and other Federal and state agencies, which was concluded in July, indicates that large volumes of low-level radioactive wastes can be disposed into the river system for periods of at least 20 years, which is the limit of present experience, with no hazard.



*Before SNAPTRAN–3.* During April, an experiment (SNAPTRAN–3) was conducted at the National Reactor Testing Station to determine the effect of a sudden water immersion of the SNAP–10A reactor system. Such an immersion could occur if there were a launch-pad or early ascent abort of the SNAP–10A which is scheduled to be flight tested in the spring of 1965. Photo shows the interior of the SNAPTRAN–3 water immersion test tank with the SNAP–10A–type reactor, surrounded by a neutron absorbing sleeve, mounted on a pedestal in the center preparatory to filling the tank with water. Around the reactor are an array of instruments and two of the reflecting mirror periscopes for high speed photographing of the effects of the surrounding water on the small aerospace reactor when the sleeve was suddenly withdrawn. The effects of the resulting destructive excursion are shown on the two following pages.

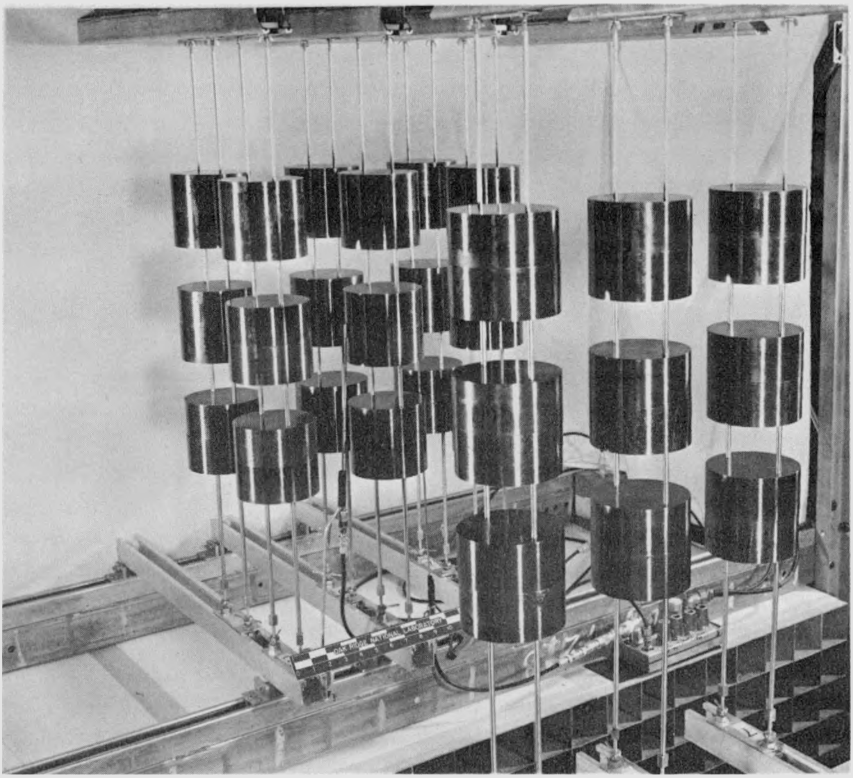


*After SNAPTRAN–3.* On April 1, an experiment at the National Reactor Testing Station confirmed predictions that a SNAP–10A space reactor would undergo a destructive excursion if it were to fall into the sea during a launch abort, thus eliminating the possibility of a significant radiological hazard. Photo shows the debris in the SNAPTRAN–3 test chamber after the 10A's nuclear core was suddenly exposed to full water reflection when a protective sleeve was withdrawn. Silhouette photos of how the SNAP device blew itself apart within 0.0027 of a second after the immersion are shown on the next page.



*SNAPTRAN–3 Silhouettes.* The above series of National Reactor Testing Station photos show eight frames taken from the motion picture coverage of the SNAPTRAN–3 test. The large cylindrical object in the photographs is the SNAP–10A reactor core vessel, which is about 9 inches in diameter and 12 inches deep. The small round objects next to the vessel are water-filled ping-pong balls, used to give an indication of how the water, which completely surrounded the vessel, moved during the test. All of the pictures were taken through the water by means of a mirror periscope. The first picture was taken early, before any noticeable expansion occurred. The second shot in the sequence (about 0.001 second after the first) shows the core vessel barely starting to bulge. In the third shot (about 0.00125 second after the first) the bulge is more pronounced; also, in this picture part of the front surface of the vessel is illuminated by electronic flash lamps and some details on the vessel walls may be seen. The remaining five pictures complete the history of the expansion, as silhouetted against the backlights (the last one being about 0.0027 second after the first). Also in these pictures the water-filled ping-pong balls can be seen to move and flatten somewhat. The experiment showed there was no significant radiological hazard associated with inadvertent water immersion of the SNAP–10A reactor under launch abort conditions.

In August, field tests were carried out at the National Reactor Testing Station to determine the feasibility of using an inert iodine 129-labeled gas coupled with neutron activation analysis of samples for a long-range (10- to 20-mile) tracer of atmospheric motions. Although sample analyses are not yet complete, it is hoped that procedures can be developed which will significantly aid meteorologists in predicting the path and dispersion of airborne radioactive materials released to the atmosphere.



*Safety Study.* "Tinker toy" assemblies of uranium metal cylinders enriched to 93.2 percent in uranium 235 are being studied at the Oak Ridge National Laboratory's critical experiments facility as part of an AEC study aimed at ensuring the safe transport and storage of fissile materials. The cylinders shown here each weigh 21 kg (46 pounds) and are supported on stainless steel rods. Although the cylinders are individually subcritical, the neutron exchange between the units in this 27-unit array is such that all surfaces must be separated by more than 2.5 inches to prevent criticality (ability to create and sustain an atomic chain reaction). When surrounded by 6 inches of paraffin, which reflects neutrons back into the array and thus enhances the neutron exchange, a separation distance greater than 7.5 inches is required for the assembly to remain subcritical.

### *Low and Intermediate Level Waste Studies*

Studies on wastes of low- and intermediate-levels of radioactivity involve the development, testing, and application of improved systems for their handling, treatment, and disposal. It is normally possible to use relatively simple chemical or ion exchange treatment methods to sufficiently decontaminate low-level wastes to permit their discharge to the environment.

The "hydrofracturing" method of disposing of intermediate-level radioactive waste was successfully demonstrated in February 1964 at the Oak Ridge National Laboratory. In this process, horizontal fractures are initiated between layers of bedded shale by injecting water under pressure through a well to depths of 700 to 1,000 feet. Liquid wastes (concentrated salt solution), mixed with cement and other ingredients to form a slurry, is subsequently injected down the well and out into the fractures, forming a "pancake" of waste slurry. The slurry sets in a short time, completely immobilizing the radioactivity at a depth and in a relatively impermeable formation sufficient to eliminate any possibility of contamination of the contiguous environment.

### *High-Level Waste Studies*

At present, the AEC and private industry are faced with reliance upon confined storage for the high-level radioactive wastes from fuel reprocessing operations using, in general, tanks of carbon steel or stainless steel equipped with decay heat removal systems. The present restrictions of tank storage for the long term—such as potential leakage and the necessity of liquid waste transfer for periods of hundreds of years—has resulted in the initiation of an extensive "conversion-to-solids" research and development program. Several approaches are under study for the conversion to oxides or relatively nonleachable glasses, including the use of heated pots, radiant-heated spray columns, and continuous glass forming processes.

Salt formations have been determined to be the most suitable depository for the storage or ultimate disposal of solid high level wastes. Extensive laboratory and field studies in salt have resulted in the design and construction of a disposal field experiment in an abandoned salt mine near Lyons, Kan. Operation of this field demonstration is planned for mid-1965.

## ANALYSIS AND EVALUATION

Analysis and evaluation activities in the nuclear safety research and development program supplement other program activities and provide assistance in planning and directing the overall program. Emphasis has been placed on the generation, analysis, evaluation, and dissemination of information on nuclear safety technology, with particular attention to areas which are not covered in the other nuclear safety research and development activities, e.g., operating and safety experience at reactor facilities, human factors affecting reactor operator performance, and the improvement of safety analysis techniques.

Analytical and experimental investigations are also being conducted to establish more adequate specifications—including inspection and quality control techniques—for reactor vessels, piping, and other primary system components.

To collect, process, evaluate, and disseminate nuclear safety technology information, the Nuclear Safety Information Center (NSIC) at Oak Ridge National Laboratory, which has completed its first year of operation, utilizes the part-time services of recognized scientists who remain active in their specialties while contributing to the work of the NSIC. The center produces the quarterly journal, Nuclear Safety, which provides current coverage of nuclear safety technology in summary form. A smaller but fully operative replica of the Nuclear Safety Information Center, designated as the Technical Information Center, was included in the United States exhibit at the Third United Nations International Conference on the Peaceful Uses of Atomic Energy.

# Part Four
# Other Major Activities

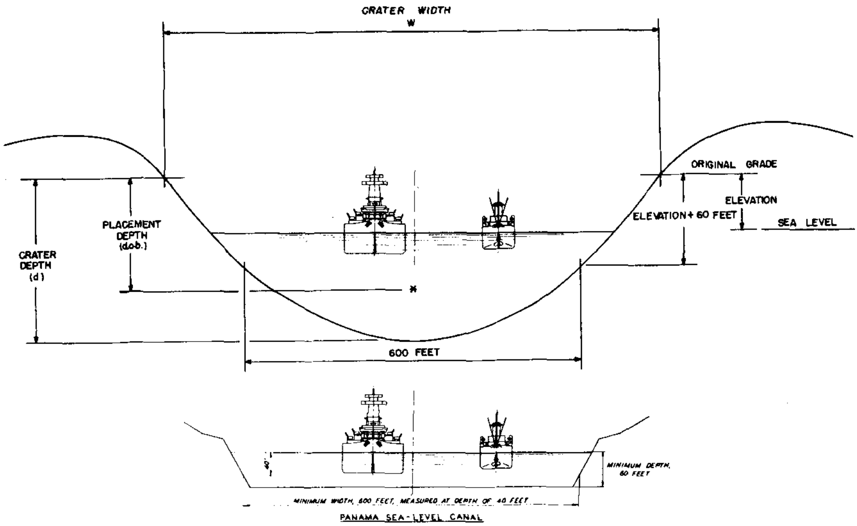
Seven other programs are contributing to continued progress and the development and use of atomic energy. Although they amount to only 12 percent of the Commission's budget dollar, they constitute the national effort in broad fields including the utilization of nuclear explosions for peaceful purposes (Plowshare Program); development of new uses for radioisotopes; international atomic energy activities; developing information on the effects of radiation on living systems; advancement of basic knowledge in the physical sciences; providing manpower trained in nuclear sciences; and the dissemination of technical information on the results of AEC-supported work.

# PLOWSHARE PROGRAM

The Commission's Plowshare program for developing industrial and scientific applications for nuclear explosives is based on the premise that the tremendous and relatively inexpensive energy available from nuclear explosives can be useful for a variety of peaceful purposes. Scientific applications for nuclear explosives can use the neutrons and the seismic waves produced by the explosion; industrial applications can use the energy released in nuclear explosions to move earth for canals and harbors and to break rock deep underground for mining and for other applications.

## 1964 PROGRESS

Truly significant progress, both practical and theoretical, was made in 1964. Plowshare developments during the year have clearly underlined the considerable steps being taken toward achievement of the many potential industrial and scientific applications of nuclear explosives. A stepped-up program of seven field experiments together with continuing laboratory investigation and analysis was responsible for this important progress toward the realization of the promise of Plowshare. The more important of these experiments were Projects Sulky and Handcar and the Dub and Par device development events. During 1964, Plowshare benefited from advances in explosive and emplacement technology which will reduce the radioactivity reaching the atmosphere from cratering explosions. The knowledge of cratering and row charge effects was significantly expanded as was understanding of the effects of completely contained nuclear explosions in various underground media. A major breakthrough in the scientific application of nuclear explosives to quickly produce isotopes of ultraheavy elements was realized. These developments served to facilitate further progress in evaluating potential applications of nuclear explosives for both contained and excavation type projects. Of related significance was legislation providing for the establishment, by the President, of an Interoceanic Canal Commission to study sites for construction (possibly by nuclear means) of a sea-level isthmian canal connecting the Atlantic and Pacific Oceans.




*Depth Comparisons.* Drawings compare the depth of a new sea-level trans-isthmian canal if it were dug with nuclear explosives (*top*) and by conventional excavation (*bottom*) on the basis of a 600-foot wide channel. Not only could a new canal be dug by nuclear means at much less cost than conventional excavation, but the width and depth could be varied, as desired, by the placement depth of the nuclear explosive. The possibility of a new Atlantic-Pacific Ocean sea-level canal is to be studied by the Interoceanic Canal Commission, authorized by Congress during 1964 to evaluate proposed routes and construction costs by nuclear and conventional means.

## EXCAVATION PROGRAM

Nuclear excavation technology is based on the ability of thermonuclear explosives to break and move tremendous quantities of earth quickly and economically in large-scale applications. The excavation program consists of several parallel efforts, all directed toward developing an excavation technology that will ultimately enable large-scale excavation projects to be carried out economically and safely. The program can be divided into the following areas: (*a*) Nuclear explosives development, which seeks to design special explosives for excavation; (*b*) cratering studies, consisting of both field tests and theoretical studies; and (*c*) safety studies, which seek to make certain that in any excavation project public health and safety would be assured.

Continuing progress was made during the year in developing the theoretical understanding of cratering, particularly that which can be applied to excavation by the simultaneous detonation of rows of explosive charges (row-charge cratering).

## CRATERING EXPERIMENTS

### *Dugout*

Project Dugout, detonated on June 24 at the Nevada Test Site, was the first small-scale excavation experiment carried out pursuant to a Commission decision of 1963 to concentrate, for the time being, on such experiments and other activities in lieu of larger excavation experiments.[1] This was a chemical-explosive, row-charge experiment in hard rock (basalt) to develop further understanding of the fundamental processes involved in row-charge cratering and to extend row-charge cratering experience from detonations in unconsolidated material (alluvium) to dense, hard rock.

Dugout was a simultaneous detonation of a row of five 20-ton chemical explosive charges. The charges were spaced a distance apart approximately equal to one single-charge crater radius (45 feet) and produced a trench about 287 feet long, 136 feet wide, and 35 feet deep. Previous experiments in desert alluvium had shown that when detonated simultaneously, a row of charges would produce a trench-shaped crater; Dugout indicated that many of the row-charge cratering concepts in alluvium may be extended to hard rock. Because of the differences between nuclear and chemical explosions, however, it is not possible to scale the results of Dugout directly to nuclear excavation projects.

### *Sulky*

The second small-scale experiment in excavation was Project Sulky, the detonation on December 18 of a 100-ton nuclear explosive 90 feet deep in basalt at the Nevada Test Site. Sulky was the first nuclear cratering detonation to be carried out under the terms of the limited nuclear Test Ban Treaty. It was designed to explore cratering mechanics in a hard, dry rock at a greater scale depth of burial than previously used and to study the dispersion of the very small amount of radioactivity which would become airborne under these conditions. Because of the greater sealed depth of burial, no crater, in the usual sense of the word, was formed. Instead, the rock broken by the detonation was not thrown into the air with sufficient force to cause it to fall outside the detonation region. The mass of broken rock fell back into the cavity and formed a circular mound, roughly 25 feet high and 80 feet in diameter at the top. Most of the planned technical measurements were successfully made and a great deal of

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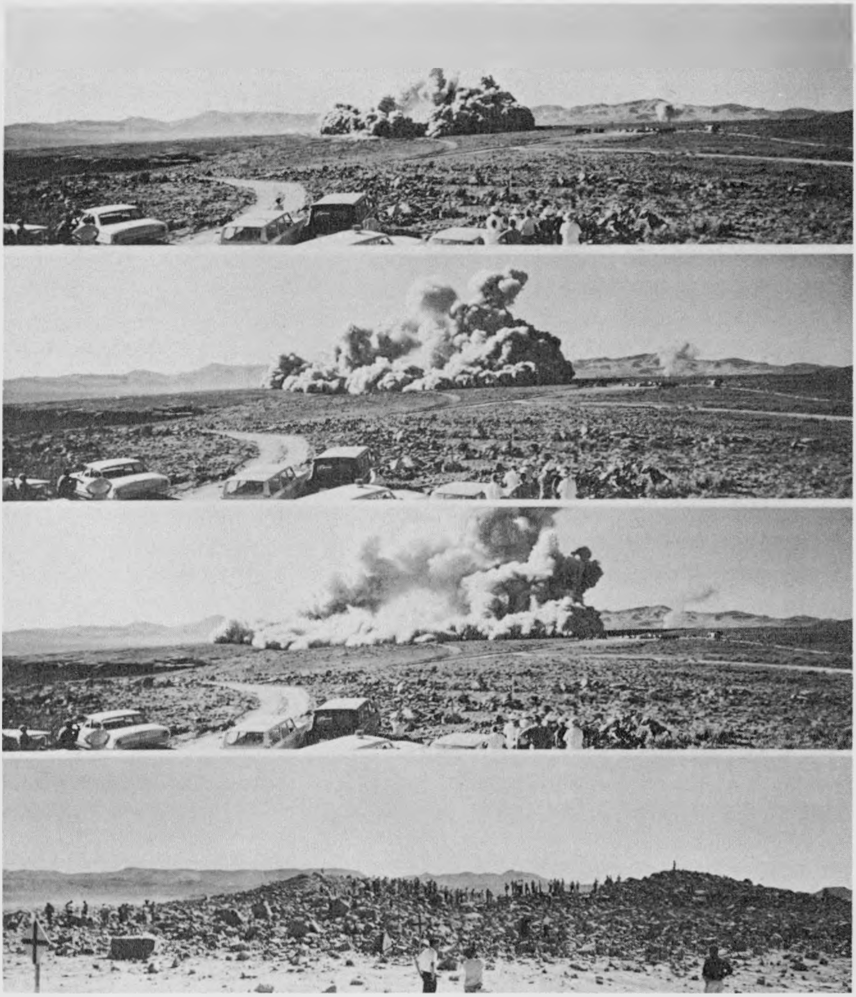
[1] See pp. 211–213, Annual Report to Congress for 1963.



*Project Dugout.* On June 24, as a part of its studies to develop canal-digging techniques with nuclear explosives, the AEC detonated a row of five 20-ton chemical high explosive charges simultaneously at the Nevada Test Site. The Project Dugout detonation provided information on the type of craters formed by a row-charge in dense, hard rock. Photos above show the detonation, in various stages. The main cloud from Dugout, shown in the formative stage *at top* rose to a height of about 4,000 feet; the base surge was 2,000 to 3,000 feet in diameter. The trench-shaped crater was about 287 feet long, had an average of 136 feet in width, and an average depth of 25 feet. In general, the width and depth of the crater exceeded predictions. *Bottom* photo shows newsmen and scientists inspecting the lip of the crater. Photo on page 160 shows size and shape of the trench.

useful data on cratering mechanics and radioactivity distribution were obtained.

In nearby areas outside the Nevada Test Site, however, there was so little radioactivity that technical analysis to distinguish which measurements were due to natural background radioactivity and which were due to Sulky were still underway at the end of the year. Sulky was the only Plowshare experiment carried out during the year which involved consideration of the effect of the nuclear Test Ban Treaty. It confirmed prior expectations that with proper design, excavation experiments could be carried out without causing radioactive debris to be present beyond national boundaries.[2] Data from the experiment will contribute to a better technical understanding of the factors to be taken into account in designing future excavation experiments.

## OTHER EXPERIMENTS

### *Sedan Crater Exploration*

During 1964, post-shot exploration of the area beneath the crater caused by the 100-kiloton (kt) Sedan event of July 6, 1962,[3] consisted of drilling four holes at the crater bottom to obtain information on the quantity and distribution of radioactive isotopes retained in the fallback. Secondary purposes included measurement of physical characteristics of the fallback—such as temperature, radioactivity, and density—and development of a cratering model that could be used for better prediction and understanding of craters formed in other areas and in other media. Results indicate that a significant amount of the tritium produced by the thermonuclear Sedan explosion was trapped in the fallback. The tritium distribution suggests that condensation of initial steam and chemical exchange with water in the fallback material played a major role in trapping tritium during the venting and crater formation process.

### *Explosives Development*

One of the primary objectives of the Plowshare Program is to reduce the amount of radioactivity released to the atmosphere from a cratering explosion. One approach to this problem has been the development of thermonuclear explosives that derive only a small part of their energy from fission, while another approach is the development of special emplacement techniques. The successful Klickitat

[2] See p. 217, Annual Report to Congress for 1963.

[3] See pp. 214–215, Annual Report to Congress for 1963; pp. 247–249, Annual Report to Congress for 1962.

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*"Dugout" Trench.* Although the Project Dugout experiment was conducted in a hard rock geological medium with conventional high explosives rather than nuclear explosives, it indicated that many of the cratering concepts developed through detonations in soft alluvium may also be applicable to hard rock. "Dugout" was conducted as a part of the AEC's studies on use of nuclear explosives to dig canals and channels. The trench-like effect produced by the simultaneous detonation of the five 20-ton chemical explosives is shown in the photo. The size of the excavation can be compared with the vehicles shown in circle *at right*.

(February 20) and Ace (June 11) device development tests provided information regarding the first objective. Regarding emplacement techniques, the 100-kt Sedan explosion had released less than 10 percent of the radioactivity produced to the atmosphere. Work is underway to develop special emplacement techniques that may further reduce this fraction. In June, the Dub experiment, a low-yield underground detonation, was a highly successful first step indicating that basic predictions concerning emplacement techniques are correct.

### *Future Excavation Experiments*

In view of the success of the small-scale excavation experiments and reduction of radioactivity escaping from cratering detonations, planning is proceeding for larger scale experiments necessary to advance nuclear excavation technology to a usable point. For example, a 100-kiloton experiment to test cratering predictions in hard rock is planned and would complement results of the 1962 Sedan event conducted in alluvium. Also under study is a nuclear row charge experiment in terrain of varying elevations (hills and valleys) to aid in determining emplacement and spacing of devices to produce a uniform channel or pass through uneven topography. Such experiments are currently being studied and analyzed to assure that they can be conducted under the nuclear Test Ban Treaty.

## CONTAINED EXPLOSIONS

Completely contained (underground) nuclear explosions have many potential applications in science and industry. Among these are the breaking-up of underground rock for block-caving mining, in-place leaching of ores, and oil and gas production stimulation. Scientific applications of contained nuclear explosions include neutron studies and heavy-isotope production. Considerable progress was made in these areas in 1964.

### *Theoretical Understanding*

Significant progress has been made in the understanding of deeply buried nuclear explosions. Measurements made following nuclear explosions in five different media (tuff, alluvium, salt, dolomite, and granite) have provided a good understanding of physical effects such as cavity size, chimney height, and fracture distribution.

A useful numerical model has been developed at Lawrence Radiation Laboratory-Livermore for predicting the dynamic response of the medium to a nuclear explosion. This model, starting from an extensive physical description of the medium, depth of burial and yield of the explosive, gives a comprehensive picture of the effects of the explosion in terms of peak particle velocities, shock-wave time of arrival, temperatures, pressures, and pressure pulse shapes in the medium. The results of the 1961 Gnome[4] explosion at Carlsbad, N. Mex., have been successfully simulated in this manner.

## MEDIA EXPERIMENTS

### *Handcar*

Project Handcar, a 10-kiloton, contained nuclear explosion at a depth of 1,320 feet in dolomite (a carbonate rock similar to limestone) at the Nevada Test Site was detonated on November 5 to extend knowledge of the effects of nuclear explosions to this rock type. With the exception of Gnome, which was fired in salt, all previous experience with contained Plowshare explosions had been in silicate rocks, granite, alluvium, and tuff. Carbonate rocks, however, make up an important fraction of the earth's crust, and many potential Plowshare applications may involve this type of rock. Many natural gas and petroleum reservoirs are associated with carbonate rocks, as are numerous mineral deposits. This nuclear explosion, in a carbonate medium, liberated large quantities of carbon dioxide ($CO_2$) and carbon monoxide (CO) which enhanced effects of the explosion. The permeability of the dolomite in the area above the shot point and outside the apparent chimney was significantly increased by the explosion.

The Handcar detonation provided information useful for:

(*1*) Measuring the cavity radius, chimney height, radius of cracking and permeability changes, resulting from a nuclear explosion in a carbonate, gas-forming medium;

(*2*) Determining the behavior and disposition of carbon dioxide and carbon monoxide gas generated by such an explosion;

(*3*) Determining the disposition of radioactivity produced by a nuclear explosion in a carbonate medium; and

(*4*) Investigating shock and seismic effect of a detonation in a high velocity (*i.e.*, the speed of transmission of elastic waves) rock overlain by low velocity material such as alluvium.

The medium in which Handcar was detonated was an almost pure dolomite, ($CaMg(CO_3)$). Additional post-shot investigations are planned during 1965.

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[4] See pp. 254–259, Annual Report to Congress for 1962.

### *Hardhat*

Investigation of the Project Hardhat chimney area continued during 1964. Hardhat was a five-kiloton Department of Defense (DOD) experiment in granodiorite of February 1962, and of interest to Plowshare because of the similarity of the medium to many mining applications. Measurements indicate a void volume equal to that of a sphere with a radius of 63 to 65 feet; this is one measure of final cavity size, since the cavity volume is distributed in the void space of the chimney on collapse. The rubble chimney extended 281 feet above the shot point. Post-shot fractures beyond the chimney extend at least 180 feet horizontally out from the chimney center line and there is increased permeability for another 160 feet. Based on these limited data, it appears that fractures can be expected to extend laterally about three times the cavity radius distance from the chimney center line, and less than 1½ times the cavity radius below the shot point.

Circulation losses of drilling fluid used in vertical post-shot drillings above the shot point, indicate possible increased permeability as high as 480 feet above that point. Similar permeability increases were noted for the 1961 Gnome experiment. This effect may be of importance in the leaching of valuable minerals through introduction of chemical solutions into a nuclear chimney area, for stimulating natural gas reservoirs by fracturing host rock with nuclear explosives, and in creation of underground terminal gas storage facilities. Further studies on the Hardhat chimney area will continue in 1965.

### *Shoal and Salmon*

The Shoal [5] and Salmon nuclear detonations were conducted as part of the DOD's Advanced Research Project Agency's Vela research and development program to improve the capability of detecting, locating, and identifying underground nuclear detonations. Shoal was an October 1963 12-kiloton contained nuclear explosion in granite 1,200 feet underground near Fallon, Nev. Salmon was an October 22, 1964, 5-kiloton contained nuclear explosion 2,700 feet underground in the Tatum Salt Dome near Hattiesburg, Miss. Plowshare add-on experiments were carried out in connection with both events. A fracture evaluation experiment, undertaken for Plowshare by the U.S. Bureau of Mines attempted to determine the extent of subsurface shock-induced fractures by the Shoal detonation; however, the presence of many geological faults and fractures in the Shoal medium reduced the effectiveness of the project. As a part of Salmon, the results of a

[5] See pp. 69–70 and 223, Annual Report to Congress for 1963.

structural response experiment and measurement of ground shock spectrum experiment are being analyzed for the Plowshare program.

### SCIENTIFIC PROGRAM

#### *Par*

The Par event was successfully conducted underground at the Nevada Test Site on October 9, 1964. The purpose of the experiment was to test the design of a nuclear device suitable for producing isotopes of heavy elements. Analysis of debris samples recovered by drilling indicate that a major advance has been made in the production of heavy elements by nuclear explosives. The Par experiment utilized a specially designed nuclear explosive system containing a uranium (U–238) target, and was detonated at a depth of 1,330 feet in alluvium. The explosion had a yield of about 30 kilotons. Analysis of samples of fused glass shows that the neutron flux in Par was twice as great as has been achieved in previous Plowshare underground experiments. A major indication of the success of Par is the concentration—1,000 times greater than previously achieved—of californium 254 in the Par samples. To date, scientists have observed elements as heavy as fermium 255, and are continuing to search the samples for even heavier isotopes. The Par results clearly demonstrate the practicability of using underground nuclear explosions to produce significant quantities of isotopes of ultra-heavy synthetic elements.

## PLOWSHARE APPLICATIONS

Many potential Plowshare experiments, projects, applications, concepts, and ideas are under various stages of study or development.

### EXCAVATION APPLICATIONS

The Commission has received a large number of suggestions for using nuclear explosives in excavation projects in the United States and elsewhere in the world. These include digging canals and harbors, clearing navigation obstructions, and cutting passes through mountains for land transportation. The following three specific projects are currently receiving the most attention.

#### *Interoceanic Canal*

Studies of the feasibility of excavating a sea-level, trans-isthmian canal with nuclear explosives continued during 1964. Public Law 88–609, enacted during September, 1964, authorized the President to appoint a five-man Commission to make a full and complete investigation and study to determine the feasibility of, and the most suitable site for, the construction of a sea-level canal connecting the Atlantic and Pacific Oceans. In addition, the Commission would investigate the best means for constructing such a canal, whether by conventional or nuclear excavation, and the estimated cost of each.

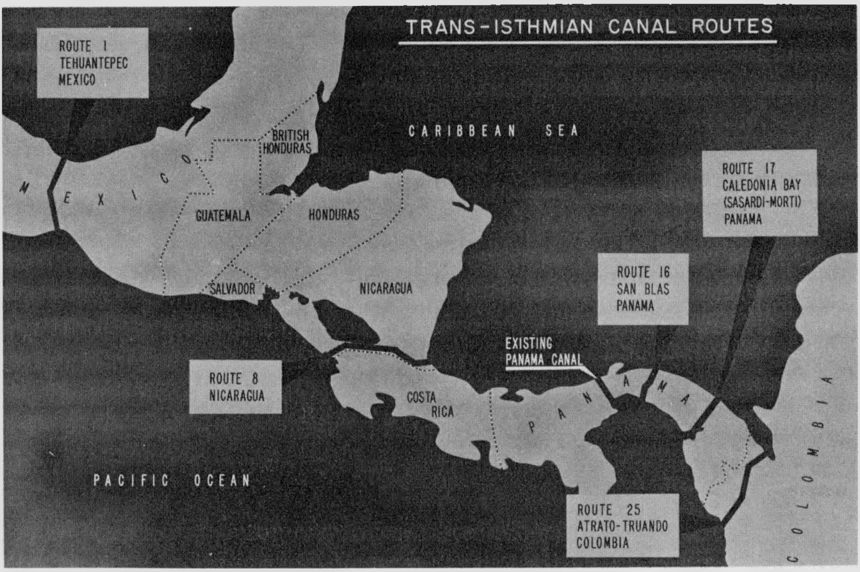
The AEC's participation in the study will include: (*a*) On-site bio-environmental surveys and studies to assure that excavating a canal by nuclear explosives could be done safely in the American Isthmian region; (*b*) assistance in the development of engineering design and costs for the nuclear excavation portion of such a canal. The AEC's nuclear excavation development program is designed to develop and demonstrate the technology required for use in the study through laboratory research, field experiments, and useful projects.

### *Carryall*

During 1964, several AEC offices, in cooperation with the Lawrence Radiation Laboratory-Livermore, gave consideration to Project Carryall, especially the costs, the prerequisite cratering experiments, and the other technical developments necessary to carry out such a project. Carryall is a joint feasibility study of a mountain pass excavation through the Bristol Mountains (near Amboy) in southern California by the AEC, the Atchison, Topeka and Santa Fe Railroad, and the California Division of Highways. Following the preparation of the feasibility study, consideration was given to possible schedules for the project on the assumption that the necessary studies and experiments will ultimately indicate that the project is feasible, safe, and otherwise possible and desirable. If mutually satisfactory schedules can be arranged, the next step in the project would be collection of data on the site and more detailed engineering and safety evaluations.

### *Tennessee-Tombigbee Waterway*

During 1964, the AEC agreed to cooperate with the Tennessee-Tombigbee Waterway Development Authority, the U.S. Army Corps of Engineers, and other appropriate authorities in evaluating the technical feasibility of using nuclear explosives to excavate approximately 3 miles of the "divide cut" through low hills in the Northeast corner of Mississippi (the highest terrain) on the proposed waterway. The waterway project would connect the Tennessee River with the Tombigbee River and directly link the mid-continent's 10,000-mile inland waterway system with the southeastern Gulf area. The total project would include digging a canal some 250 miles long and building six locks.




*Route Study.* A number of different routes have been proposed from time to time for a new trans-isthmian canal to overcome the ship-size restrictions of the existing Panama Canal. Drawing *above* shows five of the more-frequently mentioned routes. Chart *below* lists the salient features of these routes including the Panama Canal, and previously estimated construction costs. The conventional construction costs are from a study made in 1947; the nuclear excavation costs were the result of a 1960 study. Note that the conventional costs are on the basis of a 600-foot width and 60-foot depth canal, while the nuclear costs are based on a 1,000-foot width and 250-foot deep channel. The Interoceanic Canal Commission was authorized by Congress during 1964 to investigate and determine the most feasible site for a new canal, whether it should be constructed by conventional and nuclear means, and the estimated costs for each.

| Site | Length (Miles) | Maximum Elevation of Divide (Feet) | Estimated 1/ Costs for Conventional Excavation (Millions) | Estimated 2/ Costs for Nuclear Excavation (Millions) |
|---|---|---|---|---|
| Mexico (Tehuantepec) | 125 | 810 | $13,000 3/ | $2,300 |
| Nicaragua (Greytown-Salinas Bay) | 140 | 760 | 4,100 | 1,900 |
| Panama (San Blas) | 37 | 1,000 | 6,200 | 620 |
| Panama (Sasardi-Morti) | 46 | 1,100 | 5,132 | 770 |
| Panama 4/ (Canal Zone) | 46 | 590 | 2,287 | |
| Colombia (Atrato-Truando) | 102 | 950 | 5,261 | 1,200 |

1/ Estimates are based on a canal 600 feet wide and 60 feet deep.

2/ Estimates are based on a canal 1,000 feet wide, 250 feet deep at the center and include the construction costs of all operating facilities.

3/ Estimate for lock canal only.

4/ 1960 estimate for converting present canal into a sea-level canal 600 feet wide and 60 feet deep.

## NATURAL RESOURCES APPLICATIONS

### *Mining by Nuclear Caving*

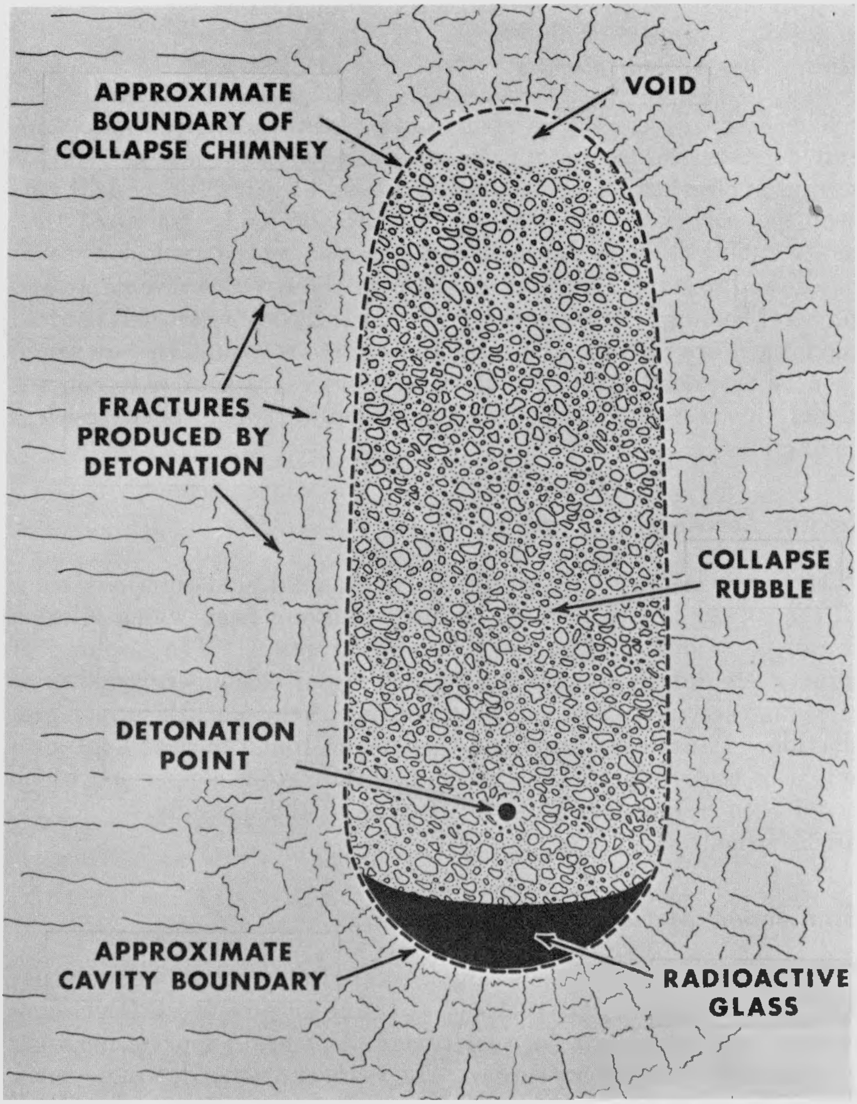
The use of nuclear explosives in mining massive, deeply buried mineral deposits has been studied extensively. For such a use, one or several nuclear explosives would be emplaced by drift or by drill hole near the bottom of the ore body. The thoroughly fractured rock in the rubble chimney (or chimneys) created by the explosion would be allowed to stand for about 6 months to allow radioactive decay and physical cooling. Mine workings would then be constructed beneath the broken ore zone but above the radioactive melt, and the ore would then be recovered. The actual mining process is similar to conventional "block caving"; this Plowshare application is called "nuclear caving."

### *In-Situ Leaching of Copper*

If certain copper ores are treated with mild acid solutions, some of the copper is dissolved in the leach solution, from which solution it can be recovered by several suitable processes. The leaching of mine waste dumps and the in-situ leaching of old underground mine workings accounts for about nine percent of the world's copper production. It has been suggested that underground nuclear explosives might be used to break large amounts of low-grade copper ore, which could then be leached-in-place. Studies of this possible application are being continued.

### *Stimulation of Natural Gas Reservoirs*

Many natural gas deposits cannot be profitably tapped because they are entrapped in "tight" rocks, (i.e., the reservoirs—rock formations containing the gas—are not very permeable, and the movement of gas through the rock is very slow). There are extensive deposits of natural gas in tight formations in the United States and two mechanical effects of underground nuclear explosions can be expected to improve production in such situations. First, the chimney of broken rock produced in the host formation by an underground nuclear explosion will provide a large effective well bore. Second, explosion-induced fracturing of the formation outside the chimney area may provide an




*Nuclear "Caving."* The great explosive force of nuclear energy holds potential for many beneficial uses. One technique being developed under the AEC's Plowshare program is "nuclear caving" in which large bodies of underground rock can be thoroughly fractured to create a chimney of rubble. Such underground engineering with nuclear explosives would have applications in the mining of ores, recovery of gas and oil from sand or shale, sewage disposal, subterranean gas storage or water reservoirs, and geothermal heat utilization. Drawing shows the main features of "nuclear caving" which is similar to conventional "block caving" used in mining with high explosives. However, the nuclear method is on a much larger scale and the heat from the detonation can be put to use in some situations.

even larger region in which the permeability is increased. This region of enhanced fracture permeability may extend out to distances three to five times the radius of the chimney.

The Continental Oil Co. and the El Paso Natural Gas Co. have calculated the production of nuclear stimulated wells, making reasonable estimates of chimney diameter and the extent of fracturing outside chimneys. Both companies calculate that nuclear stimulation is probably feasible from the technical viewpoint, and may be economically attractive, depending on the costs and diameters of nuclear explosives which might be available on a production basis. Preliminary studies indicate that radioactive contamination of gas produced from nuclear-stimulated reservoirs is not a major problem; however, additional studies are being done to confirm this.

### *Petroleum Recovery*

The United States' tremendous hydrocarbon reserves that are trapped in the oil shale formations of Colorado, Utah, and Wyoming remain untapped as do other potential deposits throughout the world, since there is no economical method of removing the oil from the rock. The U.S. Bureau of Mines and several oil companies are developing retorting techniques by which broken shale can be heated to liberate the oil. Retorting is technically feasible, but the cost of present, conventional methods is fairly high. Plowshare may be able to provide help by breaking up large quantities of shale with underground nuclear explosions.

### *Water Resource Development*

The U.S. Geological Survey is continuing studies [6] of the application of nuclear explosions to water resource development. The studies involve investigation of the technical and economic feasibility of employing nuclear explosives to develop and conserve both surface and underground water resources. In addition, the University of California's Hydraulics Laboratory has been conducting independent studies in the same subject area, but with a slightly different emphasis.[7]

## SCIENTIFIC APPLICATIONS

Nuclear explosions have already served as a valuable research tool in such fields as neutron physics and geophysical investigations, and

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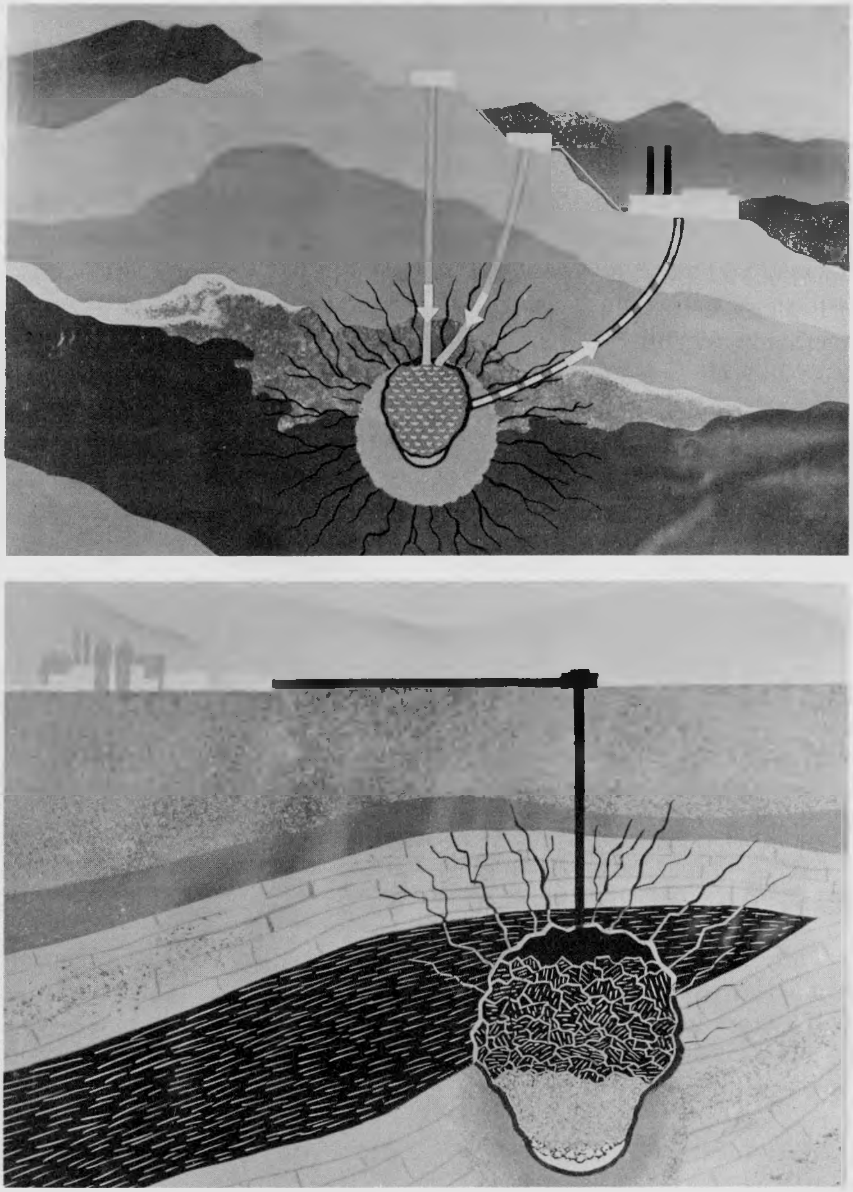
[6] See p. 225, Annual Report to Congress for 1963.

[7] UCRL Report No. 7850, "Economics of Ground Water Recharge by Nuclear and Conventional Means," available from Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, Springfield, Va., for $2.00.



*Copper and Oil Recovery.* Two potential uses of underground nuclear detonations and the in-situ leaching of copper ores and recovery of oil entrapped in shale formations. Drawing *above* shows how the in-place leaching of copper ore could be carried out. A subterranean nuclear detonation in an ore body (shaded area at tip of arrows on left) would break up large quantities of the ore-bearing earth or rock. By circulating a mild acid solution down through the fractured material the copper would be leached out and suction-pumped up to the recovery plant. Drawing *below* shows how petroleum could be recovered from shale formations. The nuclear explosive would break up large quantities of the oil-bearing rock from which the oil could be liberated by heat.

heavy element chemistry. With the development of new experimental techniques appropriate to the unique output of a nuclear explosion, it can be expected that use of the nuclear explosion phenomena for scientific research will expand greatly over the coming years.

### *Heavy Element Production*

Based on the production and subsequent identification of two new elements, einsteinium and fermium, from the 1952 Mike thermonuclear explosion at Eniwetok, scientists at Lawrence Radiation Laboratory—Livermore and Los Alamos Scientific Laboratory have been developing special nuclear explosives specifically designed to produce the large neutron flux necessary to create rare transplutonium isotopes and, possibly, new elements by instantaneous multiple neutron capture.[8] Such research is of fundamental interest in the field of nuclear physics and chemistry and would extend work carried out with accelerators and reactors.

The heavy element device development test Par, conducted at the Nevada Test Site during October was quite successful and indicated that a major advance has been achieved in the design of such a device. (The results of this experiment were discussed in the preceding section under "Scientific Program.")

Another part of the heavy element program is a project, called Coach,[8] in which the special heavy element producing, nuclear explosive would be detonated in a salt formation so that significant quantities of the isotopes produced could be recovered by mining and leaching. A site in an underground salt bed near Carlsbad, N. Mex., has been selected for this project and some preliminary site preparation has been done. However, there are no plans at the present time to proceed with Project Coach, pending further development of the nuclear explosive design which will produce heavy elements with low enough yields to be safely detonated at the present Carlsbad site, and pending further definition of requirements for heavy elements.

### *Geophysical Investigation*

Nuclear explosions are particularly valuable in studying the structure of the earth because, unlike earthquakes, their exact location, time,

[8] See pp. 220–221, "Annual Report to Congress for 1963."

and energy can be made known. Considerable work has already been done in this area, *e.g.*, seismological research in connection with the 1961 Gnome detonation led to a revised understanding of the geological structure of the midcontinental region of the U.S.[9] Nuclear explosions can also be carried out in seismic areas where the lack of earthquakes has not provided the seismic signals necessary for structural studies.

### *Neutron Physics Research*

Among the several aspects of basic physics research which can be carried out with nuclear explosions, the most significant, in terms of present state of development of experimental techniques, is neutron cross-section measurements. This involves experiments similar to those conducted in conjunction with the neutron pipe and wheel in Project Gnome.[10] Further experiments of this nature to obtain valuable neutron capture and fission cross-section data are presently being studied by scientists at the Los Alamos Scientific Laboratory.

## OTHER POTENTIAL APPLICATIONS

Certain other potential Plowshare applications which have been suggested to the AEC are being studied or considered.

### *Terminal Gas Storage*

Some interest has been indicated in the possible use of nuclear explosions to create underground gas storage facilities near market areas. For good efficiency, long pipelines from gas production areas to market areas must be kept flowing at full capacity throughout the year. The market for gas, however, fluctuates markedly from day to day and month to month, since a large fraction of the gas is used for space heating. Storage capacity near the terminal (i.e., market) ends of pipelines provides the needed flexibility. Heretofore, this capacity has been found principally in depleted oil and gas reservoirs. In some areas, however, all such storage capacity is in use, and gas companies are looking for new ways of expanding storage facilities.

A preliminary review suggests that the chimney and permeable zone created by a contained nuclear explosion may provide the needed capacity in some areas at a more desirable location and at a cost well below that of developing depleted gas fields which may be too remote from the consuming area.

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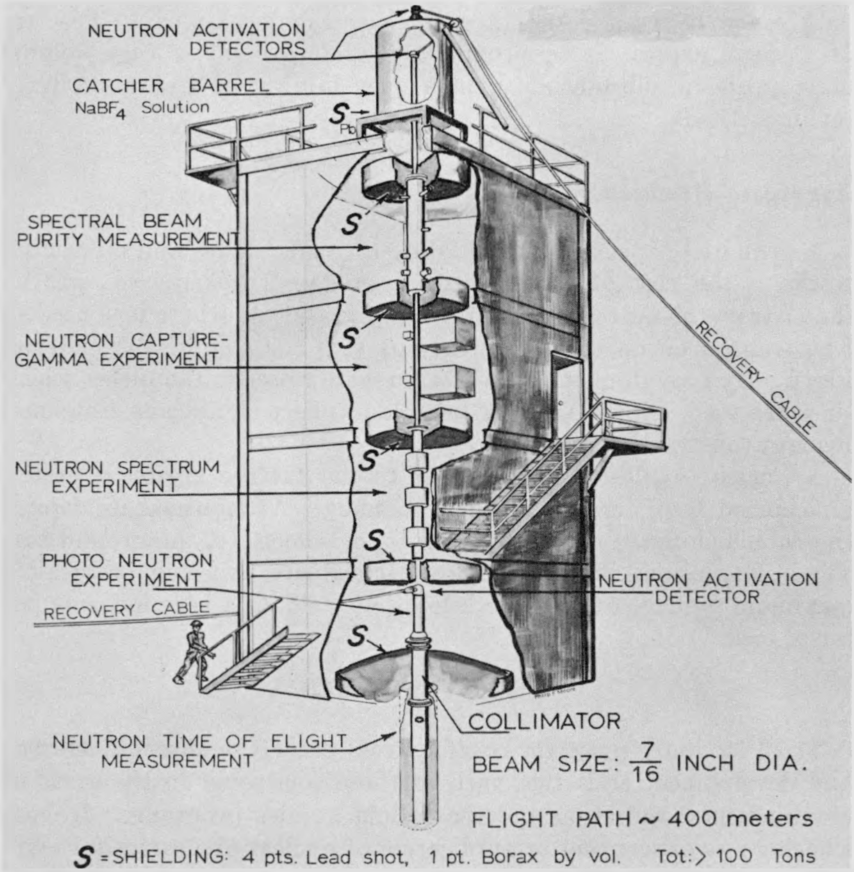
[9] See pp. 168–177, "Fundamental Nuclear Energy Research—1963."
[10] See pp. 170–176, "Fundamental Nuclear Energy Research—1963."




*Neutron Experiment.* A scientific peaceful use for nuclear explosions occurred in connection with an AEC–DOD nuclear weapons development test carried out during the year at the Nevada Test Site. The experimental techniques for using nuclear explosives for scientific research have been under development at Los Alamos Scientific Laboratory for some time, and have included the vacuum tube and wheel used in the Plowshare Gnome experiment in 1961. The drawing shows the experimental apparatus used by LASL to perform seven distinct physics experiments with the intense flux of neutrons released from the weapons test explosion. This highly successful "pure science" application provided fundamental knowledge not obtainable by any other known means. The LASL experiments were mainly directed toward acquiring knowledge about nuclear reactions which occur in different target elements when neutrons of various energies encounter the nucleus of the target elements. "Follow-on" experiments are frequently added to weapons tests for the benefit of the Plowshare program.

## *Waste Disposal*

The creation of underground storage space for wastes by using nuclear explosives may be feasible. In regions where there is no underground movement of water, liquid waste could be stored in the void space between rocks in a nuclear rubble chimney. The use of nuclear explosives to provide the underground storage volume may result in substantial savings over mining or hydraulic fracturing methods.

### *Aggregate Production*

A principal expense in the building of roads, dams, and other civil works is the cost of transporting aggregate (broken rock, gravel, sand) from the nearest source of supply to the site where it is needed. The transportation cost frequently exceeds the cost of the material itself. By providing supplies of aggregate closer to the places where they are used, Plowshare may be able to effect significant economies in many construction projects.

A nuclear explosive buried close to the surface creates a crater. One buried deeply creates a rubble chimney. At intermediate depths, the rubble chimney may extend up to, or almost to, the ground surface. Explosions in this range of burial are expected to break a maximum tonnage of rock per kiloton of yield, at a very low cost per ton of rock.

## SAFETY STUDIES

The Plowshare program benefits from other Commission research and development activities, such as those conducted in the areas of environmental radiation and the fallout studies programs. In considering any experiment or application of nuclear explosives for civil, industrial, or scientific purposes an intensive series of studies and evaluations are conducted to assure that public health and safety will be safeguarded.

Some specific work being conducted in the safety area to contribute knowledge for use in these analyses and reviews is shown below.

### *Ground Water Contamination*

Applied research sponsored by the Plowshare program during 1964 included continued studies of the movement of radioactivity in ground water to see to what extent cratering or contained detonations contaminate the ground water near the explosion. This continued research is conducted in order to provide up-to-date assessments of ground water contamination for purposes of evaluating new Plowshare sites, applications, and impact of the development of new Plowshare explosives on this safety area. Out of these studies has come the conclusion that radioactive contamination of ground water is not likely to be an insurmountable problem in any envisaged Plowshare application.

### *Chimney Contamination*

Included in the study of several specific contained Plowshare applications, have been the possible effects on safety and costs of residual radioactivity. In silicate-base rocks, about 90 percent of the fission product radioactivity is captured by the melt, which subsequently cools and solidifies to a glass-like slag. The remaining 10 percent is dispersed through the chimney as noncondensible gas. Some of these isotopes and their radioactive daughters are adsorbed onto the broken rock surfaces. Elements which might be found in a chimney 6 months to a year after detonation include tritium, krypton, xenon, strontium, cesium, and ruthenium. Experience with the Hardhat experiment showed that the external exposure of miners inside the Hardhat chimney averaged 11 milliroentgens per work shift 15 months after the detonation, which is well within relevant occupational health guides.

### *Shock Studies*

Nuclear explosion-induced shock damage to various installations was investigated extensively during 1964. Among the installations considered were support facilities for nuclear tests and residential-type buildings. Results indicate that no damage is suffered by prefabricated steel buildings subjected to ground motions as high as 5-g acceleration, and 150 cm/sec particle velocity. Newly built residential structures can withstand peak surface particle velocities of approximately 20 cm/sec without damage, whereas previous industrial experience has been that minor cracking of plaster in poorly constructed homes might be expected at peak velocities of 11 cm/sec.

## PROGRAM DEVELOPMENTS

### *Third Plowshare Symposium*

The Third Plowshare Symposium, "Engineering with Nuclear Explosives," was held April 21–23, 1964, at the University of California's Davis Campus. It was sponsored by the Department of Applied Sciences (Davis), and the Lawrence Radiation Laboratory—Livermore; the American Society for Engineering Education; the American Nuclear Society; and the U.S. Atomic Energy Commission. The

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symposium [11] drew world wide attention and was attended by 700 visitors including representatives from the United Kingdom, France, Australia, Canada, Mexico, Switzerland, South Africa, Israel, and the International Atomic Energy Agency.

### *Projected Charges for Thermonuclear Explosives*

During 1964, the Commission released new charges for Plowshare explosives. The charges are for the use of industry in making estimates to compare the costs of nuclear and conventional techniques for accomplishing a proposed project. Potential users can figure for planning purposes on a charge of about $350,000 for a nuclear explosive with a yield equivalent to 10 kilotons of TNT and a charge of about $600,000 for a nuclear explosive with a yield equivalent to about two megatons of TNT. The tentative charge would cover only arming and firing services as well as the explosive itself. Charges for related services and safety studies are not included, and must be considered separately for each individual case.

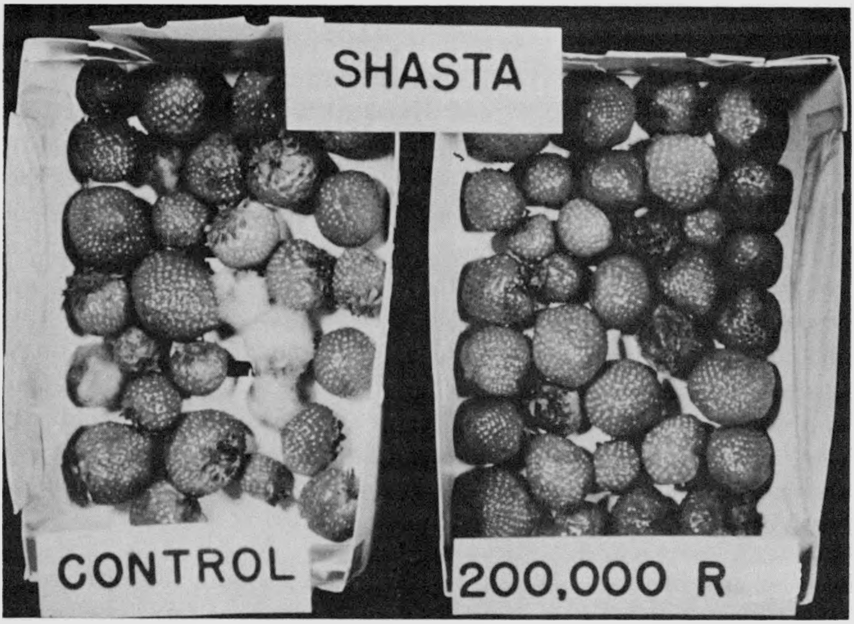
## RADIOISOTOPES DEVELOPMENT

The overall purpose of the Commission's isotopes program is to develop and demonstrate applications of isotopes and radiation technology which are important to the national economy and welfare. The program also includes the production and distribution of isotopes in types and quantities necessary to insure that through AEC and industry efforts national requirements are satisfied, and development of technology for the production, separation, and purification of isotopes by using both AEC and industry resources.

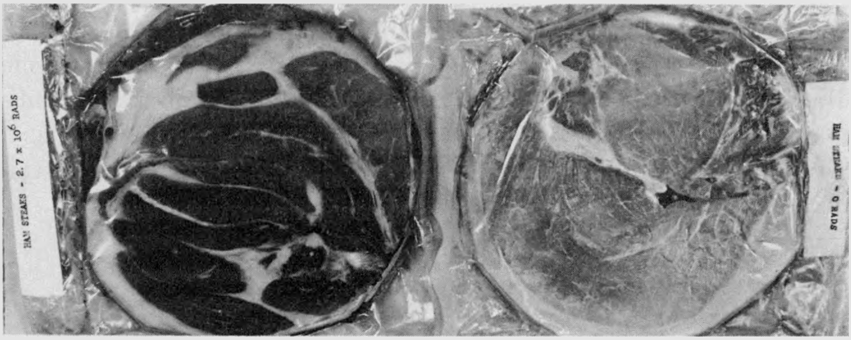
## RADIOISOTOPE PRODUCTION AND SEPARATIONS TECHNOLOGY

Research and development efforts are continuing to insure that appropriate radioisotope products are made available to satisfy the changing needs of the country's science and technology. The objectives of the fission products development program are: (*a*) To develop or improve separation processes for the long-lived fission elements, (*b*) to develop processes and procedures for the conversion of fission products into useful compounds and source forms, and (*c*) to determine the physical and chemical properties of radioactive sources.

[11] The proceedings were printed in TID–7695, "Engineering with Nuclear Explosives," available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va., for $4.50.




*Extended Shelf-life.* Normally, fresh strawberries have a cold storage-life of 7 to 10 days. However, AEC-sponsored research on radiation pasteurization has shown that irradiation can extend this shelf-life to about 2 weeks. Photo *above* shows two baskets of shasta strawberries from California. The unirradiated berries (*left*) began to form mold after the seventh day; the 200,000-rad pasteurized fruit (*right*) was still fresh and wholesome after a week although the vitamin-C content was slightly lower than that of the unirradiated berries, but the difference was of little nutritional significance. Photo *below* shows, on *left*, a ham steak that was sterilized under the U.S. Army's Program by 2.7 million rad and on the *right* an unirradiated sample. After a year of being held at room temperature, the ham which had been sterilized by gamma irradiation still appeared fresh and wholesome; the unirradiated sample had turned gray and had an unappetizing appearance. The AEC's food irradiation program is directed toward pasteurization of products to lengthen the time the food can appear on market shelves under refrigeration, while the U.S. Army's work is directed toward sterilization of foodstuffs so that they need not be kept refrigerated and will last almost indefinitely without spoilage.



***Fission Products***

*Conceptual plant.* Process studies continued at Oak Ridge National Laboratory (ORNL) and Hanford to provide technology for the design and construction of a large scale purification and encapsulation facility at Hanford—the conceptual Hanford Isotopes Plant [12] (HIP)—for the major fission products strontium 90, cesium 137, cerium 144, and promethium 147 which would be removed from the highly radioactive wastes from plutonium production as these wastes are processed for their long-term storage. Such a facility should provide these major products at low enough costs and in quantities sufficient to stimulate their use for both radiation and thermal applications. Proposals have been received from private industry for the construction of a commercial fission product conversion and encapsulation facility at Hanford in connection with the operation of the AEC's chemical processing facilities.

*Cerium separation.* During the past year, a technique for the separation of cerium 144 from the other rare earths by electrolytic oxidation and differential extraction was developed at ORNL. This method provides for separating cerium 144 from other fission product rare earths in equipment well adapted to hot cell operation and without the addition of an oxidizing agent.

*Thermal diffusion system.* An experimental thermal diffusion system was developed by ORNL and Mound Laboratory for enriching krypton 85 to 45 percent from its normal abundance of 5 percent in fission krypton.[13] A nonflow, equilibrium system requiring 54 days to attain equilibrium will be used to process 3,000 curies/yr. of 45 percent krypton 85. Several potential users have indicated demand for krypton 85 in the enrichment range of 20–45 percent for analytical applications.

*Technetium recovery.* Experimental recovery of kilogram quantities of technetium 99 from radioactive wastes was accomplished at Hanford. Previously ORNL had recovered similar quantities from uranium recycle residues. Technetium 99 offers promise as an anticorrosion agent, possible use as a superconducting material, and as a refractory material (such as tungsten) alloying agent for high temperature nuclear application.

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[12] See pp. 51–52, Annual Report to Congress for 1963.
[13] See p. 95, Fundamental Nuclear Energy Research—1964.

### *Neutron Products*

The neutron-produced radioisotope program includes investigations in the use of nuclear reactors for isotopes production. Major effort in the past has been on satisfying customer requests and reducing the production costs for the more widely used isotopes. Development work has been expanded to explore production of the less-known radioisotopes which have characteristics desirable for medical and scientific investigation. A systematic program to develop ways for exploiting both AEC and private reactors for isotope production is now in progress, including the possible use of the AEC's ultra-high flux reactors, such as HFIR [14] for the manufacture of products which could not be produced in lower-flux reactors.

### *Cyclotron Products*

The processing and distribution of cyclotron isotopes has for a number of years been carried out by private industry. The 86-inch cyclotron at ORNL, however, is the only large accelerator routinely available for production of isotopes in the United States. During 1964, more than 45 different radioisotopes were routinely produced for private processors.

Several new cyclotron-produced isotopes were also developed by ORNL during the past year. These include gallium 67, which has possible application in the detection of bone tumors, and yttrium 87, which decays to metastable strontium 87, a medically useful isotope for detection of bone diseases, blood circulation time, cardiac output, and radiocardiography.

### *Sealed Source Safety Testing*

Since the source safety program started, 379 sources, representing all of the basic designs, have been subjected to a variety of mechanical and environmental tests. Of these, 223 were radioactive sources and 156 were mock sources made by source manufacturers for the program. Included were medical, radiography, teletherapy, gage, neutron, and old sources sent to ORNL for burial, and several special items, including alpha calibration sources, watch dial paints, and static eliminator foils. Of the total sources, 308 were tested this past year.

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[14] High Flux Isotopes Reactor, expected to be in operation in 1966.

### *Production and Sales*

A total of 573,917 curies of processed radioisotopes had been distributed during the first 11 months of 1964 from Oak Ridge National Laboratory, in a total of 10,387 shipments with an associated gross income of $2.12 million. This represents a decrease of 11 percent in shipments and an increase of 21 percent in gross income over the same 1963 period.

### *Sales Withdrawals*

The AEC withdrew from the routine production and distribution of chromium 51, iron 55, cobalt 58, cesium 134, and cerium 141 effective June 23, and strontium 85, effective October 15, since they are now being produced by private organizations in sufficient quantities to meet ordinary commercial demands. These radioisotopes are used principally for biological research and for medical research, diagnosis and treatment. In all, during the past 5 years, the AEC has withdrawn from commercial production of 10 radioisotopes.

On September 16, the AEC published in the *Federal Register*, for public comment, the proposed formal procedures for AEC withdrawal from routine production and distribution of radioisotopes which are reasonably available from commercial producers. In doing so, the AEC reaffirmed its policy and intent to transfer its commercial radioisotope production and distribution activities to private industry as rapidly as possible consistent with the overall national interest. The AEC would continue to produce some radioisotopes as necessary for governmental uses or sale. Under the proposed formal procedures, the AEC will withdraw either voluntarily, or in response to a formal petition filed by private industry.

## ISOTOPIC POWER FUELS DEVELOPMENT

The recent successes of isotopic power supplies for such applications as navigation satellites, automatic weather stations, lightbuoys, and underseas electronic equipment have engendered a considerable number of additional applications, including Surveyor, the Nimbus satellite, and the Medium Altitude Communications Satellite. Additionally, serious consideration is currently being given to the use of isotopic power for manned missions, such as an extended Apollo flight and the manned Orbiting Research Laboratory, as well as for oceanographic applications, including underseas navigational devices. Mission requirements can be satisfied only through the use of various radioisotope fuels, including plutonium 238, strontium 90, promethium 147, curium 242, polonium 210, cerium 144, curium 244, and cesium 137. Consequently, development, production, processing, fabrication and encapsulation of isotopic power materials is being carried out on a broad front to satisfy the current and future needs of SNAP (Systems for Nuclear Nuxiliary Power) and related auxiliary power programs. (See Nuclear Reactor Programs, Part Three.)

*Plutonium 238.* SNAP generators currently powering navigational satellites in space use plutonium 238 metal as fuel. A fuel form, capable of satisfying both operational and aerospace nuclear safety criteria for sustained periods at temperatures up to 1,100° C., has been developed at Mound Laboratory and is now being evaluated.

*Polonium 210.* During the past year, the preparation and characterization of high temperature polonium 210 compounds, in particular the mono- and sesqui-polonide compounds, has been intensively pursued at Mound Laboratory. Materials of interest are being tested at sustained operating temperatures up to 1,600° C. with no visible signs of degradation. It is anticipated that during the next several years, this temperature capability can be raised to 1,850° C.

*Curium 242–244.* ORNL, working in cooperation with the Savannah River Laboratory (SRL), has the responsibility for the development and production of appropriate curium 242 fuels, as well as for the curium 244 fuels. Currently, curium 242 fuels are being developed for lunar landing vehicle thermoelectric power supplies. Flight-qualified fuels to satisfy this mission are now in the final stages of product characterization.

A curium 244 fuels development effort at ORNL was started during the past year, using curium 244 produced at SRL.

### *Fission Products*

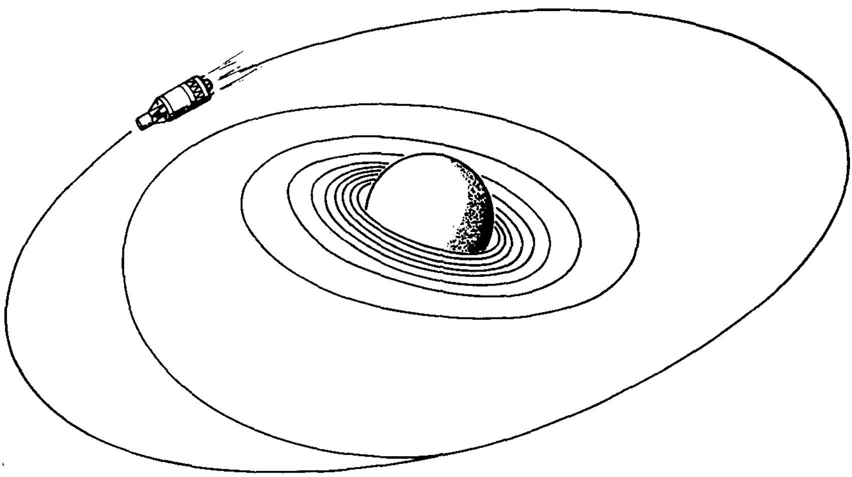
Oak Ridge National Laboratory, Hanford, the Nuclear Division of the Martin Co., Quehanna, Pa., and Nuclear Materials & Equipment Corp., Apollo, Pa., are working on the development of acceptable fission product isotopic fuels of strontium 90, promethium 147, cerium 144, and cesium 137 for terrestrial and/or space application. A material has been developed which appears capable of meeting the operational requirements imposed by the SNAP–17 generator, as well as the aerospace nuclear safety criterion of burnup to submicron particles upon exposure to re-entry heating.

## THERMAL APPLICATIONS PROGRAM

Thermal applications include the development and fabrication of systems based on the utilization of isotopic decay heat, which have significant performance advantages over systems powered by other sources. Radioisotopes represent a highly reliable, long-lived compact source of thermal energy, capable of functioning completely independent of the surrounding environment. When applied to space technology, the use of radioisotope thermal energy promises inherently simpler, more reliable, and lighter weight means of accomplishing certain propulsion and heating tasks which currently are performed by non-nuclear systems. The current method for supplying heat for these applications is the production of electricity, with subsequent conversion to heat.

### *Poodle Space Propulsion System*

The Poodle propulsion system employs a low-thrust, direct cycle rocket engine using the thermal energy generated by isotope decay to heat hydrogen which is expelled through a nozzle. The small rocket engine, or thruster, would have a total thermal power on the order of 5 kilowatts and would be capable of producing a thrust of 0.25 pounds



*Radioisotope Powered Propulsion System.* **Conceptual drawing of a space craft being boosted to a 24-hour synchronous orbit by a radioisotope powered Poodle thruster (small rocket engine). Such low-powered thrusters, which would be propelled by hydrogen heated by the decay of radioisotopes, are expected to extend the capabilities of smaller, less-expensive launch vehicles. The concept is under development for the AEC by Space Technology Laboratories, Redondo Beach, Calif.**

at a specific impulse [15] of 700–800 seconds. Development of the technology for this radioisotope use is underway at Space Technology Laboratories, Redondo Beach, Calif. Possible missions for Poodle include:

(*1*) Propelling payloads to high earth orbits, such as 24-hour synchronous equatorial orbit for communications relay satellites or navigational aids.
(*2*) Deep space probes with total mission velocities in excess of 60,000 ft/sec. Such a velocity will carry a space probe to within 18 million miles from the sun and yet permit the probe to escape the solar system.
(*3*) Attitude control and artificial gravity systems for large manned orbiting laboratories and manned interplanetary spacecraft for extending the orbit lifetime of low-altitude satellites by compensating for atmospheric drag.

Significant progress in the Poodle program has been made during the past year. Full-size thrusters have been operated, using electrically resistive heat, and polonium 210-fueled subscaled thrusters have been fired at Mound Laboratory in cooperative demonstration program with the U.S. Air Force.

## RADIATION PRESERVATION OF FOOD

National and international interest and accomplishments in the development and application of radiation processing of food continues to increase.[16] A recent International Atomic Energy Agency (IAEA) sponsored panel on the Application of Food Irradiation to Underdeveloped Countries concluded that food irradiation studies had reached the point where some potential application in developing countries may be possible.

Progress can be gauged by the fact that over 12 different petitions for production of irradiated foods for public consumption have been presented by the Army, AEC, or industry to the Food and Drug Administration. Four petitions were approved and issued in the past year. These include: (*a*) Use of cesium 137 for radiation sterilization of bacon, (*b*) use of cobalt 60 for inhibition of sprouting in white potatoes, (*c*) use of cesium 137 for sprout inhibition of potatoes and disinfestation of wheat and wheat products, and (*d*) approval of certain packaging materials for radiation processed foods.

The principal objective is to develop radiation pasteurized products, especially marine products and fruit, which can last three to four

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[15] Ratio of thrust to propellant mass flow rate.
[16] See pp. 191–196, Annual Report to Congress for 1963.

times their normal refrigerated storage period. The elements of this program are to develop the radiation pasteurization of selected products to the point of demonstrating technical and economic feasibility, including establishment of wholesomeness, and to develop prototype commercial radiation facilities.

### *Preservation Factors*

Laboratory-scale radiation pasteurization has shown that the shelf life of marine products can be extended for 30 days or more. Examples, the shelf life of shrimp and haddock can be doubled and that of Pacific crab and of soft shell clams can be extended five times. These results lead to an anticipated extension of areas within which fresh fish can be marketed.

The shelf life of fruit can be extended by a week or so. However, the principal benefit lies in the reduction of high losses during storage and distribution. The reduction of spoilage varies for each fruit, depending on its perishability. For example, approximately 25 percent of California's fresh strawberry crop is spoiled before it reaches the consumer. It has been demonstrated that radiation pasteurization can reduce this loss by about 75 percent.

### *Acceptability Factors*

Three products, shrimp, haddock, and *petrale* sole, or flounder, have successfully passed consumer feeding tests at Fort Lee, Va., in trials conducted in cooperation with the Department of the Army. Tests on strawberries, cod, ocean perch, oranges, and peaches are scheduled for 1965. Results from tests at the University of Hawaii indicated that mangoes, irradiated to 400,000 rads, were considered very acceptable.

### *Wholesomeness and Public Health Safety*

To evaluate any possible health-related effects which might be encountered through consumption of radiation-processed foods, the AEC has sponsored research studies in the areas of wholesomeness, toxicity, biochemistry, physiology, and microbiological safety. Certain of these studies have been in effect for several years while others have only recently been initiated. Results are used in petitions submitted to the Food and Drug Administration (FDA) requesting approval for human consumption of low-dose irradiated foods.

In long term, chronic toxicity studies with rats which are fed a diet containing irradiated soft-shell clams (35 percent of total solids of the diets), no toxic effects have been manifested by the animals after 10 months. Short term, subacute toxicity animal feeding studies were initiated in September and October on radiation-pasteurized sweet cherries, apricots, apples, pears, plums, strawberries, and onions. These studies are being carried out according to a protocol (detailed outline of necessary work) formally approved by the FDA, and will essentially complete the anticipated toxicity research requirements for these products.

Studies are underway to assess the growth and toxin production potential of *Clostridium botulinum* type E spores in irradiated haddock fillets and soft-shell clams under a variety of time-temperature storage conditions which are expected in future commercial practice. The studies include inoculating the soft-shell clams with type E spores to enhance toxin production. In general, none of the clam samples held at 33° or 35° F. increased in toxicity regardless of the inoculant level or the radiation dose. However, samples of clams inoculated with concentrations up to a million *Cl. botulinum* spores and held for normal periods of storage time at 45° F. without irradiation treatment may increase in toxicity. There is also an increase in toxicity when samples are inoculated at the high levels at which a significant number of spores would survive after a particular radiation dose and are then held at 40° F. or 45° F. Very little data have been obtained with haddock, but there appears to be a reduction in the number of spores after inoculation into haddock fillets. Products inoculated at the 100 and 10,000-spore level and then irradiated at 150,000 rad and held for 8 or 10 days at 45° F. or for 12 days at 40° F. have not increased in toxicity. These products will be tested after longer periods of storage.

Investigations were initiated during 1964 to determine the natural incidence of *Clostridium botulinum* type E in the Pacific Northwest and Southern Gulf (Louisiana) waters and pertinent marine products found in these areas. These new projects will complement the already existing laboratory studies on growth and toxin production from pure cultures of various strains of type E spores grown on synthetic and marine culture media.

Factors controlling outgrowth and survival of bacteria which are of potential public health significance (*clostridia*, *salmonellae*, *enterococci*, and *coliforms*) and interactions with naturally occurring spoilage flora of marine products before and after irradiation have been investigated. Results thus far indicate that radiation pasteurization is feasible for seafoods. On the other hand, elimination or reduction of less-resistant normal spoilage flora may result in secondary qualitative changes which could reduce normal competition among spoilage organisms, and permit out-growth of more resistant surviving organisms of public health significance when suitable growth conditions are present.

### *Packaging*

Packaging materials for use in the radiation processing of prepackaged foods have been cleared by the Food and Drug Administration as a result of a petition submitted to FDA by Hazleton Laboratories, Inc., Falls Church, Va., on behalf of the AEC. The packaging materials cleared are nitro-cellulose-coated cellophane, glassine paper, wax-coated paperboard, and five plastic films. Industry assisted in the selection of these materials and in several cases initiated independent industry-sponsored research. Research by several contractors, based on the possible needs of the fishery industry, is proceeding on additional materials.

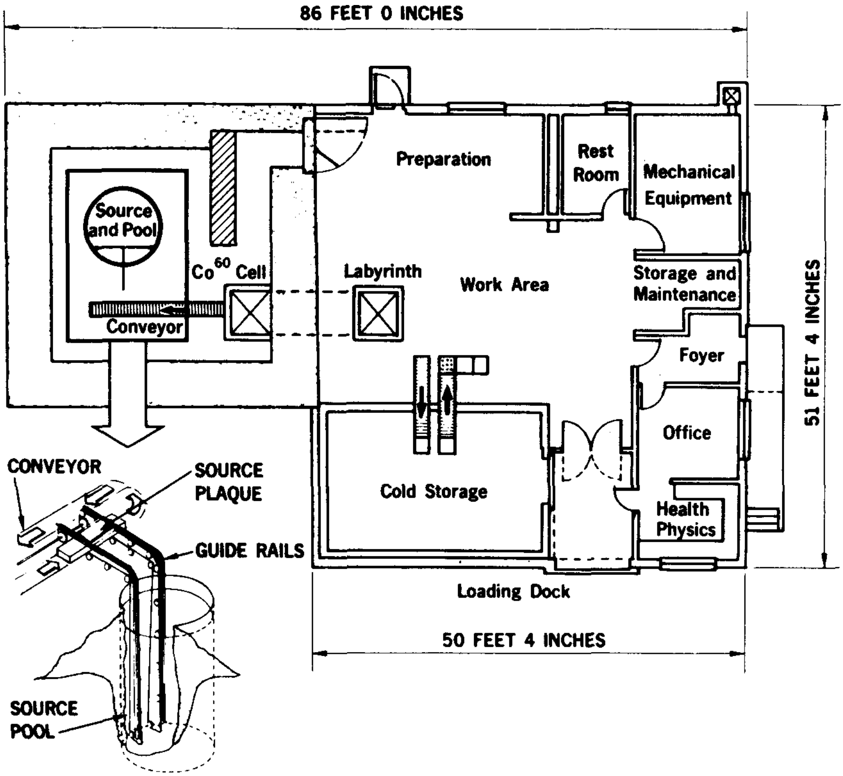
### *Irradiators*

Construction starts on several irradiators, three of which are on a semicommercial scale, highlighted irradiator activity during 1964. The conceptual designs for the three irradiators were developed by Brookhaven National Laboratory. Larger irradiators are being provided at various research sites to translate laboratory results to commercial or semicommercial conditions.

*Marine Products Development Irradiator (MPDI).* The MPDI was completed and dedicated on September 28, and is now processing fishery products for large scale shipping, storage, and distribution tests. The facility was designed by Associated Nucleonics, Inc., Garden City, N.Y. Industry response to an invitation for participation in the cooperative large-scale testing has been favorable. The U.S. Department of Interior's (Bureau of Commercial Fisheries) Technological Laboratory, Gloucester, Mass., operates the MPDI at Gloucester.

*Grain Products Irradiator (GPI).* The AEC and the U.S. Department of Agriculture are cooperating in a project on radiation disinfestation of grain. The AEC is providing the irradiator, and the U.S.D.A. will conduct supporting research and irradiator operation. The Grain Products Irradiator, located in Savannah, Ga., will have a capacity of processing 5,000 pounds per hour of bulk grain, and a wide variety of packaged products. The source is approximately 25,000 curies of cobalt 60. The total construction project, under Vitro Engineering Co., N.Y., as prime architect engineer, has an expected completion date of late summer 1965.

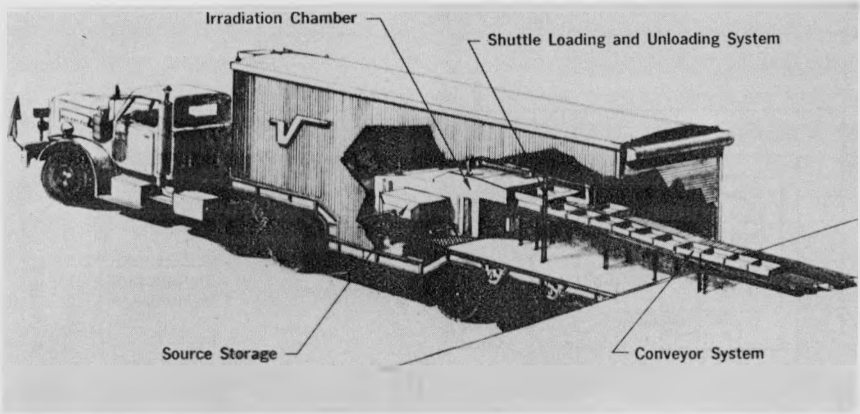
*Mobile Gamma Irradiator (MGI).* Design and construction by Vitro Engineering of a mobile, truck-mounted cobalt 60 irradiator was




*Fish Products Irradiator.* Schematic drawing of the overall Marine Products Development Irradiator (MPDI) which was put into operation during September. The Bureau of Commercial Fisheries operates the MPDI at Gloucester, Mass., for the AEC as a part of the radiation preservation of seafoods program. *Lower left* portion shows how marine products are conveyed past a 250,000-curie cobalt 60 source at a rate up to one ton per hour for irradiation pasteurization to prolong the food's shelf life in the markets. The facility was designed by Associated Nucleonics, Inc., Garden City, N.Y.

initiated during 1964. This irradiator, using 125,000 curies of cobalt 60, is designed primarily as a demonstration unit for fruits. It will be used initially in California for radiation processing of strawberries. Later uses will include processing of a variety of fruits which appear most amenable to radiation treatment. As with the MPDI, throughput will permit large-scale shipping, storage, distribution, and marketing tests. Operational availability is scheduled for late summer, 1965.

*On-ship irradiators.* Two 16-ton portable irradiators are being constructed by Nuclear Materials and Equipment Corp., Apollo, Pa., for use on fishing vessels. They will enable a light dose of radiation




*Mobile Irradiator.* Now under construction, the Mobile Gamma Irradiator (MGI) is scheduled to go into operation in mid-1965. The truck-mounted, 125,000-curie cobalt 60 irradiator will be used first for irradiation pasteurization of strawberries in California. The MGI was designed, and is under construction, by Vitro Engineering Co., N.Y.

(75,000–100,000 rad) to be administered after catch. Further processing, and a probable second radiation treatment will be administered on shore. Each of the 30,000-curie cobalt 60 units will be used, in turn, by the U.S. Department of Interior's Technological Laboratories at Gloucester, Mass., and Seattle, Wash., and by Louisiana State University. They will be available in early 1965. In addition to an on-ship throughput of approximately 100 pounds of fish per hour, the units also have a capability to pasteurize sea water for experimental use in keeping the catch fresh while in the hold of the ship. Preliminary work suggests this latter method may be quite effective.

## PROCESS RADIATION DEVELOPMENT PROGRAM

The primary objective of process radiation research is to develop the necessary technology leading to the use of large-scale sources of ionizing radiation in the production or processing of chemicals and materials.

### *Status*

Recent advances within the process radiation industry have been very encouraging. In contrast to a sales volume of approximately $20 million in 1963, the total annual sales volume of radiation-processed products, such as ethyl bromide, cross-linked polyethylene tubing, wire and film, and sterilized medical supplies, in the United

States is conservatively estimated at $70 million for 1964 and is expected to double within a year.

### *Wood-plastic Process*

One of the significant accomplishments during 1964 was the further development of a new family of wood-plastic materials using radiation as part of the hardening process.[17] The wood-plastic combination is produced by impregnating wood with a liquid monomer, and then irradiating it with cobalt 60 gamma rays. The radiation polymerizes the molecules and yields a solid plastic which:

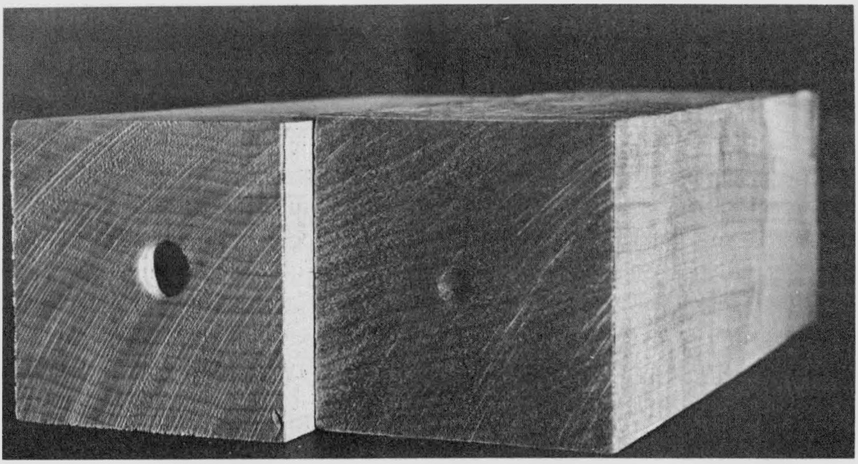
(*1*) Is harder than natural wood by several hundred percent—thus more resistant to blows, scratches, etc.;
(*2*) Has much higher compression strength;
(*3*) Absorbs moisture more slowly and therefore has more resistance to warping and swelling.
(*4*) Has much improved static bending strength (i.e., resistance to breaking upon bending);
(*5*) Retains the natural wood grain and color;
(*6*) Can be sawed, drilled, turned, and sanded, giving a hard beautiful, satin-smooth finish;
(*7*) Can be dyed in a wide variety of both natural and artificial colors; and
(*8*) Can be made flame retardant.

The major portion of this research has been carried out under an AEC contract by West Virginia University at Morgantown. During the past year a market survey was conducted by Arthur D. Little, Inc., Cambridge, Mass., to identify marketing potentials. The results of the study indicate that pilot plant production of these new wood-plastic materials by irradiation will be required to provide potential manufacturers with sufficient commercial samples of interest for end-use testing. Such field testing is required to establish process specifications, to attain desired product performance, and to further develop economic information.

Contract studies were also initiated with Vitro Engineering Co., New York City, during 1964 on a conceptual design of a pilot-plant facility and to compile all information pertaining to the process into a single report. Industry's interest in the process was evidenced by the 28 proposals received in response to solicitation for proposals to conduct these studies.

Negotiations are currently underway with the Research Triangle Institute, Raleigh, N.C., to evaluate the properties of wood-plastic

[17] See p. 199, Annual Report to Congress for 1963.



*Wood-plastic Hardness.* Photo shows the results of a comparative hardness test of a chemically-treated and irradiated piece of sugar maple (*right*) and an untreated sample (*left*) to the impact of a standard steel ball dropped from several feet. Note how the ball made only a slight indentation in the irradiated wood-plastic sample, while a large hole was made in the untreated block. The wood-plastic process was developed for the AEC by West Virginia University, Morgantown, and involves impregnating wood with a liquid monomer and then irradiating it with cobalt 60. The irradiated combination is much harder than an untreated wood.

combinations in relation to potential applications, as part of a performance and materials testing program. Studies will also shortly be initiated to delineate more fully the specific steps necessary to achieve full commercial use of the product, including locations in the U.S. for siting of plants. One such study will be performed by the Southern Interstate Nuclear Board and will cover the major wood-product industry located in the southeastern part of the United States. Another study will be conducted in the Great Lakes and the northwestern areas by the AEC's Pacific-Northwest Laboratory [18] at Hanford, Wash. The radiation-produced wood-plastic was selected by Science Service as one of the top ten scientific, medical, and technical advances of the year.

## ISOTOPE SYSTEMS DEVELOPMENT

Isotopes systems development is directed towards the development of technology and related instrumented systems for applications of isotopes in science and engineering. It encompasses three areas;

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[18] Renamed from Hanford Laboratories when Battelle Memorial Institute of Columbus, Ohio, became the new operating contractor in January 1965.

(*a*) basic technology development, (*b*) systems engineering, and (*c*) safety engineering.

### *Technology Development*

*High-resolution gamma spectroscopy.* Recent advances in lithium-drifted silicon and germanium-based diodes now make high resolution gamma spectrometers practical. In addition, germanium offers a 40 to 1 gain in gamma efficiency over silicon based materials. Research to seek more dense materials is being done at Oak Ridge National Laboratory and the Hughes Research Laboratories, Malibu, Calif., through investigation of the higher atomic number materials, including samples of cadmium telluride.

*Krypton 85 as universal tracer.* Techniques have been developed by Parametrics, Inc., Waltham, Mass., for incorporating the radioactive noble Krypton 85 gas into solids of all types.[19] The resulting solid sources are stable at room temperature and, after an initial fractional loss of activity, they become stable at an elevated temperature. Any physical or chemical disturbance of the surface such as ablation, abrasion, chemical reaction, or sublimation results in a proportionate release of krypton 85. Monitoring of this radioactivity release then measures the extent of disturbance of the surface, as well as temperature effects. One of the most significant applications made to date has been the determination of the surface temperature profile of gas turbine blades during engine operation.

Specific applications developed in the field of chemical analysis include oxygen, fluorine, and hydrogen sensors that can measure extremely low concentrations—as low as 0.1 part-per-million for fluorine. This technique makes it possible to measure other gases including ozone, sulfur dioxide, hydrogen sulfide, methane, hydrogen fluoride, water vapor, and hydrogen chloride. In solutions, analysis of as little as 31 micrograms per milliliter of water in organic solvents and as low as 1.9 micrograms of fluoride per milliliter of water have been demonstrated.

*Neutron activation analysis for law enforcement.* Coordinated basic development projects by Oak Ridge National Laboratory (ORNL), the General Atomic Division of General Dynamics Corp., San Diego, Calif., and the Alcohol and Tobacco Tax Division of the Internal Revenue Service have established the utility of neutron activation analysis [20] in a wide variety of law enforcement problems. During

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[19] See p. 93, Fundamental Nuclear Energy Research—1964.
[20] See p. 202, Annual Report to Congress for 1963.

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1964, information derived with this nuclear technique was admitted as legally acceptable court evidence for the first time in a U.S. district court in New York. Three additional Federal courts and other judiciary districts and one State court have accepted activation analysis as evidence since the first case.

In each case, the trace constituents in an object of physical evidence found on a suspect were shown to match those in a counterpart object taken from the scene of the crime. The high sensitivity and nondestructive nature of activation analysis makes it unique among analytical techniques for law enforcement application. Objects of physical evidence analyzed in four court cases to date included dirt, adhesive tape, paint, auto-body filler compound, and concrete. About 75 additional cases are now in process involving some 500 samples of physical evidence, including human hair.

Federal and State law enforcement groups have submitted materials connected with crimes to ORNL and General Atomic for analysis under this program. Results have aided the solution of many crimes and the technique is rapidly gaining acceptance as a new tool in criminal investigations.

### *Systems Engineering*

*Analytical.* For many applications of X-ray fluorescence, a radioactive source of X-rays can replace the conventional X-ray tube. A portable instrument of low cost, compactness, versatility, and simplicity in operation has merit for lunar and planetary surface analysis as well as for terrestrial applications. Such a system has been developed at Argonne National Laboratory and by Texas Nuclear Corp., Austin, Tex., as well as at other laboratories. Additionally, Tracerlab, Inc., Waltham, Mass., is investigating improvements in narrow band X-ray fluorescence techniques. A device using this technique was demonstrated at the Bureau of Customs, Baltimore, Md., on December 17, 1964. It is expected to find use as a positive and rapid means of determining the tariff category of gold-coated imported articles. To accelerate the development of useful applications of isotope X-ray sources, a catalog of beta-excited spectra is being compiled by the Edsel B. Ford Institute, Detroit, Mich. Several hundred spectra have been compiled and the final publication will be available in 1965.

*Marine and environmental.* A prototype gamma-backscatter sonde has been developed by the Lane Wells Co., Houston, Tex., in cooperation with the U.S. Navy's Oceanographic Office, to measure the density profile of the first few feet of the deep ocean floor—*in-situ* and within 5 minutes. This density information, previously obtained laboriously by core analysis, is needed to help locate ocean floor sites with high load-bearing capability to support heavy instrument packages. Self-contained, the device can make repeated scans for an 8-hour period without surfacing, and yields density data of higher accuracy than previously attained.

A prototype model of a suspended sediment concentration gauge [21] is being developed and will be evaluated by a number of Government agencies for use in areas of soil erosion, water conservation, and silting of harbors and waterways. This unit uses cadmium 109 which emits a soft X-ray. The attenuation in this X-ray beam is proportional to the concentration of sediment in the flowing water. These test efforts are being coordinated through the Federal Interagency Sedimentation Committee.

*Aerospace.* Thompson-Ramo-Wooldridge Space Technology Laboratories, Inc., Redondo Beach, Calif., have successfully demonstrated the feasibility of a radioisotope propellant measurement system for use in space vehicles in zero-gravity environment. The system monitors the dilution of a small quantity of krypton 85 gas in the ullage (empty space over a liquid in a container) gas as the propellant is expended, and with an unprecedented accuracy of one percent. It is lightweight and poses no radiation hazard.

## *Safety Engineering*

A new safety engineering investigation has been initiated to develop safety testing standards for radioisotope devices, such as radiography cameras, thickness gauges, and teletherapy units. Underwriters' Laboratories, Chicago, Ill., have collected representative pieces of equipment for testing and examination. The technical information and test procedures will be made available in 1965. They will be of benefit to American industry and regulatory agencies having responsibility for the safe use and handling of radioactive materials.

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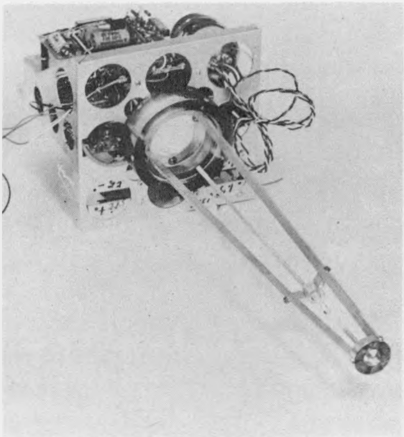
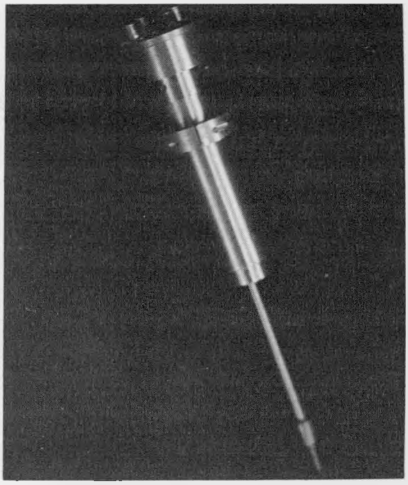
[21] See p. 203, Annual Report to Congress for 1963.





*Aerospace Sensor.* A high-altitude beta forward-scatter gauge developed for the AEC by Parametrics, Inc., Waltham, Mass., is being tested with the cooperation and support of the Office of Naval Research and the Pacific Missile Range. It is designed for use at missile and rocket ranges where knowledge of the air density up to 210,000 feet altitude is required as part of the prelaunch meteorological information. Photos show the original proof-of-principle device (*on left*) and the compact flight system (*on right*). The instrument measures the density of the rarified upper atmosphere by detecting beta particles which are scattered into the detector by the surrounding air. In photo on *left*, the detectors are in the square section; the beta particle source is at lower right; and in between is a shield to keep the particles from passing directly from the source to the sensors.

# INTERNATIONAL ACTIVITIES

The Commission's program for international cooperation is based on arrangements with other nations in the civil and, to a lesser extent, the military uses of atomic energy. International activities, in civil uses, are primarily concerned with the supply of nuclear materials for use in fueling reactors and for applications in the fields of medicine, agriculture, industry, and basic research; the exchange of technical information; the provision of training to selected foreign nationals; and cooperation with other nations and international organizations in specified areas of research and development.

# PRINCIPAL U.S. COOPERATIVE PROGRAMS

## AGREEMENTS FOR COOPERATION

The program for international cooperation in the peaceful uses of atomic energy is carried out largely through Agreements for Cooperation with the International Atomic Energy Agency (IAEA), the European Atomic Energy Community (Euratom), and through bilateral agreements with other nations. Under these agreements, 4 U.S.-built power reactors and 45 U.S.-built research reactors have been exported to other countries.

The principal initial objective of United States' international cooperation in the peaceful uses of nuclear energy was to share with other friendly nations the benefits of U.S. progress in nuclear science and technology. This international cooperation is of increasing importance to U.S. foreign policy objectives and to the AEC's technical programs. For example, the concept of internationally administered safeguards to assure that nuclear material and facilities are utilized solely for peaceful purposes is beginning to achieve widespread acceptance, and safeguards administered by the U.S. under several of its bilateral agreements have already been replaced by IAEA administered safeguards. Technical information of significance is being received from other nations as a result of information exchanges and joint work programs. In addition, the export of reactors and U.S. reactor technology by private industry, and the export of enriched uranium for reactor fuel by the Government, show prospects for becoming important assets in the United States international balance of payments.

## EXCHANGES AND COOPERATIVE WORK PROGRAMS

The United States has a direct interest in certain foreign nuclear energy developments, and arrangements have been made with other nations for the exchange of technical information of mutual benefit. These arrangements provide for personnel exchanges as well, and in some instances for U.S. financial participation in specified projects. Such exchange arrangements serve as a stimulus to both the U.S. program and the peaceful programs of other countries, and provide the participating scientists and engineers of each country with an exposure to the scientific philosophy, methods, and attitudes of the other country. The AEC also provides nuclear training for foreign nationals through its many schools and courses. (See also Nuclear Education and Training section, Part Four.)

TABLE 3.—EFFECTIVE AGREEMENTS FOR COOPERATION IN THE CIVIL USES OF ATOMIC ENERGY

BILATERAL AGREEMENTS

| Country | Scope | Effective date | Termination date |
|---|---|---|---|
| Argentina | Research | 7–29–55 | 7–27–69 |
| Australia | Research and Power | 5–28–57 | 5–27–67 |
| Austria | Research | 1–25–60 | 1–24–70 |
| Belgium | Research and Power | 7–21–55 | 7–31–65 |
| Brazil | Research | 8– 3–55 | 8– 2–65 |
| Canada | Research and Power | 7–21–55 | 7–13–80 |
| China, Republic of | Research | 7–18–55 | 7–17–74 |
| Colombia | Research | 3–29–63 | 3–28–67 |
| Costa Rica | Research | 2– 8–61 | 2– 7–66 |
| Denmark | Research | 7–25–55 | 9– 7–68 |
| France | Research and Power | 11–20–56 | 11–19–66 |
| Germany, Federal Republic of. | Research and Power | 8– 7–57 | 8– 6–67 |
| West Berlin, City of | Research | 8– 1–57 | 7–31–67 |
| Greece | Research | 8– 4–55 | [a] 8– 3–74 |
| India | Research and Power | 10–25–63 | 10–24–93 |
| Indonesia | Research | 9–21–60 | 9–20–65 |
| Iran | Research | 4–27–59 | [a] 4–26–69 |
| Ireland | Research | 7– 9–58 | 7– 8–68 |
| Israel | Research | 7–12–55 | 4–11–65 |
| Italy | Research and Power | 4–15–58 | 4–14–78 |
| Japan | Research and Power | 12– 5–58 | 12– 4–68 |
| Korea, Republic of | Research | 2– 3–56 | 2– 2–66 |
| Netherlands | Research and Power | 8– 8–57 | 8– 7–67 |
| Norway | Research and Power | 6–10–57 | 6– 9–67 |
| Panama | Research | 6–27–63 | 6–26–68 |
| Philippines | Research | 7–27–55 | 7–26–68 |
| Portugal | Research | 7–21–55 | 7–20–74 |
| South Africa | Research and Power | 8–22–57 | 8–21–67 |
| Spain | Research and Power | 2–12–58 | 2–11–68 |
| Sweden | Research | 1–18–56 | 6– 1–68 |
| Switzerland | Research | 7–18–55 | 7–17–65 |
| Switzerland | Power | 1–29–57 | 1–28–67 |
| Thailand | Research | 3–13–56 | [a] 3–12–75 |
| Turkey | Research | 6–10–55 | 6– 9–65 |
| United Kingdom | Research and Power | 7–21–55 | 7–20–65 |
| Venezuela | Research and Power | 2– 9–60 | 2– 8–70 |
| Vietnam | Research | 7– 1–59 | 6–30–74 |

See footnotes on page 197.

SPECIAL AGREEMENTS

| Organization | Scope | Effective date |
|---|---|---|
| European Atomic Energy Community (Euratom). | Joint Nuclear Power Program | 2–18–59 |
| Euratom | Additional agreement to Joint Nuclear Power Program. | 7–25–60 |
| International Atomic Energy Agency (IAEA). | Supply of materials, etc | 8– 7–59 |
| IAEA/Japan | Trilateral for application of IAEA safeguards to U.S. supplied materials | 11– 1–63 |
| IAEA/Austria | do | [c] |
| IAEA/Greece | do | [c] |
| IAEA/Norway | do | [c] |
| IAEA/Philippines | do | [c] |
| IAEA/Viet Nam | do | [c] |
| IAEA/Argentina | do | [c] |
| IAEA/Portugal | do | [c] |
| IAEA/Thailand | do | [c] |
| IAEA/Iran | do | [c] |
| IAEA/China | do | [c] |
| U.S.–U.S.S.R.[b] | Memorandum on cooperation in peaceful uses (information and personnel exchange). | 5–21–63 |
| U.S.–U.S.S.R.[b] | Agreement on cooperation in desalination. | 11–18–64 |

EFFECTIVE AGREEMENTS FOR MUTUAL DEFENSE PURPOSES

| | |
|---|---|
| NATO [d] | Mar. 29, 1956 |
| Australia [d] | Aug. 14, 1957 |
| Belgium [d] | Sept. 5, 1962 |
| Canada [d] | July 27, 1959 |
| France | July 20, 1959 |
| France [d] | Oct. 9, 1961 |
| Germany, Federal Republic of [d] | July 27, 1959 |
| Greece [d] | Aug. 11, 1959 |
| Italy [d] | May 24, 1961 |
| Netherlands [d] | July 27, 1959 |
| Turkey [d] | July 27, 1959 |
| United Kingdom [d] (subsequently amended) | July 20, 1959 |

SUMMARY

In effect: 22 research and 14 research and power agreements, one power agreement, three special agreements—Euratom (2) and IAEA (1), 11 trilateral safeguards agreements, 2 exchange agreements with U.S.S.R. and 11 Mutual Defense Purposes Agreements.

[a] Extending amendment signed, but not yet in force.
[b] Under the current U.S.-U.S.S.R. Exchanges Agreements in scientific, technical and cultural fields signed February 22, 1964.
[c] Effective date to be established.
[d] Provides for various exchanges of classified information.

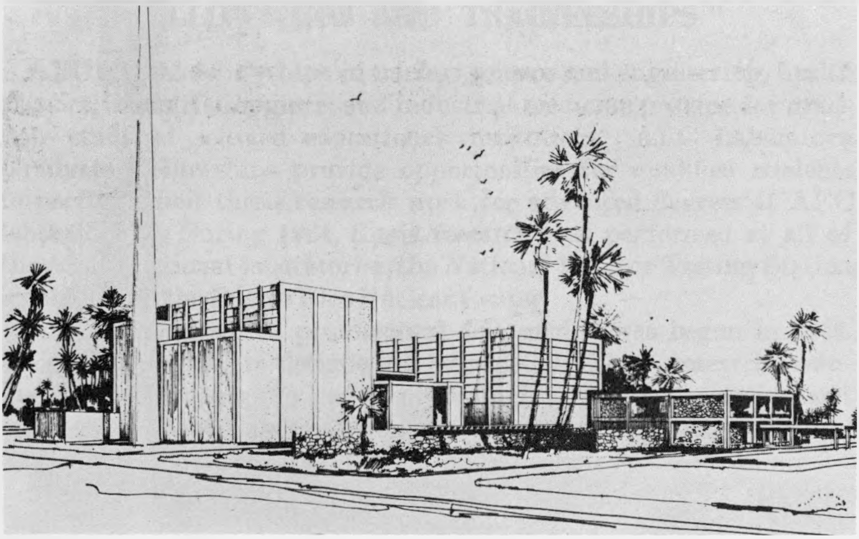
***Major 1964 Activities***

*United Kingdom.* An active interchange of information on a broad scale continued in 1964 with the United Kingdom. Negotiations were completed to amend the Agreement for Cooperation to provide for the sale to the United Kingdom of 400 kilograms of contained uranium 235 for use in the U.K. civil research and development program. Discussions were held on extending the exchanges on fast reactors and advanced gas-cooled reactor systems. With respect to the former, no decision has been reached; in regard to the latter, it has been proposed that the agreement be extended in its present form until July 20, 1965, when the U.S.–U.K. civil uses agreement expires and at which time further extension of the agreement will be considered. Additional negotiations included discussions regarding the possible establishment of bilateral collaboration on water reactors.

*Canada.* The United States and Canada have long maintained an active collaboration and exchange of information in the nuclear fields. Principal cooperation continued to be in the development of heavy water power reactors. Under this cooperative program, the AEC, subject to authorization of funds, is spending $1 million a year in the U.S. over a 10-year period in support of the Canadian program. Canada, in turn, has provided extensive information to the AEC on the heavy water reactor concept.

*France.* Bilateral cooperation with France in the peaceful applications of atomic energy, initiated in 1956, covers a broad exchange of unclassified documents and reciprocal visits in a variety of specialized areas of mutual interest.

*India.* Under a 1963 Agreement for Cooperation with India, the United States will assist India in the construction of a 380,000 electrical kilowatt (ekw) nuclear power station at Tarapur, 62 miles north of Bombay. The station's two 190,000 ekw boiling-water reactors will be built by the General Electric Co. Under the 30-year agreement, the United States will sell to India enriched uranium reactor fuel and will exchange information on plant design, construction and operation, and on problems of nuclear health and safety. The initial inventory of fuel will be provided on a deferred payment basis. Construction on the Tarapur complex began during 1964 and the station is scheduled to be operational by 1968. The value of the fuel required over the life of the agreement is estimated to be $100 million. The agreement provides that, at a suitable time, the International Atomic Energy Agency (IAEA) will be requested by the two countries to assume the responsibility for administering the safeguards set forth in the Agreement for Cooperation.



*Tarapur Project.* The United States is assisting India in the construction of a 380,000 electrical kilowatt (ekw) nuclear power station at Tarapur, about 62 miles north of Bombay. Drawing shows how the plant is expected to look when completed in 1968. Under a 30-year agreement, the United States is lending India $80 million for expenditures in the United States for the design and construction of the plant, including the fabrication of the initial fuel charge. The agreement also calls for sale of enriched uranium—estimated at $100 million over the 30 years—and exchange of information on the design, construction and operation of the plant, and on problems of nuclear health and safety. Construction of the plant, which will use two 190,000-ekw General Electric boiling water reactors, started during 1964 and the plant is scheduled for 1968 operation. Artist's drawing shows the general site arrangement—reactor building on *left*, turbine building in *center*, and administration building at *right.*

*Australia.* The United States and Australia have actively continued the information exchange program established under the 1961 agreement on high-temperature, gas-cooled reactor technology exchange program. Under this agreement information is exchanged on alloys of uranium and beryllium and alloys of thorium and beryllium, dispersion of uranium and thorium oxides and carbides in graphite, neutron physics, reactor materials, coolant circuits, core dynamics, and waste disposal development and management. Two Australian scientists are presently assigned to AEC facilities for 2-year periods under the agreement and an additional Australian assignment has been proposed. A U.S. scientist has completed a 1-year assignment at the Australian's Lucas Heights facility and another scientist's 2-year assignment ended in December 1964.

*Euratom.* During the year, the AEC and Euratom [22] agreed to joint efforts in the development of fast neutron reactors, under an Additional Agreement for Cooperation. The cooperative program provides for a detailed exchange of information on all fast neutron reactor programs for civilian central power station applications, and for supporting research and development programs in which the AEC or Euratom will participate during the 10-year period of the exchange. The AEC and Euratom each will provide comparable levels of support for this effort for the period 1963–1967.

*Japan.* The AEC has undertaken with Japan, as a result of a 1962 exchange of letters, an unclassified information exchange program in the technology of uranium ceramic fuels including basic chemical and metallurgical properties, methods of specimen preparation, fabrication techniques, behavior under irradiation, and compatibility with other materials. The first United States-Japan meeting to exchange information in the field was held in Tokyo in May 1963. The second such meeting was held at Hanford, Wash., in October 1964. By the close of 1964, each side had exchanged substantial numbers of reports, as well as samples for comparative analysis. Individual scientists in the United States and Japan have corresponded directly on ceramic fuel subjects of mutual interest.

*Soviet Union.* Under the U.S.–U.S.S.R. Memorandum for Cooperation in the field of utilization of atomic energy for peaceful purposes, exchanges of delegations of scientists in the fields of solid state physics, controlled thermonuclear reactions, and desalination were successfully completed. Exchanges on radioactive waste disposal and power reactor development were made in late 1964. In addition, the AEC and the U.S.S.R. State Committee on the Utilization of Atomic Energy conduct a modest reciprocal exchange of unclassified documents on a monthly basis. Scientists of both countries continue to visit nuclear energy facilities in conjunction with attendance at conferences or through visits arranged by other organizations participating in the U.S.–U.S.S.R. Exchange Program.

*Poland.* Polish scientists have been given greater opportunities to study and work in U.S. universities through participation in unclassified research supported by the AEC. A publications and professional level film exchange has continued through 1964. Poland hosted the third meeting of the IAEA's Nuclear Data Scientific Working Group in November 1964.

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[22] The European Atomic Energy Community (Euratom) was formally established in 1958 to advance the development and growth of nuclear industries in Belgium, the Federal Republic of West Germany, France, Italy, The Netherlands, and Luxemburg.

## MATERIALS SUPPLIED ABROAD

### *Policy on Lease and Sale of Nuclear Materials*

The AEC's general policy for supply of enriched uranium and heavy water abroad has been to permit lease for research reactors, but to sell these materials for power purposes. During 1964, a dollar limitation of $125,000 was announced on the amount of material normally available, on a lease basis, for a single new facility. In addition, nonpower producing facilities were defined as all nuclear reactors and subcritical assemblies which do not produce usable power. Foreign operators of nonpower producing facilities requesting materials substantially in excess of the $125,000 limitation will be encouraged to purchase the entire quantity, with the understanding that the enriched uranium purchased may be returned for credit against future orders of enriched uranium.

### *Value of Materials Distributed*

Through 1964, the AEC has distributed abroad special nuclear and other materials in an approximate total value of $117.5 million: through sale $66.9 million; lease $31.7 million; and deferred payment sales $18.9 million.

Arrangements are in progress under which the AEC will sell to Euratom, at regular published charges, plutonium and enriched uranium for the Community's near-term fast reactor program. This arrangement includes the Euratom purchase of about 410 kilograms of plutonium from the AEC for use in fuel irradication tests and in the SNEAK and MAZURCA critical experiment facilities in Karlsruhe, Germany, and Cadarache, France, respectively. Enriched uranium of approximately equal value required for the fast reactor program through 1967, will be provided on short term lease with a purchase option.

### *Effect of Private Ownership Law*

On August 26, 1964, President Johnson signed into law an amendment to the Atomic Energy Act of 1954 providing for the private ownership of special nuclear materials. A significant provision of the amendment authorizes the AEC to enter into arrangements with domestic licensees to supply uranium enrichment services; contracts for this purpose can also be executed with other nations and multinational groups. Under a system of uranium enrichment services, or "toll enrichment," the AEC would accept depleted, normal, or enriched uranium in return for an appropriate quantity of uranium containing a higher concentration of the uranium 235 isotope. The foreign purchaser would pay the AEC in accordance with established charges for enrichment. Under the new law, these services are authorized to commence on January 1, 1969, though contracts may be drawn as soon as acceptable criteria have been developed, for enrichment services starting after the effective date.

### *Ad Hoc Barter Arrangements*

In the interim preceding implementation of toll enrichment, the AEC may consider on a case-by-case *ad hoc* arrangement with other nations for the barter of enriched uranium required before 1969, accepting natural uranium as partial payment. The AEC and the Spanish Government have agreed in principle to the first such arrangement, whereby the AEC will accept an amount of Spanish-produced natural uranium equivalent to feed material required to produce the initial enriched uranium core for Spain's first nuclear power plant, the 150,000–155,000 electrical kilowatt (ekw) Union Electrica Madrilena (UEM) plant being built by Westinghouse near Madrid. This material will be accepted on a barter basis in partial payment for the enriched uranium sold to Spain for the first core of the reactor.

### *Deferred Payment Sales Contracts*

By the start of 1964, two deferred payment fuel sales contracts, covering a fuel supply for 20 years and a deferral of payments for the first 10 years, had been executed between the AEC and Euratom for power reactors in Italy: SENN (a 150,000 ekw-boiling water reactor) and SELNI (a 242,000 ekw boiling water reactor).

During 1964, a deferred payment sales contract arrangement was concluded with Euratom covering a fuel supply period of 20 years to provide fuel for SENA (a 266,000 ekw pressurized water reactor) in France. Another is presently being negotiated with India covering a period of 25 years for the supply of enriched uranium for the Tarapur reactors (two 190,000 ekw-boiling water reactors) at Tarapur, India. In both contracts payments will be deferred for the first 10 years. A deferred payment sale contract is also under negotiation to provide fuel for the KRB project (a 237,000 ekw boiling water reactor) in West

Germany. The fuel requirements for these five reactors are valued in excess of $300,000,000 at the Commission's current uranium prices.

### *Chemical Processing of Foreign Reactor Fuels*

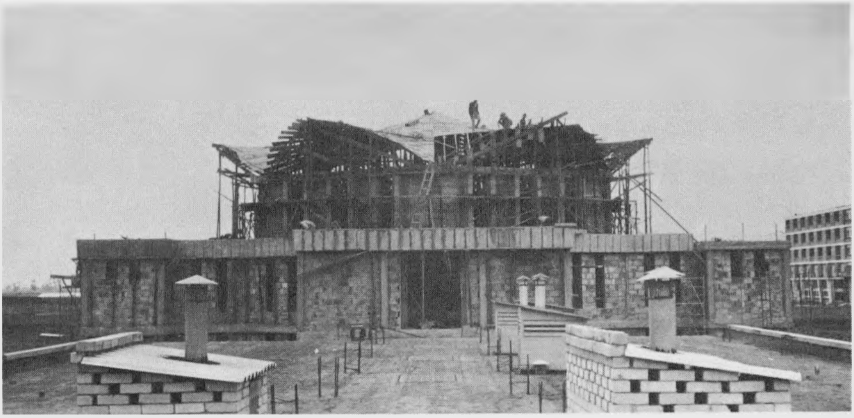
Significant events in 1964 in the chemical processing of foreign reactor "spent" fuel elements included: (*a*) Five shipments of Canadian irradiated fuel elements to the AEC's Idaho chemical processing plant; (*b*) an AEC offer to accept delivery of highly enriched "spent" fuel from domestic and foreign research reactors for chemical processing at the Savannah River plant (previously such shipments were restricted to the Idaho plant only); (*c*) the seventh and last shipment of Swedish highly enriched irradiated fuel to Idaho, completing the first batch of fuel under the AEC processing contract with Sweden, and the first three shipments of the second batch of Swedish fuel elements to Savannah River; and (*d*) initial negotiations with France, Germany, Japan, and Euratom for the return of their irradiated fuel for processing at the Savannah River plant until such processing can be performed by private industry. (See also Production section, Part Two.)

### *Exports and Imports of Special Nuclear Material*

There were approximately 280 exports and 20 imports of special nuclear material. Of special interest were some 12 shipments of irradiated fuel elements from research reactors in Sweden and Canada, without incident. Movement of irradiated fuels from abroad is proceeding on a routine commercial basis. The ports of New York, Tampa, Portland (Oreg.) and Redwood City (Calif.) now permit the shipment of irradiated fuels through their ports, raising the total of U.S. ports allowing such shipments to 21.

## RESEARCH REACTOR UTILIZATION

A total of 26 research reactor grants was made, from 1956 to 1962, under the AEC's research reactor grant program. The grants are limited to $350,000 or 50 percent of the project cost, whichever is less, with payment of the grant to be made on completion and criticality of the reactor. Six research reactor grant projects are still under construction. The remaining 21 have been completed and grant commitments paid. A special grant was made to the Philippines in 1959, for which Congress had authorized $500,000 in 1955.



*Colombian Research Reactor.* Construction of the research reactor at the Institute of Nuclear Affairs in Bogotá was well underway when this photo was made in mid-1964. The Lockheed-built 10-kilowatt (thermal) research reactor is expected to be in operation early in 1965. A U.S. grant of $350,000 toward the cost of the reactor has been approved for presentation upon completion of the facility.

### *"Sister" Laboratory Program*

Several of the countries receiving AEC research reactor grants are in the initial phase of nuclear energy development. As a means of assisting these countries in the effective utilization of their facilities, a "sister" laboratory program has been initiated. Under this concept, a major U.S. research institute accepts responsibility for advising the foreign country, through periodic visits and correspondence, in the planning, organization, and execution of a research reactor program. Assistance is provided in acquiring minor items of equipment necessary to the program being developed which are not available in the developing country.

In 1964, a cooperative arrangement under which Brookhaven National Laboratory had been assisting the Turkish Cekmece Nuclear Research and Training Center was extended for an additional year, and arrangements were completed for Argonne National Laboratory to assist the Korean Atomic Energy Research Institute in Seoul.

## AREAS OF MAJOR INTERNATIONAL INTEREST

## NUCLEAR POWER REACTORS

### *Increasing Competition*

The United States met with increased foreign competition in the furnishing of power reactors, fuel fabrication, and chemical processing during 1964. Decreasing capital costs, standardization in reactor components, and increasingly reliable cost estimates have stimulated international interest in commercial nuclear power to a marked degree. Significantly large projects are planned or under construction in the industrialized nations and several developing countries are conducting nuclear power surveys. The supply of enriched uranium fuel, the technical cooperation with nuclear power projects abroad, and the promotion of foreign sales by U.S. nuclear industry continue to be major goals in the international program.

### *Fast Breeder Reactors*

Emphasis on fast breeder reactor development has increased significantly, particularly in countries having well developed nuclear power programs. Fast reactor programs are now in progress in the Euratom Community, United Kingdom, the Soviet Union, and are under study with Japan and Sweden. Negotiations on a more detailed exchange between the U.S. and the U.K. in this area are underway. A fast reactor exchange with Euratom was signed on May 27.

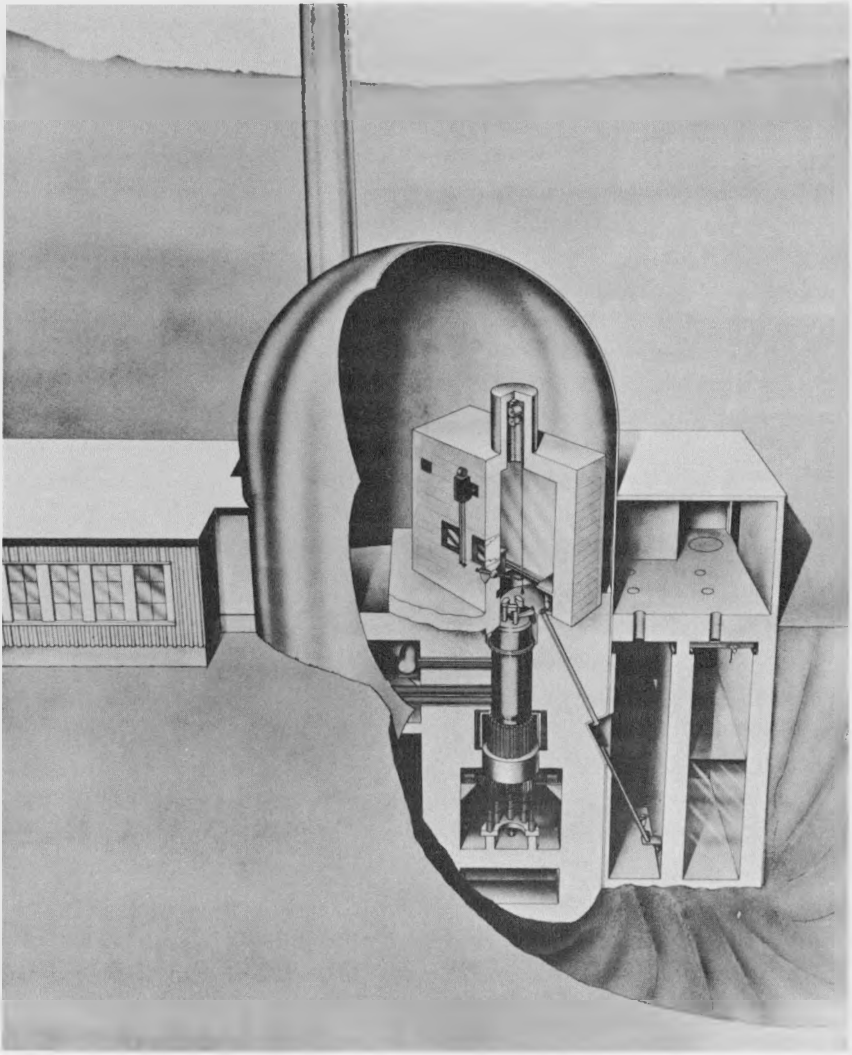
### *Safeguards*

On February 26, 1964, the International Atomic Energy Agency (IAEA) Board of Governors, by unanimous vote, placed into effect the system of safeguards for reactors with a power rating greater than 100 thermal megawatts. This extension to the system of safeguards previously approved for reactors rated at less than 100 thermal megawatts, provided the IAEA with safeguards procedures applicable to any nuclear reactor.

Trilateral agreements for the IAEA administration of safeguards to replace those previously administered by the United States under bilateral Agreements for Cooperation were signed in 1964 with Argentina, Austria, Republic of China, Greece, Iran, Norway, the Philippines, Portugal, Viet-Nam, Thailand, and an agreement, the first of its kind, had been signed with Japan in 1963. Brazil and Israel have agreed to accept IAEA administered safeguards no later than the termination date of the recent short term extension of their respective Agreements for Cooperation. The provisions of the foregoing safeguard agreements are similar to those of the trilateral agreement between the United States and Japan and the IAEA which entered into force on November 1, 1963.

On June 15, 1964, the United States and the IAEA signed an agreement for continued application of Agency safeguards to three U.S. reactor facilities: the Graphite Research Reactor and the Medical Research Reactor at Brookhaven National Laboratory; and the Piqua

Organic Moderated Reactor facility at Piqua, Ohio, which had been under IAEA safeguards and inspection since 1962. This agreement also extended the application of IAEA safeguards to a fourth U.S. reactor facility, the Yankee Nuclear Power Station at Rowe, Mass.



*SEFOR Project.* Cutaway drawing of the Southwest Experimental Fast Oxide Reactor (SEFOR), a 20,000 thermal kilowatt sodium-cooled reactor, which will be built near Fayetteville, Ark. The reactor construction by General Electric and research programs are to be jointly financed by the AEC, the Southwest Atomic Energy Associates, the European Atomic Energy Community, and the private West German firm of Gesellschaft fur Kernforschung. Construction will start during 1965 and completion of the experimental plant is scheduled for 1967. The plant, which will not produce electricity, will be used for international research and development on fast breeder reactors.

The first inspection of the Yankee reactor by the IAEA under the new agreement was held during the week of November 16, 1964. Application of Agency safeguards to the Yankee Power Station was invited by the United States in March 1964, at the 18-nation disarmament conference in Geneva, in order to assist the IAEA in developing inspection techniques for large reactor facilities and to encourage other countries to invite the application of international safeguards to their own large power reactors. The Yankee Nuclear Power Station was placed under Agency safeguards with the cooperation and assistance of the Yankee Atomic Electric Co., owner and operator of the station.

## DESALINATION

In 1964, the United States gave a strong support to the International Atomic Energy Agency (IAEA) as a focal point for international cooperation in the study of dual-purpose nuclear power/water desalting plants. The AEC and the Department of the Interior participated in IAEA panel meetings in April and September to exchange information with other countries on nuclear desalting. At the September meeting, the U.S. offered the services of a desalination expert to the IAEA, and training for qualified individuals nominated by the IAEA at U.S. facilities engaged in desalting activities.

### *Desalting Studies*

*Israel.* The United States and Israel began cooperative studies on a possible nuclear power/desalting project in Israel pursuant to an agreement reached during Israeli Prime Minister Eshkol's visit to Washington in June. A team of U.S. and Israeli reactor, water desalting, and power and water distribution experts was established to conduct preliminary surveys and make recommendations as to further courses of action. Following the initial joint survey conducted in the summer of 1964, a recommendation was made to undertake a detailed engineering study to determine the technical and economic feasibility of the most appropriate means of meeting the water and power needs of Israel. The IAEA participated in all meetings as an observer.

*Mexico.* An initial cooperative study with Mexico, under IAEA auspices, was under consideration to determine the feasibility of a large combination nuclear power/desalting plant near the Gulf of California which would help to meet water and power needs in the States of Sonora and Lower California in Mexico, and Arizona and California in the United States.

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*Soviet Union.* During June, President Johnson announced a U.S.-USSR cooperative program for the exchange of technical information in the nuclear desalting field. An initial meeting in Washington in July, to discuss general problems and consider possible areas of cooperation, was followed by a Soviet tour of U.S. desalting and reactor facilities. A formal agreement on cooperation in the field of desalination, including the use of nuclear energy, was signed in Moscow on November 18, during a reciprocal visit of U.S. desalting experts to the Soviet Union.

## NUCLEAR LIABILITY

The AEC continued its efforts, in cooperation with other agencies, to develop international solutions to nuclear liability problems, although no international conventions on nuclear liability have yet been brought into effect. The Paris Convention of 1960 for land-based reactors (which has been signed by 16 members of the Organization for Economic Cooperation and Development) was reconciled with the Vienna Convention of 1963 (developed by the International Atomic Energy Agency and signed by seven member states). The IAEA Committee on the Vienna Convention met in April to consider the territorial scope of the convention and the exclusion of small quantities of nuclear material from coverage; the small-quantity limitation was adopted by the IAEA Board of Governors. Considerable progress was made and reported. The second meeting of the Standing Committee on the Brussels convention of 1962 on nuclear ship liability (which has been signed by 14 states) was held at Monaco in June. The committee drafted articles on international jurisdiction and qualification of international organization as licensing authorities under the Convention. The Inter-American Nuclear Energy Commission (IANEC) considered a draft regional convention and forwarded it to members of the Organization of American States for review. AEC staff members, appointed as delegates, participated in the preparatory work of the Vienna, Brussels, and IANEC committees.

# INTERNATIONAL AND REGIONAL ORGANIZATIONS

### *International Atomic Energy Agency (IAEA)*

Chairman Seaborg stated in his address to the Eighth General Conference of the International Atomic Energy Agency (IAEA), held in Vienna, September 14–19, that "in a significant sense, the Agency has come of age." The Chairman referred to the Agency's increasingly responsible role in the establishment of an effective international safeguards system, the application of nuclear energy for desalination purposes, the growth of economically attractive nuclear power, the promotion of uniform health and safety standards for the handling of radioactive materials, the continuation of a technical assistance program, and the convening of many panels, conferences, and symposia of world wide scientific interest. The Agency sponsored an International Center for Theoretical Physics at Trieste, Italy, which began operation in October. The latest in the IAEA series of regional study group meetings on research reactor utilization were convened in Bucharest, Rumania, and in Trombay, India.

The United States continued its support for the Agency in 1964 through the provision of cost-free experts, fellowships, and equipment grants for the Agency's technical assistance program. The United States also offered, for the sixth successive year, to donate $50,000 worth of special nuclear materials for use in Agency research and medical therapy projects.


*IAEA Conference.* **During the Eighth General Conference of the International Atomic Energy Agency (IAEA) in Vienna, Austria, September 14–19, AEC Chairman Glenn T. Seaborg renewed the United States' donation of special nuclear materials for use in IAEA research and medical projects. Photo shows Dr. Seaborg during his September 15 address to the conference when the U.S. offer of $50,000 worth of special nuclear materials was made for the sixth consecutive year.**

### *Inter-American Nuclear Energy Commission (IANEC)*

The fifth meeting of the IANEC convened in Chile in March 1964 in conjunction with the Fifth Inter-American Symposium on the Peaceful Applications of Nuclear Energy. The Commission reviewed alternate versions of a Convention on Civil Liability for Nuclear Damage; a new draft will be prepared based on comments to be received from member states for submission to the Organization of American States. An IANEC conference on nuclear power was scheduled for February 1965 at the Puerto Rico Nuclear Center.

A major activity of IANEC has been the planning for cooperative training, education, and research in the nuclear sciences. A survey of the facilities of Latin American universities has been carried out over a 3-year period as a basis for these plans and a related manpower study of requirements for national atomic energy programs will be undertaken.

### *European Atomic Energy Community (Euratom)*

The United States and Euratom reached agreement on the areas of work and level of effort for the second 5-year period (1964–68) of the Joint Research and Development Program. The program of work is expected to continue the success of the first 5 years toward the ultimate objectives of (*a*) the improvement of the performance of the boiling and pressurized water type reactors participating in the Joint Reactor Program, and (*b*) lowering fuel cycle costs. Each party agreed, subject to appropriations, to provide about $15 million for the joint program in the second 5-year period. As in the past, U.S. funds for this program will be expended through contracts with U.S. industry.

### *North Atlantic Treaty Organization (NATO)*

Negotiations were concluded in 1964 with the North Atlantic Treaty Organization for a new Agreement for Cooperation for Mutual Defense Purposes. The agreement was approved by the North Atlantic Council. It was submitted by President Johnson to Congress on June 30, 1964.

The new agreement which will replace the one concluded with NATO in 1955, will permit increased flexibility in the communication of restricted data for consultation with the North Atlantic partners on the common problems of the nuclear defense of Europe. The agreement specifically prohibits the transfer of any atomic weapons or atomic weapons parts, or the communication of any information for the purpose of assisting NATO or any of its members in the design, development, or fabrication of nuclear weapons. In his transmittal message to the Congress, President Johnson described the new agreement as "representing a logical and useful step in our continued and varied efforts to ensure wider allied participation in NATO nuclear defense."

# INTERNATIONAL CONFERENCES AND EXHIBITS

The Commission's support of international conferences and exhibits continued during 1964 under its program to stimulate the free exchange and dissemination of information on the peaceful applications of atomic energy throughout the scientific and industrial communities of the world. As a part of this program, the AEC participates in, and provides financial support for, selected international scientific conferences on atomic energy, and plans, produces, and operates U.S. international nuclear energy exhibits.

## INTERNATIONAL SCIENTIFIC CONFERENCES

During 1964, 15 conferences on atomic energy and related fields held under the auspices of U.S. organizations received financial assistance. As part of this same program, the AEC also participated in seven conferences organized by the International Atomic Energy Agency (IAEA), and one held under United Nations—IAEA auspices. All conferences supported by this program are reviewed against the established criteria for consistence with the needs and policy of the Commission.[23]

Tables 4 and 5 list the international conferences financially supported and/or participated in by the AEC during 1964.

## GENEVA CONFERENCE

The Third United Nations' International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, Switzerland, August 31–September 9, was attended by more than 3,000 scientists, engineers, government officials, and others throughout the world with a high degree of interest in the peaceful atom. The United States had an official delegation of 196—135 accredited delegates and 61 staff members—and 219 persons who attended as observers and paid their own expenses. Seventy-seven member states of the United Nations and ten

[23] See p. 244, Annual Report to Congress for 1963.

TABLE 4.—INTERNATIONAL SCIENTIFIC CONFERENCES FINANCIALLY SUPPORTED

| Title | Sponsoring organization | Place | Date |
|---|---|---|---|
| Third International Conference on Marine Biology. | American Institute of Biological Sciences. | Princeton, N.J. | Jan. 19-22. |
| Estuaries | Sapelo Island Research Foundation. | Jekyll Island, Ga. | Apr. 1-4. |
| Isotope Drugs in Experimental Pharmacology. | Chicago University | Chicago, Ill. | June 7-9. |
| Human Genetics—29th CSH Symposium on Quantitative Biology. | Cold Spring Harbor Laboratory for Quantitative Biology. | Cold Spring Harbor, N.Y. | June 5-12. |
| International Biophysics Meeting. | International Organization for Pure and Applied Physics. | Paris, France | June 22-27. |
| Effects of Radiation on Hereditary Fitness of Mammalian Population. | Roscoe B. Jackson Memorial Institute. | Bar Harbor, Maine | June 29-July 1. |
| Photobiology | NAS-NRC | Oxford, England | July 26-30. |
| Biochemistry | Federation of American Societies for Experimental Biology. | New York, N.Y. | July 26-Aug. 1. |
| Tenth International Botanical Congress. | Botanical Society of America | Edinburgh, Scotland | Aug. 3-12. |
| Third United Nations International Conference on the Peaceful Uses of Atomic Energy. | UN-IAEA | Geneva, Switzerland | Aug. 31-Sept. 9. |
| Radiation Preservation of Foods. | National Academy of Sciences | Boston, Mass. | Sept. 27-30. |
| Lubrication | American Society of Lubrication Engineers. | Washington, D.C. | Oct. 13-16. |
| Correlation of Particles Emitted in Nuclear Reactions. | American Physical Society | Gatlinburg, Tenn. | Oct. 15-17. |
| Low Energy X-ray and Gamma Radiation Sources. | IIT Research Institute | Chicago, Ill. | Oct. 20-21. |
| Genes and Chromosomes—Structure and Function. | Organization of American States and National Research Council of Argentina. | Buenos Aires, Argentina. | Nov. 30-Dec. 4. |
| Symposium on Relativistic Astrophysics. | University of Texas | Austin, Tex. | Dec. 15-18. |

TABLE 5.—AEC PARTICIPATION IN IAEA-SPONSORED CONFERENCES

| Title | Place | Date | Number of U.S. participants | Number of participants at AEC expense |
|---|---|---|---|---|
| Use of Induced Mutations in Plant Breeding. | Rome, Italy | May 25-June 1 | 9 | 6 |
| Medical Radioisotope Scanning | Athens, Greece | Apr. 20-24 | 30 | 14 |
| Assessment of Radioactive Body Burdens in Man. | Heidelberg, Germany | May 11-16 | 20 | 11 |
| Radiochemical Methods of Analysis | Salzburg, Austria | Oct. 19-23 | 26 | 15 |
| Use of Radioisotopes in Animal Nutrition and Physiology. | Prague, Czechoslovakia | Nov. 23-27 | 7 | 14 |
| Chemical Effects Involved During Nuclear Reactions and Radioactive Transformations. | Vienna, Austria | Dec. 7-11 | 13 | 18 |
| Inelastic Scattering of Neutrons | Bombay, India | Dec. 15-19 | 12 | 5 |

specialized and related agencies, including the International Atomic Energy Agency (IAEA), took part in the conference.[24]

### *Nuclear Power Progress*

Delegates heard a comprehensive report of progress made in the development and uses of nuclear power since the last conference held in 1958. The major conclusion regarding progress in the past 6 years was that economic nuclear power had come of age in many areas of the world.

Papers presented at this conference emphasized the fact that the world will require huge increases in electric energy during the rest of the 20th century, and that even now many nations are looking toward nuclear power to fill their needs. The conference revealed that the present focus of competitive nuclear power is on large-size reactors; *i.e.*, sizes upward from 500,000 electrical kilowatts. For example, the Federal Republic of Germany, the United Kingdom, and the Union of Soviet Socialist Republics as well as the United States have reaffirmed their intentions to proceed with large water-cooled and moderated reactors, each having an electricity generating capacity of several hundred thousand kilowatts.

There was agreement among almost all countries represented at the conference on the need to develop breeder reactors. For more intermediate energy needs, some other countries announced they were developing advanced converter reactors.

Progress is being made in the development of many specialized types of reactors. In the field of direct thermoelectrical conversion and special applications, interest focused on a compact direct-conversion, uranium dicarbide-fueled fast reactor disclosed at the conference by the U.S.S.R., and on the 500-watt electrical SNAP–10A reactor, under development in the United States since 1957.

Several official sources commented on the effectiveness of the U.S. papers program which consisted of 98 of the 748 presented to the United Nations. In addition to the interest shown in the U.S. papers dealing with nuclear reactors and specialized uses of nuclear power, papers on isotopic development and on the Plowshare program also received considerable attention.

Dual-purpose reactor plants for nuclear desalting of sea water and power production were the subject of reports presented by the United

[24] The AEC has published a summary of the conference, "Atoms for Peace Conference 1964," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $0.00.

*News Conference.* Preliminary to the opening of the Third United Nations International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland, members of the United States delegation held a press conference on August 29 with representatives of the world's communications media. Delegates shown in photo (*front row, left to right*) are: AEC Commissioner James T. Ramey; Dr. Frederick Seitz, President of the National Academy of Sciences and member of the President's Scientific Advisory Committee; Dr. I. I. Rabi, member of the U.S.–U.N. Scientific Advisory Committee and former Chairman of the Board of Trustees, Associated Universities, Inc. (contractor-operator of the AEC's Brookhaven National Laboratory); AEC Chairman Glenn T. Seaborg; Dr. Henry D. Smyth, U.S. Representative to the International Atomic Energy Agency; Ambassador Roger W. Tubby, U.S. Representative to the United Nations' Mission located in Geneva; and AEC Commissioner Gerald F. Tape.

States, the U.S.S.R., and France. It was predicted that one or more nuclear power-desalination installations would be built and in operation within the next 4 to 8 years.

**Delegates Optimistic**

Chairman Seaborg in his summation speech, reiterated the overwhelming consensus of the delegates that by the turn of the century more than half of the world's electricity would be generated by nuclear energy. He stated "* * * We have achieved economic nuclear power in limited but important areas. I believe this conference marks the beginning of the age of nuclear power. We can now foresee the end of the spectre of an energy shortage which has haunted the world since the beginning of the Industrial Revolution. As nuclear power technology progresses, I believe we can provide in the future enough energy for all other peoples of the world * * *"

## INTERNATIONAL SCIENTIFIC EXHIBITS

### *Geneva Exhibit*

More than 22,000 scientists, delegates, technicians, and other visitors attended the 18,000-square-foot U.S. exhibit at the Third Geneva Conference, which supplemented the U.S. papers presentation. In addition to graphically supplementing the papers presentation, the exhibit was developed on a person-to-person basis—manned and staffed by U.S. scientific and technical personnel capable of explaining each subject in detail—to inform delegates from all parts of the world of the new and promising ideas in the atomic energy field. Of particular interest to foreign scientists were the exhibits on fast breeder reactors, the SNAP–7F unmanned weather station device, and the SNAP–8 and –10A, space vehicle power supply generators. The exhibit was opened auspiciously with a visit from U.N. Secretary General U Thant. He viewed President Johnson's filmed message to the conference which sounded the keynote for the conference and exhibit in these words: "* * * today we begin to know its (nuclear power's) hope as a power house of peace * * *."

Included in the exhibit area was a Technical Information Center where some 20,000 persons visited to consult the reference library, to examine the display of recent technical books, and to study the microfiche (microfilm) collection of nuclear safety information.

Some 2,000 microfiche duplicates of documents requested by delegates were prepared and distributed.

A four-volume set of books on nuclear energy, dedicated to the late President Kennedy and containing a foreword by President Johnson, had been prepared by the AEC for the conference. These books deal with education and the atom, nuclear power, research, and radioisotopes and radiation.

### *Madrid Showing*

During 1964, the AEC's large traveling European exhibit was shown in Madrid, Spain, from April 15 to May 13, 1964. The exhibit drew a capacity crowd of 78,500 visitors, demonstrating to the public and scientific audiences many of the more important and current advances in the peaceful uses of atomic energy.

Many visitors to this exhibit received specially conducted tours of the training and research reactor and gamma irradiation facility. Over 8,000 high school students attended 3-hour class instructions on atomic energy given by Spanish teachers who had been trained

*U.S. Exhibit Area.* Photo shows part of the 18,000-square-foot United States exhibit area at the Palais Des Nations in downtown Geneva, Switzerland, during the Third United Nations International Conference on the Peaceful Uses of Atomic Energy, August 31–September 9. Some 22,000 people visited the exhibit area after it was "opened" by U.N. Secretary General U Thant.

by the Oak Ridge Institute of Nuclear Studies. More than 2,000 visitors received consultations at the exhibit's technical instruction center and viewed films at the film library and over 900 university students and scientists attended coloquias on the fundamentals and uses of atomic energy. A total of 2,645 Spanish scientists and students attended 36 lectures given outside the exhibits by U.S. scientists on various peaceful applications of atomic energy.

A research and training reactor was in operation during the exhibit, and physics and nuclear engineering students from the University of Madrid used it to perform experiments in reactor kinetics. Advanced experiments for Spanish scientists in studying reactor characteristics by pulsed neutron and pile oscillator technique were also conducted. A comprehensive program for qualitatively analyzing Spanish monazite sand using activation analysis techniques was conducted with the reactor and equipment loaned from private industry.

A total of 6,143 specimens were irradiated, including 193 irradiations made on seeds, larvae, fly eggs, mice, plastics, and nematodes, as a part of the gamma irradiation program. Students were taught principles and problems of chemical dosimetry at the cobalt 60 gamma irradiation facility and took back irradiated samples to their laboratories for analysis.

A whole-body counter was demonstrated as part of the biomedical section of the exhibit.

## BIOLOGY AND MEDICINE

Research in the biological, medical, and environmental sciences as supported by the Commission ranges in scope from the interaction of radiation with molecules of biological interest, to the interaction of radiation with ecological, meteorological, and oceanographic systems. Within this broad objective are the following primary objectives:

(*1*) To increase basic knowledge of the effects of radiation on all living systems.

(*2*) To use this knowledge in evaluating the consequences for man, and in solving the practical health and safety problems, of all atomic energy programs and devices.

(*3*) To promote use of special nuclear materials and radioactive materials in medicine, biology, and agriculture, and for diagnosis and treatment of cancer.

These objectives include a number of individual subprograms which are mutually interdependent for an overall effect on scientific progress. The more noteworthy results of recent basic research in some of these areas are described in a special Commission report supplementing this Annual Report to Congress.[25] This portion of the Annual Report to Congress describes selected major activities during the past year related to nuclear civil effects[26] and research facilities under construction.

## NUCLEAR ENERGY CIVIL EFFECTS

### *ORNL Civil Defense Research Project*

In mid-1964, a Civil Defense Research Project sponsored jointly by the Atomic Energy Commission and the Office of Civil Defense, Department of Defense, was established at the Oak Ridge National Laboratory. A small scientific staff was organized to conduct broad

[25] "Fundamental Nuclear Energy Research—1964." Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, price $0.00.

[26] During 1964 a new edition of "The Effects of Nuclear Weapons" (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, price $3.00) was printed. It incorporates new information developed since the 1962 edition was printed.

analysis of the cost and feasibility of alternative methods of civil defense and of their probable effectiveness in a wide variety of situations. In conducting its studies, the staff draws heavily upon the resources and technical staff of ORNL and other AEC laboratories.

### *Dosimetry for Nuclear Bomb Survivors of Hiroshima and Nagasaki*

Under a long-term project, the AEC's Oak Ridge National Laboratory undertook the task of developing a method of evaluating the radiation doses received by the survivors of the nuclear bombings of Hiroshima and Nagasaki, Japan. Data for this project which was started in 1956 and designated "Ichiban" have been obtained in nuclear weapons tests, Operation BREN,[27] laboratory experiments, physical surveys in Japan, and in calculational studies. The approach to the problem has been as fundamental as possible with emphasis on quantitative measurements and calculations of the energy, angular, and spatial distributions of weapons radiations in an air-over-ground geometry. Spatial distributions of dose in various shields, including Japanese dwellings, have been measured. Techniques have been developed in conjunction with the Atomic Bomb Casualty Commission[28] for verifying the location of survivors and accurately describing their shielding environments. Simple empirical equations have been developed which permit the calculation of the shielding factors for Japanese residential-type structures with a probable error of approximately ±6 percent.

*Operation HENRE.* In furtherance of these dosimetry studies, a High Energy Neutron Reactions Experiment (HENRE) is being readied for field operations at the Nevada Test Site during 1965. The experiment will be concerned with the propagation of 14-Mev (million electron volts) neutrons in the atmosphere. It is funded jointly by the Defense Atomic Support Agency and the AEC.

A linear accelerator and titanium tritide target will be mounted in the hoisting mechanism of a 1,527-foot steel tower in much the same manner as were the unshielded Health Physics Research Reactor and a large cobalt 60 source for Operation BREN in 1962. The accelerator-target system being built for HENRE is designed to produce trillions of neutrons per second for periods up to 4 hours.

During the field phase of the experiment, measurements will be made to determine energy, angular and spatial distributions of radiations.

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[27] See pp. 318–324, Annual Report to Congress for 1962.

[28] The Atomic Bomb Casualty Commission was established in August 1947 as a permanent medical organization to study the effects of the Hiroshima—Nagasaki bombings; it is a National Academy of Sciences—National Research Council activity and is funded by the AEC.

The results of the measurements made possible by the essentially monoenergetic neutron source will contribute significantly to radiation transport calculations and provide data on the energetic gamma rays produced by the inelastic scattering and capture of neutrons in air.

## NEW BIOMEDICAL RESEARCH FACILITIES

### *Biological Research Laboratories*

Construction was completed at the Oak Ridge National Laboratory to provide two new laboratory areas—for mammalian tissue culture and plant physiology research and pathology and physiology studies. The mammalian tissue culture and plant physiology addition provides approximately 9,180 square feet of floor space. The other laboratories and offices will use 5,000 square feet of floor space. The entire area will be provided with atmospheric control in order to establish a suitable standard condition. The air-conditioning system for the new laboratories will be designed to provide fresh air continuously with-

*New Lab Area.* Photo shows part of one of the new laboratories completed during 1964 at Oak Ridge National Laboratory for studies on low-level effects of radiation. The investigator shown is measuring platelet count in blood from irradiated rats. The equipment shown is apparatus for determining platelet numbers, size, and uptake of radioactive tracers. Photo is of a portion of the new pathology and physiology laboratory.

out recirculation, since recirculated air might contribute to the contamination of bacterial cultures or spread disease among the experimental animals. The cost of the new laboratories was $895,000.

The facilities allow expansion of work concerned with the investigation of radiosensitivity of mammalian and especially human cells using chromosome analysis to estimate radiation hazards. Plant physiology studies will encompass combined studies using biochemical, cytological, and anatomical approaches to basic problems of growth and differentiation that can be studied more easily in higher plants than with animals or microorganisms. The pathology and physiology laboratories are adjacent to the main animal colony. This will permit more efficient operation methods to be applied and at the same time provide for optimum use of facilities and personnel in the studies of somatic effects of small doses of radiation.

### *Fission Product Inhalation Laboratories*

Construction on Phase I of Fission Product Inhalation Project,[29] operated for the AEC by the Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex. was completed at a cost of $1,950,000. The overall facilities—permanent, and temporary, now available and under construction at the Sandia Base field site plus other permanent quarters in use at the Foundation headquarters—total 77,930 square feet. Phase II construction to be completed in early 1965, will add 22,500 feet bringing the total to 100,430 square feet. This will permit eventual retirement of some of the temporary quarters.

### *Animal Bioradiological Laboratory*

Completion of new construction, costing $980,000, has added 20,000 gross square feet to the Animal Bioradiological Laboratory located on the University of California's Berkeley campus. Built at a total cost of $1.5 million, the overall facility now provides 33,200 square feet for handling colonies of small mammals (rats and mice) as well as larger mammals (dogs and monkeys) to be used in the biomedical research program.

The types of studies calling for additional space for these animal colonies as well as expanded laboratory space for Donner Laboratory personnel, include: Experimental and surgical work on hypophysectomized and adrenalectomized mice and rats; experiments to determine the effects of small amounts of irradiation on longevity and other

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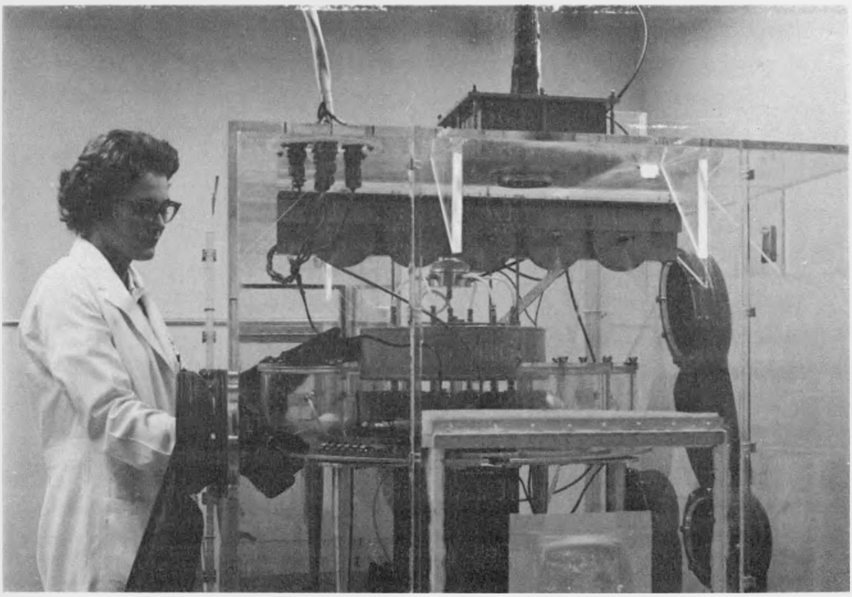
[29] See pp. 326–327, Annual Report to Congress for 1962.

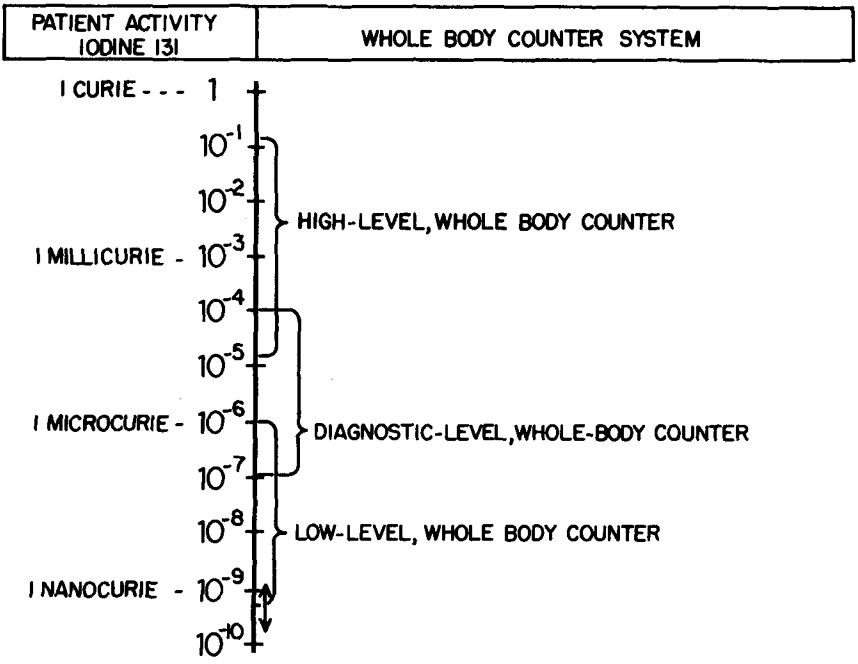
long-term detrimental effects of radiation observable in a colony of mice; and space biology experiments using heavy ion bombardment to study effects on life span of animals under simulated space conditions.

*New Inhalation Study Facility.* First-phase construction of buildings at the AEC's new Fission Product Inhalation Facility at the Sandia Laboratory was completed in late 1964. The new facility, operated for the AEC by the Lovelace Foundation for Medical Education and Research, will provide 100,430 square feet of animal kennels, veterinary and laboratory space, and administrative offices for study of the biological effects of fission product inhalation. Visible in photo *above*, on both sides of the facility are the dog kennels, which have inside quarters and outside runs. In photo *below*, a radiobiologist at the Fission Product Inhalation Facility is shown making preparations for the exposure of rats.



### *Whole-body Counter Facility*

The completion of a low-level whole-body counter for human subjects at the Medical Division, Oak Ridge Institute of Nuclear Studies (ORINS) now makes it possible to count all levels of radioactivity in the body from the highest therapeutic doses down to natural body background at this location. The low-level counting facility, which cost $205,000, was built underground and includes a shielded room, called the "Cave," constructed of extremely low-activity materials and approximately 8′ x 8′ x 8′ in size. There are provisions for moving the patients into the cave; a "clean" laboratory, office, and clean-up and change facilities; air-conditioning systems to provide positive pressure throughout; separate electrical power service for instruments; and a radiation counting system. Earth ramps from the ground to the roof of the ORINS hospital wing were also included to permit emergency evacuation of patients. The chart shows the diagnostic capabilities that now exist at ORINS with the completion of this new counter facility.




*Sensitivity Ranges.* Completion during the year of a $205,000 low-level whole body counter "cave" at the Oak Ridge Institute of Nuclear Studies (ORINS) makes it possible to determine a wide range of levels of radioactivity in the human body, from the highest diagnostic doses down to natural background. Chart shows the sensitivity ranges based on iodine 131, of the whole body counters at ORINS.

# PHYSICAL RESEARCH

The basic physical research program of the Commission is directed toward furthering man's understanding of natural laws and phenomena in the physical sciences. Investigations are undertaken in the fields of high energy physics, nuclear, atomic, and classical physics, mathematics and computers, chemistry, metallurgy, and materials, and controlled thermonuclear research. Some of the more significant achievements from this basic research program are included in the "Fundamental Nuclear Energy Research Report—1964" [30] which supplements this Annual Report to Congress. This section of the report highlights some of the unique research facilities necessary to conduct this program.

## POSSIBLE FUTURE FACILITIES

During 1964, progress was made in design studies which may lead to construction of two new particle accelerators. The studies were authorized in April 1963 as a result of recommendations made to the Commission by its General Advisory Committee and by the President's Scientific Advisory Committee.

### *200-Bev Proton Synchrotron*

Under the 1963 authorization, Lawrence Radiation Laboratory's Berkeley staff initiated a preliminary design study for a 100–300 billion electron volt (Bev) accelerator. The purpose is to establish the design parameters and criteria to arrive at a realistic cost estimate before the Commission decides whether or not to request authorization by Congress to construct the facility. The preliminary design studies do not include, at this time, the selection of a site although several representative sites are being reviewed since actual site characteristics as they relate to accelerators, parameters, and costs must be taken into account.

The Berkeley design study group has arrived at some of the design characteristics for this projected accelerator. For instance, the design energy has been chosen as 200 Bev. The injector into the main ring would be a fast cycling proton synchrotron having an energy of about 8 Bev, and a repetition rate of about 30 pulses per second. The preinjector would be a 200-million electron volt (Mev) linear accelerator. The full energy repetition rate of the main ring of the 200 Bev accelerator would be 20–30 pulses per minute. The current schedule calls for completion of a draft study report specifying the parameters

[30] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $0.00.

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of the facility by the end of 1964, and for completion of a cost estimate by about July 1965.

### *Advanced Proton Accelerator*

Brookhaven and Argonne National Laboratories have initiated studies for an advanced design proton accelerator having an energy of 600–1,000 Bev. At present, these studies are concerned primarily with exploring advanced accelerator concepts.

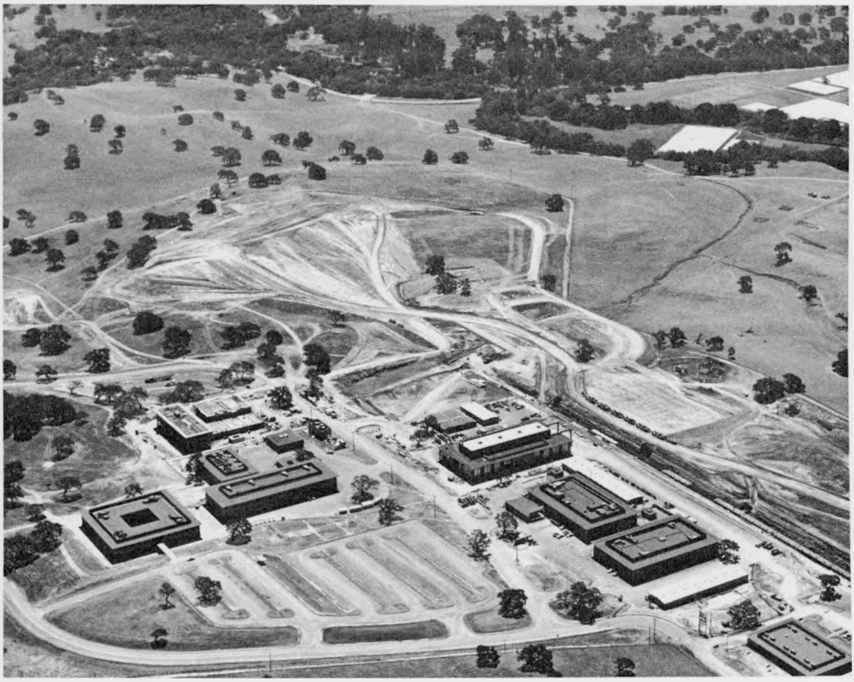
### *Conversion of AGS*

The Brookhaven design study group has also considered and proposed a conversion project to increase the intensity of the 33-Bev Alternating Gradient Synchrotron (AGS) to about 20 trillion ($2 \times 10^{13}$) protons per second. This 20-fold increase over the present maximum attainable AGS intensity could be accomplished by replacing the present 50 Mev injector with a 500-Mev linear accelerator, by utilizing multiple turn injection and by doubling the cycling rate of the AGS. An intermediate step would be to build 200 Mev of the linear accelerator injector as a first phase and increase the maximum attainable intensity to about 8 trillion protons per second. The remaining 300 Mev of linear accelerator could be added at a later date to increase the intensity to the larger value. The converted AGS would support more experiments, running in parallel, by sharing the intensity of each pulse and would provide neutrino, muon, and strange particle beams of considerably higher intensity than previously available. These higher intensity secondary beams would permit more precise studies of weak interactions, particularly neutrino processes and other important areas of high energy physics that cannot be accomplished within present AGS intensity.

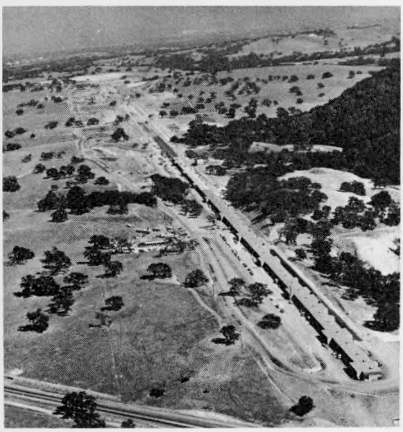
## FACILITIES UNDER CONSTRUCTION

### *Stanford Linear Accelerator*

Satisfactory progress is being made in the construction of the 2-mile-long Stanford Linear Accelerator (SLAC) located near Palo Alto, Calif. At year's end, engineering was 81 percent complete and overall construction was 32 percent complete. During 1964, the Electronics-Stores, the Fabrication and Heavy Assembly Buildings were



*Stanford Accelerator.* At year's end, the $114 million Stanford Linear Accelerator (SLAC) was about one-third completed. Photo, at *lower left*, was taken at the west end of the Klystron gallery and accelerator housing which when completed, will stretch for two miles across the Stanford University Campus near Palo Alto, Calif., at the "target area" (*upper left* corner of photo). The accelerator tunnel will be covered by 25 feet of earth before the facility is completed in 1966. Photo *above* shows some of the completed and near-complete buildings east, or "target area", and of the accelerator. Portions of the accelerator tunnel (*lower right*) have also been completed at this end of the SLAC project.



completed making a total of six [31] buildings finished. The overall facility is scheduled for completion in 1966 at a current estimated cost of $114 million.

In contrast to the conventional construction, which is being designed by the architect-engineer firm of Aetron-Blume-Atkinson almost all of the design and development work required for the accelerator itself is being done by the SLAC staff. Over 850 feet of the copper accelerator tube have been fabricated in SLAC facilities. The tube is being manufactured at a rate of 10 to 20 feet per day with maximum production of 30 feet per day scheduled for early 1965.

On August 4, radiofrequency (rf) power was transmitted, for the first time, from a klystron tube in the gallery through the evacuated waveguides to a 40-foot accelerator segment in the accelerator housing. A power level of 18 megawatts was transmitted from the klystron and received by the accelerator section with relatively little gassing difficulties.

### *High Flux Isotope Reactor*

The primary purpose of the High Flux Isotope Reactor (HFIR) under construction at the Oak Ridge National Laboratory is to produce research quantities of transplutonium isotopes.[32] The reactor design employs a central, light-water region for irradiation of the target material. The maximum unperturbed thermal neutron flux in this target region is expected to be about 5 quadrillion ($5 \times 10^{15}$) neutrons per second per square centimeter when the reactor is operating at the design power level of 100 megawatts. This target region is the center of a concentric cylindrical arrangement of target, fuel, control, and reflector regions, respectively. Each control plate tube (control rod) is approximately 5 feet long and 18 inches in diameter. The fuel elements are composed of aluminum-clad, 93-percent-enriched uranium plates with 0.050-inch-thick coolant channels between the plates. A thin annular control region separates the fuel from the beryllium reflector. As of December 31, construction was approximately 96 percent complete. The reactor is now scheduled to achieve full power operation in early 1966—about 2 years later than anticipated. The operational date was set back because of delays in delivery of critical components and because development work relative to HFIR has not been able to be accomplished at the rate originally planned.

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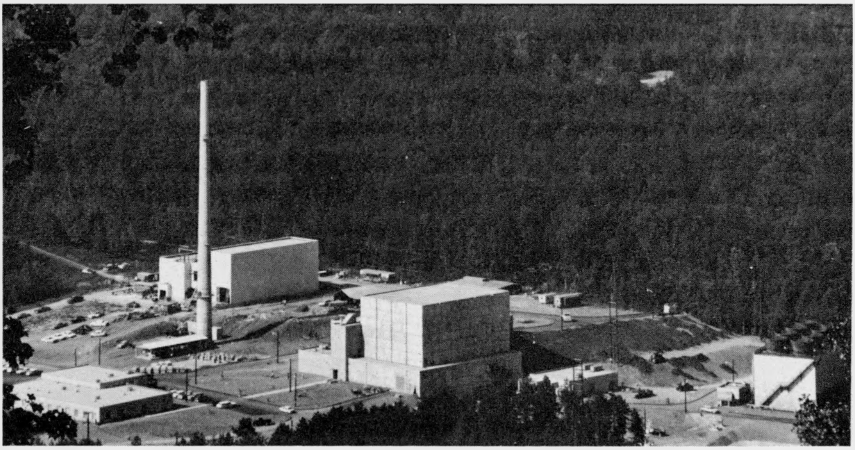
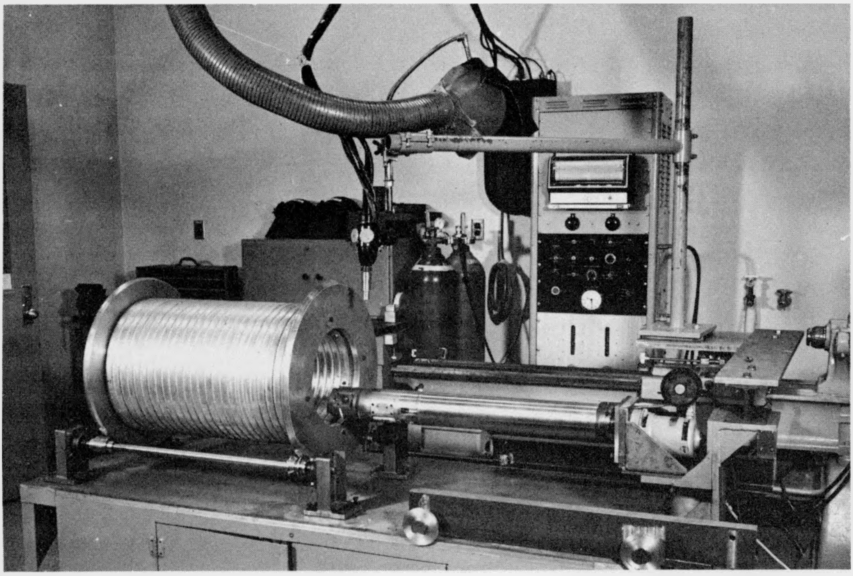
[31] The Construction Office Building, the Test Laboratory and the Administration and Office Building were completed in 1963. The Heavy Assembly Building, Control Building, Shop, Dining Room, Central Laboratory, Cafeteria, Auditorium, End Station "B", End Station "A" and the Data Assembly Building are either under construction or in various stages of design.

[32] See pp. 144–146, Fundamental Nuclear Energy Research—1962.



*Transplutonium Reactor.* The 100-megawatt High-Flux Isotope Reactor (HFIR), now under construction at the Oak Ridge National Laboratory, will be used primarily for the production of transplutonium isotopes. Photo *above,* taken in September, shows construction approximately 90 percent complete. The concrete structure shown in the center is the HFIR reactor building. At the right of the reactor building is the electrical distribution building and the cooling power. At the left is the Office and Maintenance Building and the fan shed and exhaust stack. The concrete block building behind the stack is the Transuranium Processing Plant, also now under construction. The HFIR fuel core, approximately 17 inches in diameter and 24 inches high, is made up of a 171-inner-plate element and a 369-outer-plate element. The photo *below* shows an outer element being welded by the automatic welding technique.



### *Transuranium Processing Plant*

Satisfactory progress is being made in the construction of the Transuranium Processing Plant (TRU) at Oak Ridge National Laboratory. This facility will be used for the chemical processing and recovery of large amounts of the very heavy (transplutonium) man-made elements needed for research. TRU is adjacent to HFIR in which californium, berkelium, and even heavier actinide elements will be produced by bombardment of several hundred grams of the lighter actinide elements with intense neutron fluxes. Construction of TRU is scheduled to be completed in December 1965, at a cost of $8,700,000.

## NEW RESEARCH FACILITY

### *The High Flux Beam Reactor*

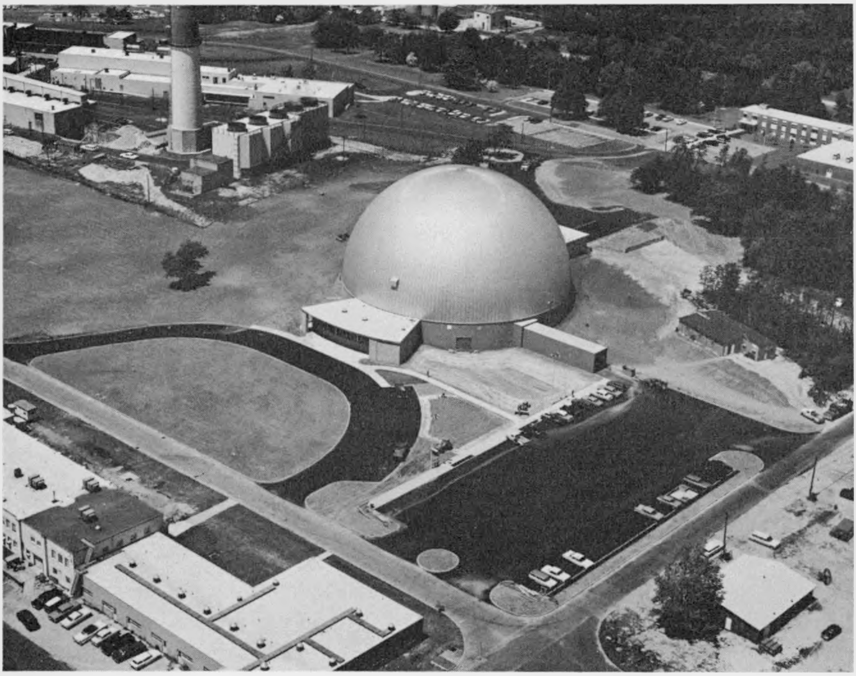
Construction of the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory was completed in September 1964. The new research facility provides an extremely high flux of neutrons which will greatly enhance basic studies on the structure of matter.

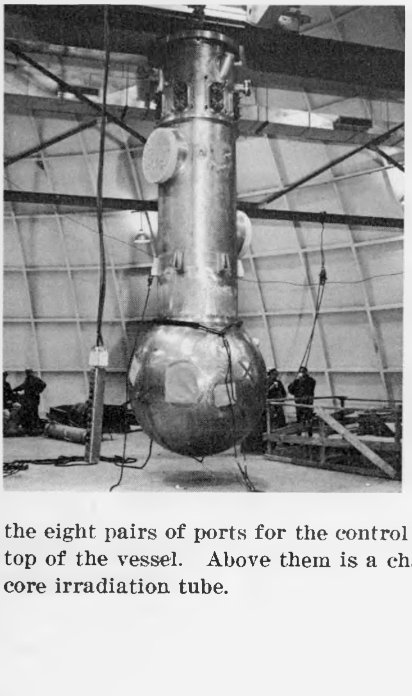
Built at a cost of $12.5 million, this newest research reactor is housed in a three-story, circular, domed, gas-tight building. The bottom floor houses the operating machinery and the spent fuel storage canal; the second or ground floor is for beam experiments and laboratories; and the top floor accommodates the control room, irradiation experiments, and fuel handling operations.

Sixteen experimental facilities have been provided; nine provide beams of neutrons for experiments outside the reactor, and seven are for irradiation experiments within the reactor—four for fast neutron exposures and three for thermal neutrons. For the nine external beams, neutrons are brought out through the shield in beam tubes. The reactor core, reflector, and beam tubes are arranged to enhance the low energy neutron flux in the beams, while decreasing the fast neutron background.

Outside the core vessel is a water-cooled thermal shield. This secondary vessel provides emergency containment to keep the core covered with heavy water ($D_2O$) in the event of a leak in the primary vessel. The reactor is controlled by 16 neutron-absorbing rods located outside the core. They are divided into two sets, with eight main rods operating above the core and eight auxiliary rods below the core. The principal neutron-absorbing material in the rods is europium oxide.

At operating power of 40 megawatts the HFBR core will have a total epithermal neutron flux of more than a quadrillion ($1.6 \times 10^{15}$) neutrons per second per square centimeter and the reflector will have





*High Flux Beam Reactor.* The new $12.5 million High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory was completed during 1964. Photo *above* is an aerial view of the containment structure of the new facility. With extremely high ($1.6 \times 10^{15}$) neutron flux, the HFBR will greatly enhance basic studies on the structure of matter. Photo at *left* shows the HFBR aluminum reactor vessel just prior to insertion into the reactor pit. Several of the holes for beam tubes can be seen in the bottom 7-foot diameter, spherical portion of the vessel which will enclose the core. The large intake (*upper*) and exit (*lower*) ports for the cooling heavy water are also shown. Six of the eight pairs of ports for the control rod drive mechanisms are visible near the top of the vessel. Above them is a channel angling down from above for an in-core irradiation tube.

a maximum thermal neutron flux of many trillions ($7 \times 10^{14}$) of neutrons per second per square centimeter.

Neutrons, as fundamental constituents of matter are an important study in themselves and are one of the most powerful tools available to scientific research in such fields as nuclear physics, solid-state physics, metallurgy and nuclear chemistry. As experimental techniques involving neutrons have improved, higher neutron fluxes especially in the epithermal range are required. The HFBR was designed to meet such requirements.

Among the experiments planned for the initial operating period are studies of the structure of liquids and solids, crystal diffraction studies, polarized neutron bombardments of magnetic materials, and the measurement of fast neutron cross sections with a new rotating chopper which separates neutrons of a specific energy from those with all other energies.

## EDUCATION AND TRAINING

The Commission operates a formal Education and Training Program, administered by the Division of Nuclear Education and Training and designed to provide assistance to individuals and educational institutions to improve the quality and quantity of scientific and engineering manpower available for the nuclear fields. Specific program efforts during 1964, as described below, included assistance to colleges and universities in establishing nuclear curricula; awarding financial grants for the purchase of nuclear laboratory equipment and materials; conducting specialized courses and faculty training institutes; and offering graduate and postdoctoral fellowships in nuclear fields of study, including the implementation of a new traineeship program.

In addition to these formal education programs, colleges and universities are encouraged to participate in numerous cooperative research projects with AEC national laboratories, many of which are actually operated by universities or associations of universities. (See Appendix 3 for a list of these facilities and operating contractors.) Extensive research projects on which many facutly and graduate students are provided research experience through temporary employment are conducted at such sites as Argonne National Laboratory, Brookhaven National Laboratory, Oak Ridge National Laboratory, Los Alamos Scientific Laboratory, Ames Laboratory, and Lawrence Radiation Laboratory. These cooperative projects embrace the utilization by faculty and graduate students of the complex and sophisticated research facilities of the national laboratories. The Commission also supports a large number of research projects on university campuses which in turn provide employment for research assistants who often submit their work as dissertations required for advanced degrees.

## FELLOWSHIPS AND TRAINEESHIPS [33]

AEC special fellowships in nuclear science and engineering, health physics, industrial hygiene, and industrial medicine provide for graduate study at selected educational institutions. AEC Laboratory Graduate Fellowships provide opportunities for qualified students to perform their thesis research work for advanced degrees at AEC laboratories. During 1964, thesis research was performed at all of the AEC's national laboratories, the National Reactor Testing Station in Idaho, and the Puerto Rico Nuclear Center.

A small program in postdoctoral fellowships was begun in 1964. These fellowships are designed to provide additional research training at AEC laboratories and sites for highly qualified scientists and engineers in the nuclear fields. Preference is given those applicants who plan to enter the teaching profession.

The number of participants for all fellowships is shown in Table 6.

TABLE 6.—FELLOWSHIPS

| Fellowships | Number of fellows—1964 |
|---|---|
| Nuclear Science and Engineering | 176 |
| Health Physics | 53 |
| Advanced Health Physics | 9 |
| Industrial Hygiene | 6 |
| Industrial Medicine | 12 |
| AEC Laboratory Graduate | 47 |
| Postdoctoral | 5 |
| Total | 308 |

A pilot program, Traineeships in Nuclear Engineering, was started in the latter half of 1964. Institutions are awarded a specific number of traineeships and choose trainees for graduate programs in the nuclear aspects of the engineering disciplines. Twenty institutions were invited to submit proposals. Selections were made in December 1964 from among 15 institutions submitting proposals. Approximately 50 trainees, who will enter the universities in September 1965, will be supported.

[33] Under the fellowship program, the AEC's funds are paid directly to the individuals who choose the university or laboratory at which they wish to study; under the traineeship program, the fund is paid to the university or college which, in turn, chooses the students for whom it will be used.

## FACULTY TRAINING PROGRAMS

### *ASEE Activities in Nuclear Engineering Education*

During 1964, summer institutes were conducted at three universities, in collaboration with the American Society for Engineering Education (ASEE), under AEC sponsorship, for faculty personnel to study in basic and advanced areas of nuclear science and engineering; 61 engineering faculty attended these institutes at the University of California at Los Angeles, North Carolina State of the University of North Carolina at Raleigh, and Kansas State University.

Two short seminars, administered by ASEE, were held at Purdue University and Pennsylvania State University for faculty to discuss, in depth, recent advances in nuclear engineering technology and their impact on engineering education.

The ASEE also sent nine consultants in nuclear engineering education to nine academic institutions to provide counseling, give lectures in various areas of nuclear engineering, and aid in development of facilities, curricula, and career guidance.

### *AEC–NSF Institutes in Radiation and the Nuclear Sciences*

The AEC and the National Science Foundation (NSF) jointly supported 48 inservice, summer and academic-year institutes for college and high school science teachers in the life and physical sciences. A total of 22 6-to-8 week courses were held for high school science teachers in various aspects of nuclear science. Four-hundred-eighty-six teachers attended these institutes. Sixteen 6-to-8 week institutes were held in reactor and radioisotope technology, nuclear physics, and radiochemistry for college teachers; 324 college faculty attended these courses.

Inservice sessions of one or two classes per week were conducted at seven colleges and universities. These were attended by 144 secondary school science teachers. Full academic-year courses in radiation biology were held for 30 college teachers at 3 universities.

In total, 2,768 high school and 1,336 college teachers have attended 200 institute sessions over the past 9 years.

### *Special Institutes*

A special 1-month program entitled "Science and Contemporary Social Problems" was presented by the Oak Ridge Institute of Nuclear Studies (ORINS) at Oak Ridge, Tenn., in cooperation with the National Science Foundation, for 30 university faculty members active in the social and natural sciences. Discussions covered questions raised by modern science and technological developments, with particular emphasis on nuclear science and its impact on society. Four other programs, of 4-to-10 weeks, were conducted for 39 college faculty to study research techniques in radioisotope and radiation technology.

## EDUCATIONAL CONFERENCES

Table 7 is representative of the numerous domestic educational conferences, symposia, seminars and meetings, sponsored or supported by the AEC during 1964.

TABLE 7.—DOMESTIC EDUCATIONAL CONFERENCES

| Conference title | Conducted by | Location | Date | Number of participants |
|---|---|---|---|---|
| AMU-ANL Nuclear Engineering Education Conference. | AMU-ANL | Argonne, Ill | Jan. 27–28 | 103 |
| Symposium on Direct Conversion. | University of Arizona | Tucson, Ariz | Feb. 19–21 | 70 |
| Second Annual Radioisotope Conference. | ORINS and ORNL | Gatlinburg, Tenn | Apr. 19–22 | 198 |
| Radiation Effects on Materials and Radiation Biology. | Associated Rocky Mountain Universities. | Albuquerque, N. Mex. | Apr. 22–24 | 195 |
| Single and Multicomponent Flow Processes. | Rutgers University | New Brunswick, N.J. | May 1 | 125 |
| Nuclear Engineering Design Seminar. | Purdue University | Lafayette, Ind | June 1– Aug. 1 | 20 |
| Fast Reactor Physics | University of Michigan. | Ann Arbor, Mich | June 3–11 | 55 |
| Topics in Biophysics | Columbia University | New York, N.Y | June 29 | 72 |
| Nuclear Marine Propulsion. | Virginia Polytechnic Institute. | Blacksburg, Va | Aug. 10–13 | 72 |
| Nuclear Education in New Era of Nuclear Power. | ORINS | Gatlinburg, Tenn | Aug. 24–25 | 102 |
| AMU-ANL Faculty-Student Conference. | AMU-ANL | Argonne, Ill | Aug. 24– Sept. 4 | 66 |

## LECTURE AND CONSULTATION PROGRAMS

### *Radiobiology Lecture Series*

A radiobiology lecture series program for colleges and high schools is administered for the AEC by the American Institute of Biological Sciences. The lectures provide a practical and efficient means of introducing nuclear science and technology into life sciences programs. During the 1963–1964 academic year, 26 speakers visited 23 high school and college campuses.

***Traveling Lecture Program***

The traveling lecture program, administered for the AEC by ORINS, provides a means by which scientists from the AEC's Oak Ridge and Savannah River facilities contribute to the scientific life of colleges and universities by lecturing, presenting seminars and colloquia. The lectures are presented at no cost to the institution. During the 1963–1964 academic year, 33 Savannah River and 126 Oak Ridge scientists made presentations to approximately 400 student-faculty audiences.

In addition, over 150 colloquium and seminar talks were given by Argonne staff members on various university campuses, primarily for graduate students and faculty members. Also, several hundred students and faculty members attended lectures and seminars at Argonne.

As a variant of the Traveling Lecture Program, a telephone lecture series utilizing two-way speakers and a conference hook-up was inaugurated with college and universities under Argonne. Three hundred students and faculty members in 20 colleges have taken part in a lecture series on radiobiology and 150 students and faculty members in 10 colleges are participating in an introductory course on the use of computers.

## EQUIPMENT GRANTS AND NUCLEAR MATERIALS SERVICES

Under its continuing program of making financial grants to college-level educational institutions to assist them in purchasing nuclear apparatus for lecture and student laboratory use, the AEC made awards as shown in Table 8. The large decrease in awards from 1963 to 1964 reflects the rescheduling of the fall series of awards until after December 31, 1964.

Since inception of the program in 1956, a total of 1,470 grants have been made to 666 institutions for the purchase of $26 million worth of equipment.

The AEC also continued the closely-related program of lending, or providing funds for the purchase of, nuclear materials needed for instructional purposes. Materials provided in 1964 were special nuclear materials (plutonium and uranium 235) contained in subcritical and teaching reactor fuel and neutron sources, heavy water, graphite, and polonium neutron sources. Seventy-two schools received materials valued at $1,310,819; related fabrication grants totaled $77,487.

TABLE 8.—EQUIPMENT GRANTS IN 1964

| Science disciplines | Number receiving grants | | Amount granted | |
|---|---|---|---|---|
| | 1963 | 1964 | 1963 | 1964 |
| Chemistry | 24 | 6 | $163,145 | $163,160 |
| Chemistry and physics | 14 | 5 | 143,670 | 32,249 |
| Engineering | 11 | 8 | 168,564 | 169,543 |
| Interdisciplinary [1] | 20 | 7 | 132,000 | 71,700 |
| Life and medical | 54 | 22 | 487,916 | 200,007 |
| Physics | 40 | 24 | 451,683 | 322,083 |
| Total | 163 | 72 | $1,546,978 | $858,742 |

[1] Grants cover both life and physical science programs.

### *Research Reactor Assistance*

Since 1950, the AEC has assisted university nuclear reactor projects by loaning fuel materials without charge and providing funds or services without charge for fuel fabrication and reprocessing (including, beginning in 1963, the cost of shipping the spent fuel), and neutron startup sources.[34] Heavy water for use as a reactor moderator is also loaned without charge. Table 9 shows the reactor assistance provided in 1964:

TABLE 9.—RESEARCH REACTOR ASSISTANCE

| Institution | Nature of assistance | Fabrication funds awarded | Dollar value of materials |
|---|---|---|---|
| State University of N.Y. (Buffalo) | Fuel fabrication | $110,000 | |
| | Loan of $U^{235}$ | | $297,250 |
| University of Michigan | Fuel fabrication | 21,133 | |
| | Loan of $U^{235}$ and Heavy Water | | 60,250 |

## OPERATION OF COURSES

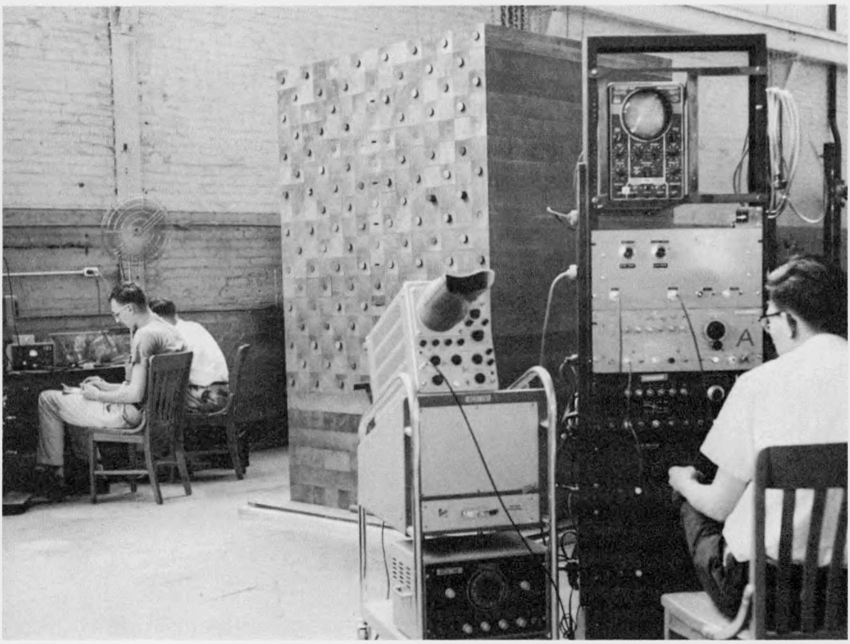
The AEC, through its contractors, offers a number of specialized training courses at its facilities.

### *Radioisotopes Techniques Courses*

During 1964, the Oak Ridge Institute of Nuclear Studies (ORINS) provided training to 268 engineers, scientists, physicians, faculty members, and others in a variety of basic and research techniques courses.

[34] Used to initiate a self-sustaining fissioning action in a reactor.

*AEC-Provided Equipment.* As a part of its nuclear education and training program, the AEC provides funds to colleges and universities for the purchase of specialized equipment for use in nuclear-associated courses. Photo *above* shows a La Sierra College, Calif., physics professor (*left*) instructing two students in a reactor-loading experiment using a non-radioactive student-training reactor provided through an AEC grant. Photo below is a general view of a University of Illinois, Urbana, nuclear laboratory with students performing a gamma attenuation experiment with the large uranium-graphite subcritical unit.



This brought the total to 5,794 individuals who have taken these courses since 1948.

### *Mobile Isotopes Laboratory Courses*

With a second mobile laboratory [35] now in operation, 19 2-week courses were given at 19 college campuses during 1964. By visiting small colleges of limited faculty which do not have specialized nuclear equipment, radioisotope techniques training was given to 186 teachers in the basic sciences. In addition, 113 advanced science majors participated in this program.

### *Medical Qualification Courses*

During 1964, ORINS provided specialized instruction to 57 registered physicians in the use of radiation and radioactive isotopes for the diagnosis and treatment of disease.

### *Nuclear Reactor Courses*

The Oak Ridge School of Reactor Technology (ORSORT) conducts reactor operations supervision and hazards evaluation courses. These courses provide training for AEC and AEC contractor employees, personnel from other Federal agencies and private industry, and also support the AEC effort to help foreign countries train personnel for their research and development programs. The Argonne Institute of Nuclear Science and Engineering (AINSE) at Argonne National Laboratory conducts special programs in reactor science and technology and nuclear engineering research for both foreign and domestic students. Participation during 1964 in these courses is shown in Table 10.

TABLE 10.—NUCLEAR REACTOR COURSES

[Enrollment—full time equivalent (FTE)—during 1963–64 academic year]

| Course | AEC and contractor | Foreign students | Other Government agencies | Industry | Educational cooperation | Total |
|---|---|---|---|---|---|---|
| ORSORT—reactor operations: | | | | | | |
| Supervision | 18 | 6 | 0 | 0 | 0 | 24 |
| Hazards evaluation | 18 | 10 | 3 | 1 | 0 | 32 |
| AINSE | 3 | 32 | 0 | 0 | 31 | 66 |
| Total | 39 | 48 | 3 | 1 | 31 | [1] 122 |

[1] The 122 FTE represents the training of 1,400 individuals (200 at ORSORT and 1,200 at AINSE).

[35] See p. 275, Annual Report to Congress for 1963.


*ORSORT Students.* Training of a practical nature regarding operation of nuclear reactors is provided domestic and foreign engineers and scientists at the Oak Ridge School of Reactor Technology (ORSORT). Photo shows group of students of a reactor operations supervision course loading fuel elements in a pool criticality facility. ORSORT courses are conducted for AEC and AEC-contractor employees as well as for personnel from nuclear programs of other countries.

# UNIVERSITY-AEC LABORATORY COOPERATIVE PROGRAM

The AEC continues to expand and strengthen its cooperative programs between American universities and its various laboratories in scientific areas of mutual interest. This arrangement permits the interchange of technical information among students, faculty, and laboratory personnel and also makes the unique equipment of the AEC laboratories available to the academic community. Students enrolled under these programs need not necessarily be from the sponsoring university organization. Results are mutually beneficial to the scientific staffs of the laboratories and the universities. The following are some of the major areas of cooperation between AEC research laboratories and neighboring universities:

(*1*) Colleges and universities sponsoring the Oak Ridge Institute of Nuclear Studies (ORINS)[36] with Oak Ridge National Laboratory (ORNL), Savannah River Laboratory (SRL), and the Puerto Rico Nuclear Center.

(*2*) Associated Midwest Universities (AMU)[37] and Associated Colleges of the Midwest (ACM),[38] and nearly 100 other midwestern liberal arts colleges and smaller universities, with Argonne National Laboratory (ANL).

(*3*) Associated Rocky Mountain Universities (ARMU)[39] with the National Reactor Testing Station (NRTS), laboratories of the Sandia Corp., and Los Alamos Scientific Laboratory.

(*4*) Center of Graduate Study, Richland, Wash. (operated by the University of Washington in cooperation with Washington State University, Oregon State University) and the Hanford Laboratories.[40]

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[36] See Appendix 3 for membership list.

[37] The Associated Midwest Universities (AMU) is composed of: The University of Arizona, Battelle Memorial Institute, Carnegie Institute of Technology, Case Institute of Technology, the University of Chicago, University of Cincinnati, Illinois Institute of Technology, University of Illinois, Indiana University, Iowa State University, State University of Iowa, Kansas State University, the University of Kansas, Loyola University, Marquette University, Mayo Foundation, Michigan Technological University, Michigan State University, the University of Michigan, University of Minnesota, University of Missouri, University of Nebraska, Northwestern University, University of Notre Dame, the Ohio State University, Oklahoma State University, Pennsylvania State University, Purdue University, St. Louis University, Washington University, Wayne State University, Western Reserve University, and the University of Wisconsin.

[38] The Associated Colleges of the Midwest (ACM), an organization of ten midwestern coeducational liberal arts colleges, includes Beloit College, Charleston College, Coe College, Cornell College (Iowa); Grinnell College, Knox College, Lawrence College, Monmouth College, Ripon College, and St. Olaf College.

[39] The Associated Rocky Mountain Universities (ARMU) is composed of: Colorado State University, University of Colorado, University of Denver, Idaho State University, University of Utah, University of Nevada, New Mexico State University, University of New Mexico, Utah State University, University of Wyoming.

[40] Name changed to Pacific Northwest Laboratory, January 1, 1965.

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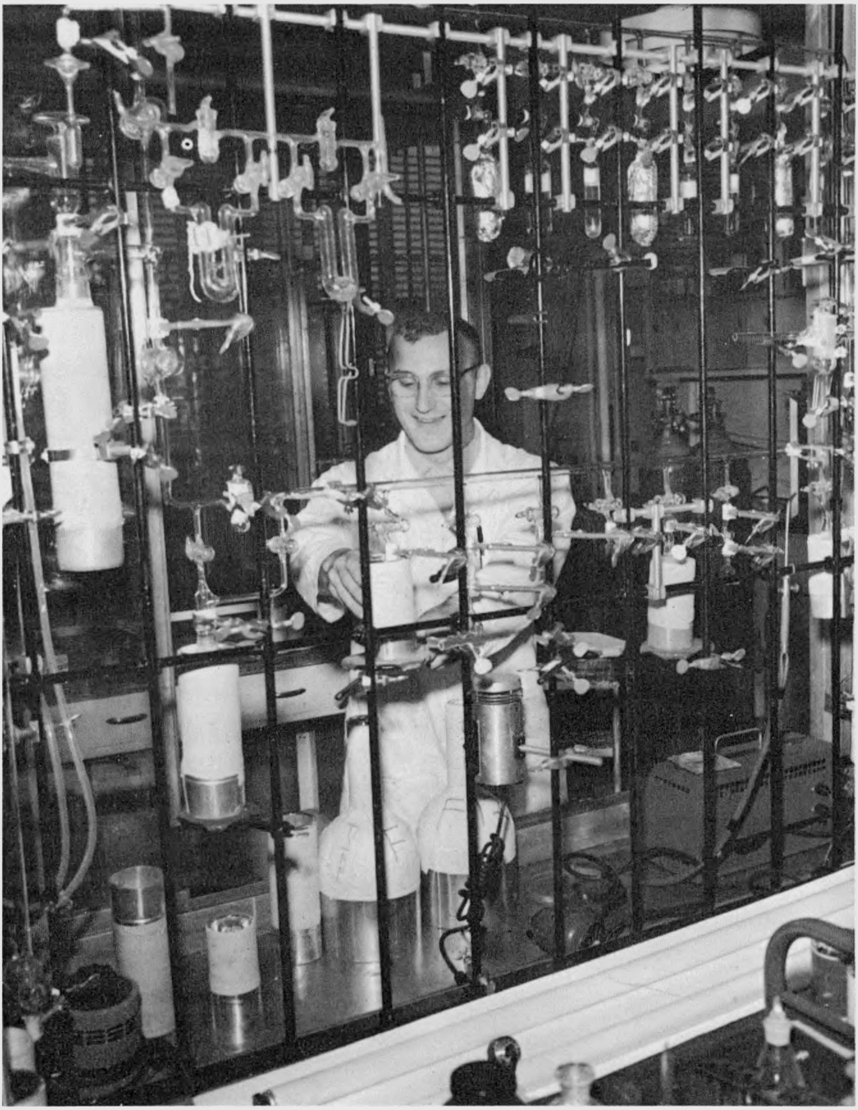


*"Argonne Semester" Student.* In existence since September 1960, the "Argonne Semester" is an off-campus program administered by the Associated Colleges of the Midwest (ACM) and Argonne National Laboratory (ANL). The program assists liberal arts colleges in updating their science programs by providing students with a semester of study and research under the guidance of ACM professors and ANL staff members. Photo shows a Coe College, Cedar Rapids, Iowa, student distilling solvents in a vacuum line during his semester spent at Argonne.

(*5*) Associated Universities, Inc.,[36] Brookhaven National Laboratory (BNL).
(*6*) Ames Laboratory with Iowa State University and other educational institutions.[41]
(*7*) Los Alamos Scientific Laboratory and Sandia Laboratory with the University of New Mexico.
(*8*) Mound Laboratory with the University of Dayton and University of Cincinnati.
(*9*) Lawrence Radiation Laboratory—Livermore, with the University of California (Davis campus).
(*10*) Lawrence Radiation Laboratory—Berkeley, with the University of California (Berkeley campus).

Major areas of cooperation during 1964 are summarized below.

### *Undergraduate Students*

College students in science who have completed their junior year are given the opportunity to participate in research training during the summer months. A total of 137 students participated during the summer of 1964 at ORNL–ORINS (57); University of Rochester (30); and Brookhaven (50).

The Argonne Semester Program of the Associated Colleges of the Midwest, instituted in 1960 by ANL and ACM, assists liberal arts colleges in updating their science programs. During 1964, 21 junior and senior college students devoted a semester to study and research at ANL under the guidance of ACM professors and ANL staff.

In addition, ANL employed 116 students in its Summer Student Aide Program and 31 undergraduate co-op students.

### *Faculty and Graduate Students*

*Research participation.* This program makes available to university scientists the unique opportunities for research found in AEC laboratories. At Oak Ridge, where the program is administered by ORINS for the AEC, 67 new participants were selected during fiscal year 1964. Short-term visitors totaled about 100. The majority were at ORNL with the others at the Puerto Rico Nuclear Center, ORINS,

[41] University of Detroit, Hamline University, Polytechnic Institute of Brooklyn, New Mexico State University, Drake University, Arizona State University, Wisconsin State College and Institute of Technology, South Dakota School of Mines and Technology, University of Wisconsin, University of Kansas, Grinnell College, Loras College and University of Missouri at Kansas City.

AEC Agricultural Research Laboratory, and SRL. At the Hanford Laboratories, four faculty members were supported for varying periods during 1964, and at NRTS 12 graduate students and 6 faculty members participated in research programs under ARMU auspices.

At the Ames Laboratory, six faculty members from six different universities participated in the summer faculty appointment program.

At ANL, 70 graduate students were employed as Student Associates during the summer months. There were also 4 M.S. and 20 Ph. D. thesis students and 62 post-doctorals. Finally, at ANL there were 80 short-term faculty appointments primarily in the summer months.

### *Faculty and Student Use of Laboratory Facilities*

During the summer of 1964, 21 undergraduate students from the University of Tennessee conducted five instructional experiments on ORNL reactors.

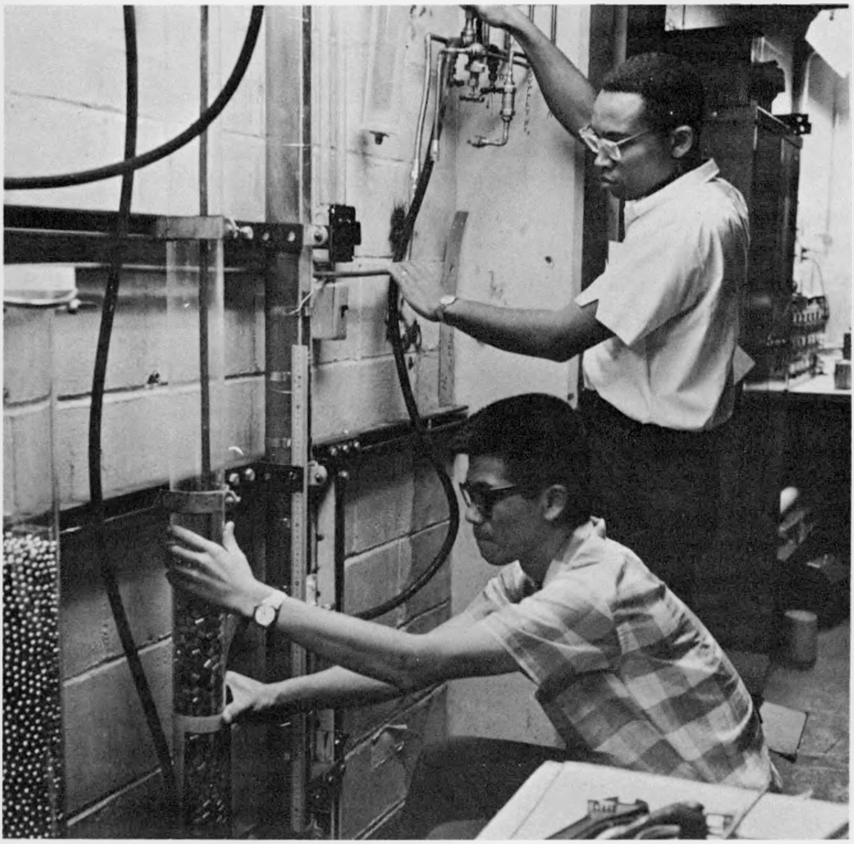
A group of six students from the University of New Mexico under the auspices of ARMU conducted experiments using a reactor at the Sandia Laboratory during the summer of 1964.

One hundred fifty AMU-sponsored students and faculty members from 16 institutions devoted 2 to 6 days performing experiments at Argonne, usually utilizing the facilities of AINSE. Two hundred faculty members from 80 liberal arts colleges and smaller universities performed experiments during "work shops" of 2 to 6 days duration. In addition, some 600 students and 100 faculty members from 35 liberal arts colleges devoted 1 to 8 days performing experiments on the Institute's instructional laboratory facilities.

ANL, through its Institute conducted two experimental courses of 2-month duration for 12 faculty members in experimental reactor physics and nuclear materials research and applications. The participants play a major role in developing these courses to fulfill specific objectives.

A 16-week lecture series in radioisotopes and radiation technology was presented at ANL for 18 college and university faculty members. The purpose of the course was to aid the faculty members in their teaching and research; the instruction accordingly emphasized basic theory and included applications of radioisotopes to the sciences. A laboratory course of 2 months duration, presented to medical professors and physicians, covered the techniques of handling and applying isotopes in medicine. Each of the above courses met once a week for the indicated period.

The summer AMU–ANL Engineering Practice School was established in 1963 and was repeated in 1964 with 19 graduate students and 2 faculty members. It is designed to provide an opportunity for stu-



*Engineering Practice School.* The Associated Midwest Universities-Argonne National Laboratory (AMU–ANL) Engineering Practice School not only provides undergraduate students a chance to obtain practical experience by working at Argonne, but also to work with nuclear-oriented students from other midwest universities. Photo shows students from Michigan State University and Washington University (St. Louis, Mo.) adjusting equipment associated with the reprocessing of nuclear fuels at Argonne during the 1964 summer course.

dents to work on a series of selected engineering projects related to the Argonne Laboratory's research and development activities.

***Resident Graduate Program***

A total of 529 students registered in the resident graduate study program conducted at Oak Ridge by the University of Tennessee during the period from summer 1963 to spring 1964; 16 students were awarded M.S. degrees and one a Ph. D. degree. The program, which is administered by ORINS, is primarily for employees of the AEC and AEC contractors at Oak Ridge. The University of Idaho, working through NRTS programs, conferred M.S. degrees on 12 of 535 students (AEC employees or its contractors) registered for 1963–1964.

### *HASL Program*

The AEC's New York Health and Safety Laboratory (HASL) has a popular summer training program of its own for college juniors and seniors. Since 1949, a total of 125 students have received training in radiochemistry, electrical engineering, health physics, radiation physics, and statistics. A large percentage of these summer trainees have, upon graduation, sought careers with the Federal Government or have continued their studies under various Federal fellowship programs. During FY 1964, HASL initiated an In-Place Filter Testing Workshop. Four 1-week courses of instruction were presented to AEC and contractor personnel, representatives from other agencies, and representatives from Canada (Chalk River Laboratories) and the UKAEA. The participants were instructed in air flow measurements, aerosols, air cleaning, filtration theory, inplace filter testing, and in the characteristics of the equipment used in aerosol technology. The end result of this training is to help the participants improve and test the efficiency of filter systems.

## DEVELOPMENT OF CURRICULA AND TRAINING AIDS

During 1964, a project was conducted with the Chicago Board of Education to study the problems of teaching nuclear science at the secondary school level. A total of 15 high schools were involved in the pilot study of providing instruction in nuclear science and radioactivity as part of their regular study in the science course selected in either biology, chemistry or physics.

A joint pilot project was conducted with the Bio-Atomic Research Foundation, North Hollywood, Calif., and the Los Angeles Unified School District during 1964. The purpose of this project was to develop suitable experiments and other materials for high school teachers, not having specialized training, and to integrate selected experiments and an understanding of radioactivity into their teaching of science.

A training program was developed at Louisiana State University, especially for radiography technicians in educational institutions and industry. The materials include a resource manual, instructor's guide and student workbook. The emphasis is on the principles of radiation, radiography, and safe handling techniques. These publications, which are expected to be of particular benefit to technical institutes, vocational schools, and labor unions, will be available at the U.S. Government Printing Office in early 1965.

As part of a two-phase study, a literature survey was made of instructional materials in radiation techniques for biological sciences at the junior college level. The study, conducted by Montgomery Junior College in Maryland, lists applicable laboratory experiments and publications currently available.

A series of 11 instructional films entitled, "Understanding the Atom" has been completed (see Appendix 4).

At the request of various cooperating universities, the Laboratory Manual of Experiments in Reactor Physics and Engineering was revised in 1964. It is now widely used by many universities on their own campuses.

## OTHER AEC EDUCATIONAL ASSISTANCE ACTIVITIES

### *International Assistance*

Training and research opportunities are afforded citizens of Free World countries in the peaceful uses of atomic energy in AEC-operated schools and laboratories for periods ranging from 6 months to a year or more.

In addition to providing instruction in those schools conducting courses primarily to meet U.S. requirements the University of Puerto Rico operates the Puerto Rico Nuclear Center (PRNC) under contract with the AEC. The center has given particular attention to the medical and agricultural problems common to many of the Central and South American countries in the tropical zones. Educational and research programs in nuclear technology are directed toward the needs of students from Puerto Rico and from Latin American countries. Graduate instruction in nuclear science and engineering is available. Enrollment in the 1963–64 academic year totaled 211.

Over the past 8 years, more than 2,700 foreign nationals have received training or have been provided research opportunities in AEC facilities, and during this period thousands of foreign scientists and representatives have visited AEC facilities.

### *Contractor Employee Training*

Some 30 of AEC's cost-type operating, research and development contractors participated in training programs during 1964. The programs are conducted in contractor-operated facilities and are designed to broaden nuclear manpower resources by providing an opportunity for part-time and temporary employment. Primary participants are students and faculty who supplement their study and teaching activities by part-time work in the atomic energy field.

Programs for improving the contractor's work force are also provided through special job related training and research assignments such as attending college-level courses or assignments of employees to other institutions for research purposes.

Table 11 shows a 2-year comparison of the types of training activities, the number of trainees, and the training time involved.

TABLE 11.—CONTRACTOR EMPLOYEE TRAINING

| | Number of participants | | | Number of man-hours | | |
|---|---|---|---|---|---|---|
| | Fiscal year 1963 | Fiscal year 1964 | Percent change | Fiscal year 1963 | Fiscal year 1964 | Percent change |
| Temporary and part-time use of students and faculty (totals of A, B, and C below) | 1,685 | 1,643 | −2.5 | 1,433,517 | 1,488,589 | +3.8 |
| A. Cooperative educational participation program | 289 | 292 | +1.0 | 219,079 | 233,100 | +1.8 |
| B. Research and engineering participation program | 1,038 | 1,039 | +0.1 | 987,086 | 1,080,200 | +10.3 |
| C. Guest appointments of employees affiliated with other institutions | 358 | 312 | −12.8 | 227,352 | 176,289 | −22.5 |
| Summer employment activities | 1,869 | 1,812 | −3.0 | 632,691 | 664,630 | +5.0 |
| Work experience training | 496 | 479 | −3.4 | 535,768 | 567,072 | +5.8 |
| Special job related training (168 hours or more) | 199 | 206 | +3.5 | 150,917 | 146,382 | −3.0 |

# TECHNICAL INFORMATION PROGRAMS

The Atomic Energy Act of 1954, as amended, states: "The dissemination of scientific and technical information relating to atomic energy should be permitted and encouraged so as to provide that free interchange of ideas and criticisms which is essential to scientific and industrial progress and public understanding and to enlarge the fund of technical information." The Commission fulfills this technical information responsibility through a wide range of programs.

## PUBLICATIONS

### *Books and Monographs*

Notable among AEC-sponsored publications during the year was a set of four volumes [42] recording many recent United States accomplish-

[42] The titles and authors are: *Education and the Atom,* by Glenn T. Seaborg, Chairman USAEC; and Daniel M. Wilkes, Assistant to the Director, Lawrence Radiation Laboratory, University of California, Berkeley. *Nuclear Power, USA,* by Walter H. Zinn, Vice President, Combustion Engineering, Inc., Windsor, Conn.; Frank K. Pittman, former Director, Division of Reactor Development, USAEC; and John F. Hogerton, consultant. *Research, USA,* by Albert V. Crewe, Director, Argonne National Laboratory, Argonne, Ill.; and Joseph J. Katz, Senior Scientist, Argonne National Laboratory. *Radioisotopes and Ra-*


*N.Y. World's Fair.* As a part of its technical information exhibit program, the AEC had two exhibits at the 1964 New York World's Fair, "Radiation and Man" for high school students and their parents, and "Atomsville, U.S.A." to which entrance was limited—by a 5-foot-high doorway—to children of 7 to 14 years. Exterior walls of the "Atomsville, U.S.A." exhibit were decorated with caricatures of scientists who have made valuable contributions to nuclear knowledge. Photo shows the exterior of the children's exhibit; note the observation booth for parents at *left*. The exhibit is scheduled to re-open with the 1965 Fair.

ments in the peaceful uses of nuclear energy. They were presented by the United States to United Nations officials and to delegates from other countries during the 1964 Geneva Conference. Dedicated to the late President John F. Kennedy, the books each contain a foreword by President Johnson.

Eighteen other books and monographs published during 1964 (see Table 12) brought to 166 the number of AEC-sponsored volumes published since 1947. The AEC actively encourages and supports the preparation of such works to help meet the need for general reference books, technical handbooks, specialized works on very limited subject areas, summary textbooks, and other aids for university teaching. Publishers of the books are, in most cases, competitively selected

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*diation*, by John H. Lawrence, M.D., Director, Donner Laboratory, University of California; Bernard Manowitz, Head, Radiation Division, Nuclear Engineering Department, Brookhaven National Laboratory, Upton, N.Y.; and Benjamin S. Loeb, Assistant to the Director, Division of Technical Information, USAEC; all published by McGraw-Hill, New York City, price $18 per volume, $62.50 per set of four.

commercial firms who bear all publication, promotion, and marketing expenses, and return royalties to the Government. Monographs are issued in cooperation with technical and scientific societies.

TABLE 12.—AEC-SPONSORED BOOKS AND MONOGRAPHS PUBLISHED IN 1964

| Title | Author or editor | Publisher |
|---|---|---|
| *Books* | | |
| Atomic Energy Encyclopedia in the Life Sciences. | C. W. Shilling | W. B. Saunders Co., Philadelphia, Pa., $10.50. |
| Noble-Gas Compounds | H. H. Hyman | University of Chicago Press, Chicago, Ill., $12.50. |
| Reactor Technology—Selected Reviews | L. E. Link | U.S. Government,[1] $6.50. |
| Low-Level Radioactive Waste | C. P. Straub | U.S. Government,[2] $1.50. |
| Reactor Handbook, Volume IV—Engineering (2d Edition). | J. H. Martens<br>S. McLain | John Wiley & Sons—Inter-Science Publishers, N.Y., N.Y., $24.50. |
| Guide to Activation Analysis | W. S. Lyon, Jr. | D. Van Nostrand, Inc., Princeton, N.J. $5.95. |
| Analysis of Essential Reactor Materials. | C. J. Rodden | U.S. Government,[2] $4.25. |
| Naval Reactors Physics Handbook, Vol. 1: Selected Basic Techniques. | A. Radkowsky | U.S. Government,[2] $6.00. |
| *Monographs* (cooperating society in parenthesis) | | |
| Pulmonary Deposition and Retention of Inhaled Aerosols (American Industrial Hygiene Association). | T. F. Hatch<br>P. Gross | Academic Press, Inc., New York City, $3.45 (paperback), $5.95 (hardback). |
| Radiation, Radioactivity, and Insects (American Institute of Biological Sciences). | R. D. O'Brien<br>L. S. Wolfe | Academic Press, Inc., New York City, $3.45 (paperback), $5.95 (hardback). |
| Radiation, Iostoptes, and Bone (American Institute of Biological Sciences). | F. C. McLean<br>A. M. Budy | Academic Press, Inc., New York City, $3.45 (paperback), $5.95 (hardback). |
| Radiation and Immune Mechanisms (American Institute of Biological Sciences). | W. H. Taliaferro<br>L. G. Taliaferro | Academic Press, Inc., New York City, $3.45 (paperback), $5.95 (hardback). |
| Welding and Brazing Techniques for Nuclear Reactor Components (American Society for Metals). | G. M. Slaughter | Rowman & Littlefield, Inc., New York City, $5.35 (paperback), $9.65 (hardback). |
| Radiation Effects on Toughness of Ferritic Steels for Reactor Vessels (American Society for Metals). | L. P. Trudeau | Rowman & Littlefield, Inc., New York City, $5.35 (paperback), $9.65 (hardback). |
| *AEC Symposium Series* | | |
| Progress in Medical Radioisotope Scanning. | R. M. Kniseley<br>G. A. Andrews<br>C. C. Harris<br>E. B. Anderson | U.S. Government,[1] $3.50. |
| Reactor Kinetics and Control | L. E. Weaver | U.S. Government,[1] $4.25. |
| Dynamic Clinical Studies With Radioisotopes. | R. M. Kniseley<br>W. N. Tauxe<br>E. B. Anderson | U.S. Government,[1] $4.50. |
| Noise Analysis in Nuclear Systems | R. E. Uhrig | U.S. Government,[1] $3.75. |

[1] Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 22151, at indicated prices.

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

### *Review Journals*

Reactor Technology, a new annual AEC review, made its first appearance in 1964. It includes descriptions of progress in areas of reactor technology which have reached a significant developmental stage, which have not been adequately covered in other literature, or which are emphasized by over-all trends in reactor development.[43]

Subscriptions sold by the Superintendent of Documents, U.S. Government Printing Office, indicate increasing public interest in the AEC's five quarterly Technical Progress Reviews. This has been particularly true in the case of "Isotopes and Radiation Technology," which was initated late in 1963 and of "Nuclear Safety," both of which are prepared by Oak Ridge National Laboratory. The other review journals and the laboratories preparing them are: Power Reactor Technology (General Nuclear Engineering Corp.) Reactor Materials (Battelle Memorial Institute), and Reactor Fuel Processing (Argonne National Laboratory).

### *Nuclear Science Abstracts*

During 1964, the AEC's Nuclear Science Abstracts (NSA), the principal abstracting journal in the nuclear field, contained approximately 45,000 abstracts, the highest for any year to date. The factors contributing most to this rise were the efforts to improve the coverage of conference literature, graduate theses, foreign patents, and foreign journal literature.

Two approaches to the use of computer techniques for more efficient storage and retrieval of information appearing in NSA were under study at the year's end. The first involves indexing NSA abstracts with a special list of keywords prepared by the European Atomic Energy Community (Euratom) and being organized for machine handling under a cooperative agreement between the AEC and Euratom. The second approach, being studied under an experimental program, involves computer processing of the conventional subject headings used in NSA.

### *Bibliographies*

Bibliographies of literatures on various aspects of nuclear science continue to be published as a further means of assisting scientists to locate references of interest. Among those published and distributed

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[43] It is available for purchase from the Clearinghouse for Federal Scientific and Technical Information of the National Bureau of Standards, Springfield, Va., for $6.50.

during 1964 was a three-volume bibliography covering radiobiological literature for the years 1958–1960, entitled "The Effects of Radiation and Radioisotopes on the Life Processes" (TID–3098).[44] A companion bibliography covering literature in this field for the years 1895–1957 is planned for publication in 1965.

### *Engineering Drawings*

The program of providing engineering drawings, specification, photographs, and bills of materials relating to various items of nuclear and engineering equipment continued to expand. Drawings made publicly available in 1964 included those of processing equipment, ultra-high speed zonal centrifuges, standardized modules of reactor instrumentation, and stress-strain measuring apparatus. The entire collection available for purchase from the Clearinghouse for Federal Scientific and Technical Information,[45] now totals some 67,000 units, of which 10,000 were added in 1964.

### *Reports Distribution*

During 1964, the AEC made available 6,300 new unclassified report titles for sale through the Clearinghouse for Federal Scientific and Technical Information; 115,000 copies of 1,500 titles were furnished as printed copies; the remaining titles as facsimile-reproduced copies or in microcopy.

Since October 1964, microcopy has been provided in photographic negative form (microfiche) conforming to the new Government standard size of 105 mm by 148 mm photographed at an 18 to 1 image reduction. This new medium of document miniaturization permits recipients to view the photographed page images either enlarged on a microfiche reader or to print out the images in the original page size by means of a microfiche reader-printer.

### *Translations*

To assure that those engaged in atomic energy work in the United States are aware of, and able to profit from, advances in other countries, the AEC has had a continuing program for translating foreign

[44] Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 22151, $15.00.

[45] Previously these engineering drawings were sold through a private contractor (Cooper-Trent Blueprint and Microfilm Corp.). With the establishment of the Clearinghouse for Federal Scientific and Technical Information at Springfield, Va., during 1964—the successor organization within the Department of Commerce to the Office of Technical Services—the sales were transferred to this outlet.

periodicals, books, and reports, especially those from the Communist countries. Approximately 1,000 AEC-sponsored translations were published in 1964. The procedures for distributing these translations have been similar to those followed in distributing other unclassified information originating in AEC, including listing in abstract journals, availability in depository libraries, and public sale.

Late in 1964, a contract was being negotiated with the American Nuclear Society under which the Society's journals, Applied Nuclear Technology and Nuclear Science and Engineering, will include up to 300 pages per year of translations of articles appearing in German and French language journals. The selection of articles to be translated will be approved by the AEC.

### *Information and Data Centers*

A number of specialized information and data centers, whose function it is to collect, analyze, synthesize, and transmit evaluated information and data in specific content fields are supported by the AEC. Centers are located where research is underway consequently where much of the information can be obtained. An Isotopes Information Center was established at Oak Ridge National Laboratory during 1964, bringing the number supported in whole or in part by the AEC to 12.

### *Educational Literature*

The popular "Understanding the Atom" series of educational booklets was increased during 1964 by 14 titles, bringing the total number to 22.[46] Several of the booklets, in Spanish and French translations as well as in English, were among the informational materials provided by the United States to delegates at the 1964 Geneva Conference.

It is estimated that during the year the AEC and its major contractors filled some 130,000 requests for informational materials from students and others. Also, approximately 6,000 packets of literature were supplied to Boy Scouts interested in qualifying for the Atomic Energy Merit Badge established late in 1963.

### *AEC Depository Libraries*

To make atomic energy information more widely available, the AEC has selected various libraries as depositories to maintain collections of

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[46] Available (single copies free) upon request to USAEC, Post Office Box 62, Oak Ridge, Tenn., 37831.

unclassified AEC research and development reports and other important informational materials. During 1964, three libraries were added, bringing the total number of the United States to 97, located in 45 States. The new libraries are at Michigan State University, East Lansing; University of California, Davis; and Mississippi State University, State College, Miss. There are also 87 depositories located outside the United States in 62 countries and 5 international organizations. The document collections currently approximate 71,000 titles in the domestic libraries and 60,000 titles in those abroad.

## EXHIBITS

### *Popular Exhibits*

Two AEC exhibits, "Radiation and Man" and "Atomsville, U.S.A." were on display in the Hall of Science at the New York World's Fair. While the former is aimed at high school students and their parents and teachers, "Atomsville, U.S.A." is a museum for children ages 7 through 14. Parents are able to observe the young visitors from outside on closed-circuit television or through one-way mirror-windows. Total attendance at the two exhibits during the 4 months they were seen in the first year of the Fair approximated 1,580,000. After the Fair closes in 1965, the exhibits will be available for extended tours of American museums.

The AEC's other traveling exhibits and its ten "This Atomic World" high school demonstration units were viewed by an estimated 1,321,419 persons in 17 States during 1964. The American Museum of Atomic Energy at Oak Ridge, Tenn., received a record 124,146 visitors during the year. Both the museum and the traveling exhibits program are operated for the AEC by the Oak Ridge Institute of Nuclear Studies.

More than a million visitors are estimated to have viewed the AEC's semi-permanent "Nuclear Science" exhibit, operated by Argonne National Laboratory, in Chicago's Museum of Science and Industry during 1964.

### *Professional Exhibits*

Two exhibits designed for professional meetings, "AEC Research—Biological-Medical-Environmental" and "Nuclear Education and Training" were displayed at the August meeting of the American Institute of Biological Sciences at Boulder, Colo.

"Neutron Activation Analysis" was exhibited at the National Science and Technology Exposition during May in Baltimore, Md., at the Pullman, Wash., Conference on Nuclear Applications in the Wood, Paper and Pulp Industries in April, and at the National Metals and Materials show in Philadelphia during October. "Your State, Your City, and the Atom" is exhibited to State and municipal officials with responsibilities related to regulating peaceful applications of nuclear energy. Durng 1964 it was displayed to such groups in Trenton, N.J.; Colorado Springs, Colo.; Miami, Fla.; and Raleigh, N.C.

### *Science Fairs*

At the 15th National Science Fair-International at Baltimore, in May, the AEC again rewarded entrants displaying the most outstanding exhibits related to nuclear science or applications. The 10 winners and their 10 alternates received certificates of achievement at the Fair. In August, the winners and their teachers were given a "Nuclear Research Orientation Week" at Argonne National Laboratory. Exhibits of six of the winners and four of the alternates were on display at the American Museum of Atomic Energy in Oak Ridge during June. To assist student competitors and stimulate their exhibition of nuclear-related projects, the AEC has published a booklet, "Atoms at the Science Fair." [47]

## "TECHNOLOGY SPINOFF"

In addition to supporting the growth of nuclear developments, the AEC has always sought to encourage the application of the results of its research and development to non-nuclear industrial use. Successful examples in the past of such "technological spinoff" have included laminar flow clean rooms developed by the Sandia Laboratory [48] new solvent extractants and solvent extraction processes, electron-beam welding techniques, and fast digital logic circuits, called Nanocards. The AEC also participated with other Government agencies in supporting the work of the Von Neumann group at the Institute for Advanced Studies, Princeton, N.J., out of which came many of today's basic techniques for computer processing.

Recently several new methods for giving further encouragement to "technological spinoff" have been featured in the Commission's technical information and industrial participation programs.

One approach has been to establish Offices of Industrial Cooperation at the AEC's national laboratories to act as central points of contact between the laboratories and the Nation's industrial community. The first such office was established at the Oak Ridge National Laboratory;

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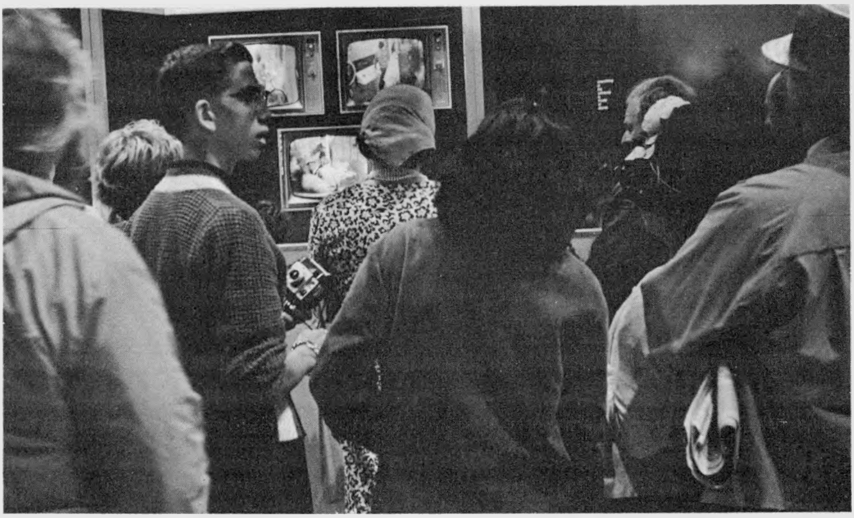
[47] Single copies may be obtained free from the USAEC, Post Office Box 62, Oak Ridge, Tenn., 37831.

[48] See p. 49, Annual Report to Congress for 1962.


*The Observers Observed.* One of the most popular exhibits for youngsters at the New York World's Fair was the "Atomsville, U.S.A." exhibit to which only children 7 to 14 years old were admitted. The youngsters were routed through a labyrinth of specially-designed "work-it-yourself" exhibits, as shown *above*, to acquaint them with nuclear energy. For the parents and older brothers and sisters the AEC provided a waiting room next to the exhibit equipped with television monitors so that the "small fry" could be observed as shown *below*.



a second was started at the Argonne National Laboratory during 1964. The Oak Ridge Office held three industrial Cooperation Conferences during 1964. Two of these had to do with liquid zonal centrifuges for separation subcellular components and viruses. The centrifuges are being developed in a joint National Institutes of Health-AEC program, using as a basis AEC gas centrifuge technology for the separation of isotopes.[49] The third conference was devoted to nondestructive test instruments and inspection techniques. The AEC also joined with NASA in April in a Conference on Industrial Applications of New Technology held at the Georgia Institute of Technology, Atlanta.

In November, the Commission initiated an experimental case-study under which AEC-industry teams will examine AEC-developed technology in three selected areas for the purpose of making recommendations as the most effective and expedient ways of identifying items of potential "spinoff" value. Results will be published and are expected to guide future spinoff activities of this kind. Contractors participating in this study are the Union Carbide Corp., the National Lead Co., the General Electric Corp., and the Goodyear Tire and Rubber Co.

Two additional steps to facilitate "spinoff" taken during 1964 were: (*a*) to permit the use for non-nuclear industrial applications of AEC's facilities, equipment and services, and (*b*) to encourage consultations by industry with AEC contractor personnel regarding non-nuclear applications of AEC-developed technology. Such assistance is provided on a full-cost recovery basis wherever practicable.

[49] See pp. 24 and 255, Annual Report to Congress for 1963.

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## Part Five

# Support-Type Activities

A number of the Commission's activities are of a supporting nature rather than directed toward a specific field of interest in the Nation's atomic energy program. These supporting roles cover a wide range of endeavor that directly affects the nuclear industry as well as providing across-the-board support for the AEC's scientific and technical programs.

# INDUSTRIAL PARTICIPATION

From the inception of the atomic energy program, the Government has drawn extensively on the skill and experience of American industry in meeting its major responsibilities. Over the years, the Commission has consistently encouraged a deeper involvement of private industry both in Government-sponsored atomic energy activities and in the development of a viable private nuclear industry.

### *Industry Associations*

The spirit of cooperation between Government and industry has contributed much to the United States position of world leadership in the development and use of nuclear power. To carry forward this joint effort, good channels of communication are indispensable. Serving as a focal point with industry within the AEC's Washington, D.C., Headquarters, the Division of Industrial Participation maintains continuing liaison with many industry associations and arranges periodic informal meetings between the Commission and groups such as the Atomic Industrial Forum, the U.S. Chamber of Commerce, and the Manufacturing Chemists' Association for the exchange of ideas and resolving common problems in the commercial development of atomic energy. Other industry groups which are actively concerned with the atomic energy program include the National Association of Manufacturers, the Edison Electric Institute, American Public Power Association, the National Security Industrial Association, and the Aerospace Industries Association.

# BROADENING INDUSTRIAL BASE

During 1964, the industrial base of the atomic energy program continued to broaden either through Commission actions or as private industry made further independent expansions in its participation.

### *AEC Actions in Support of Industry*

*Withdrawal actions.* Whenever it is practicable and reasonable to do so, the AEC has withdrawn from many areas in which it originally had an exclusive capability as industry has demonstrated competence to provide materials and services on an economic and competitive basis.

During 1964, the Commission took two major additional withdrawal actions:

(*1*) Sold a Government-owned plant for the production of high purity magnesium following a demonstration of the ability of private industry to supply material meeting AEC specification (see Production section, Part Two); and

(*2*) Discontinued routine production and distribution of six radioisotopes as these became available from commercial sources (see Isotopes Development section, Part Four).

*Other actions.* The Commission took other actions during 1964 which further broadened the opportunities for industrial participation in atomic energy activities. Among these, the AEC:

(*1*) Made an offer to consider proposals to allow use of a production reactor, at each of the Hanford and Savannah River sites, for private commercial purposes since the two reactors are no longer needed for production purposes (see Production section, Part Two).

(*2*) Started transformation of the Hanford Plant from a single-contractor operation to one involving at least six contractor-operators (see discussion under "Hanford Diversification and Contractor Replacement" in Part One).

(*3*) Continued cooperation with private industry in efforts to establish a film dosimeter standards laboratory on a private basis rather than as a Government operation (see subsequent discussion in this Industrial Participation section).

(*4*) Started the 9-year transition from a Government-monopoly ownership of special nuclear materials with passage of legislation which provides for private ownership. The Commission initiated and strongly supported this legislation which is generally considered "the most sweeping amendment to the Atomic Energy Act since 1954 (which) will vitally affect the future legal and economic structure of the entire atomic energy industry"[1] (see "Private Ownership," Part One).

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[1] Representative Chet Holifield, Chairman of the JCAE Subcommittee on Legislation. at the opening of hearings on this legislation, July 30, 1963.

### *Private Support for Development Work*

During 1964, industry exhibited a continuing recognition of its responsibility for bearing a significant share of development costs [2] in the nuclear energy program. For example:

(*1*) Babcock & Wilcox and the East Central Nuclear Group (14 electric utilities) announced a jointly-funded program to develop a supercritical pressure, steam-cooled fast breeder reactor for the production of electric power (see Nuclear Reactor Development, Part Three).

(*2*) Aerojet General and Union Carbide would undertake a study on development of reactors for chemonuclear purposes under a proposed joint Government-industry financing arrangement.

(*3*) Westinghouse and Dow Chemical announced an agreement to build and operate a new laboratory to develop advanced methods for reprocessing fuel and fabricating plutonium fuel (see Production, Part Two).

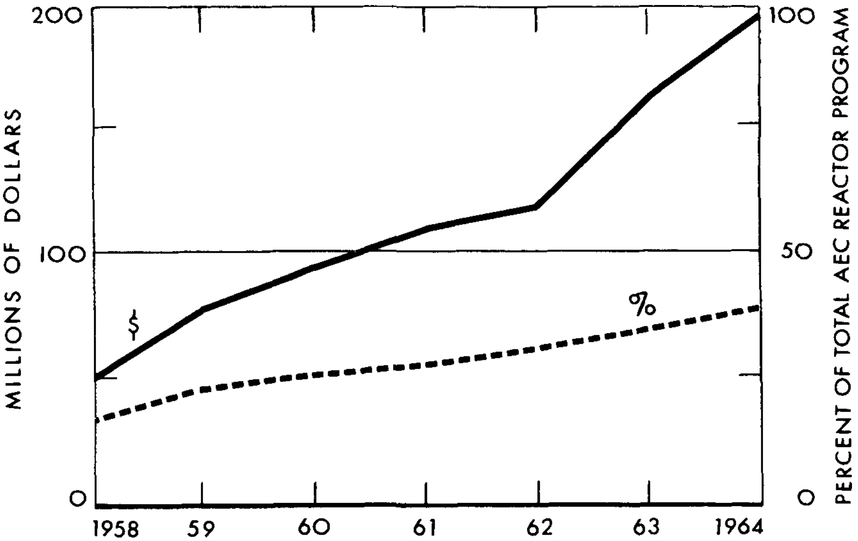
(*4*) Proposals were received from Babcock & Wilcox, General Electric, and United Nuclear for development and construction of improved reactors for maritime use under joint Government-industry financing arrangements (see Nuclear Reactor Development section, Part Three).

(*5*) General Electric announced its intention to build a fuel reprocessing plant in the western United States using a fluoride volatility technology. The cost will exceed $15 million (see Production, Part Two).

### *Development Work in Industrial Laboratories*

Table 1 shows the distribution of AEC research and development (exclusive of that related to production and weapons activities) by type of organization. Both the dollar value of work in industrial laboratories and the percentage of such work in terms of total research and development expenditures increased again in 1964 as they have for the past several years. This reflects the trend in reactor development activities as technology matures and the transition from the research laboratory to the main-stream of industry takes place. The graph shows the steady year-to-year increase in both the dollar value and percentage of reactor research and development going to industry.

[2] Chairman Seaborg has said: "Even though I am pleased at the investment private companies . . . have made, it seems to me that a still larger share must be undertaken by industry as nuclear energy more and more enters the mainstream of American business. The Federal Government cannot be expected to continue to ask Congress for support for research and development without the indication that industry also recognizes the harvest to be reaped in this field by accepting for itself an increasing share of the burden." (Remarks at Lynchburg, Va., April 11, 1964, AEC Public Release No. S–7–64, April 11, 1964).




*Steady Growth.* Graph shows, on a dollar and a percentage basis, the steady growth of the AEC's research and development work on nuclear reactors that is being done by private industrial laboratories.

TABLE 1.—DISTRIBUTION OF RESEARCH AND DEVELOPMENT EXPENDITURES

[Fiscal years—millions of dollars]

| Type of organization | RD [1] | | R [2] | | BM [3] | | ID [4] | | PNE [5] | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 |
| Industrial | 164.1 | 197.5 | 1.8 | 1.3 | 1.8 | 1.8 | 1.4 | 2.2 | ------ | ------ | 169.1 | 202.8 |
| AEC laboratories | 283.7 | 283.9 | 134.4 | 145.3 | [a] 42.6 | 48.5 | 3.2 | 4.2 | 9.8 | 12.5 | 472.9 | 494.4 |
| Universities | 3.1 | 2.8 | 54.3 | 52.0 | 14.4 | 14.8 | 0.7 | 0.8 | ------ | ------ | 72.5 | 70.4 |
| Other nonprofit | 4.2 | 4.1 | 2.7 | 2.4 | [a] 3.3 | 3.0 | 0.5 | 0.4 | ------ | ------ | 11.8 | 9.9 |
| Other Government | 7.3 | 14.0 | 1.5 | 2.9 | 3.0 | 2.9 | 0.3 | 0.3 | ------ | ------ | 12.1 | 20.1 |
| Total [b] | 462.4 | 502.3 | 194.7 | 203.9 | 65.1 | 71.0 | 6.1 | 7.9 | 9.8 | 12.5 | 738.4 | 797.6 |

[1] Reactor development.
[2] Physical research.
[3] Biology and medicine.
[4] Isotopes development.
[5] Peaceful nuclear explosives.
[a] Revised from 1963 Annual Report.
[b] These totals do not agree exactly with totals shown in the Annual Financial Report. Depreciation on Commission-owned facilities and cost of special nuclear material consumed are not included here but are included in the Annual Financial Report. Also, this table includes some estimates of expenditures based on contract commitments.

### *Appalachia*

The Commission continued its participation in the President's Appalachian Regional Commission (PARC).[3] In its final report, PARC urged close future relations between its successor and the AEC. Subsequently, on April 1, the AEC met in Atlanta, Ga., with representatives of most Appalachian States to discuss possible steps to encourage productive use of nuclear energy in this region.

### *Southern Interstate Nuclear Board*

In February, the Southern Interstate Nuclear Board (SINB) presented the AEC with its Operational Plan for 1964 to foster the peaceful uses of nuclear energy in its 17 member States. In keeping with the spirit of the Congressional Charter for the Board,[4] the AEC examined its existing programs for opportunities for cooperation with SINB. Two AEC contracts have been placed with the Board, one for a study of the application of radiation pasteurization of fruits in the South, and the other for an evaluation of state training requirements in radiological health for its member states in the SINB region. Also, representatives of the Board have visited the AEC's Savannah River, S.C., plant and facilities at Oak Ridge, Tenn., to explore the development of cooperative relationships.

### *Use of Existing Technology*

The AEC's technology utilization activities previously mentioned (see Technical Information, Part Four) seek to encourage commercial use of the results of AEC research and development. In support of this goal, the AEC's industrial participation program seeks to focus the attention of industry upon possibilities of using technology, ideas, innovations, and inventions from AEC operations, working through industrial and trade associations, and state offices of industrial development.

### *Access Permit Program*

To assist private industry in keeping abreast of nuclear developments in classified areas of work, classified information developed in AEC work is made available to persons engaged in private nuclear

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[3] Commissioner Ramey represented the AEC on this Commission.

[4] Section 4 of Public Law 87–563 specifically authorized the AEC to cooperate with SINB in areas of common interest. Nathaniel Welch of Auburn, Ala., was appointed in April 1963 by the late President Kennedy to serve as Federal Representative to the Southern Interstate Nuclear Board, the executive agency of the Southern Interstate Nuclear Compact. Mr. Welch's reporting channel to the President is through the Chairman of the AEC.

*"Technology Spinoff."* Many ideas and devices developed under AEC-sponsored work are finding practical applications in private industry. Whole-body counters for the direct *in vivo* measurement of internal radioactive contaminants in human subjects have become nearly indispensable tools for routine personnel monitoring as well as for research purposes—particularly for early detection of insoluble particulates in the lungs which are not generally detected by conventional methods of urinalysis. However, the heavy steel shields generally used with whole-body counters to obtain very low backgrounds are expensive and cannot be readily moved around, especially at an industrial location. If whole-body counting is used routinely for monitoring personnel from several nuclear work areas located at considerable distances from the counting facility, the continuing costs resulting from lost working time while subjects are being transported to and from the facility are even greater. Consequently, this very sophisticated technique is not as widely used as it would be if the costs were lower. A portable whole-body counter was conceived and built by the Health and Safety Laboratory of the AEC's Idaho Operations Office for routine use at the National Reactor Testing Station and offers promise for general industrial use. The prototype shown in the photograph weighs only 650 pounds and can easily be mounted on a small van to permit moving the counter routinely to all areas desiring service while keeping operating costs at a minimum. Under normal conditions, minute quantities of most gamma-emitting nuclides such as cesium 137 can be detected in a human subject in a 10-minute count. It is estimated that a complete instrument with a 100-channel pulse-height analyzer and printer can be fabricated for about $7,000. The counter has not yet been demonstrated off the NRTS site since it is in almost constant use.

industrial or scientific work under the Access Permit Program. As of mid-December 1964, there were 547 access permits in effect (416 for access to Secret Restricted Data and 131 for Confidential) as compared with 598 in 1963 (454 for Secret and 144 for Confidential).

AEC information in Category C-24, Isotope Separation-Gas Centrifuge Method, is no longer available under the Access Permit Program.

TABLE 2.—ACCESS PERMIT HOLDERS BY PRINCIPAL FIELDS OF INTEREST

| | Nov. 30, 1963 | Dec. 14, 1964 |
|---|---|---|
| Batteries (nuclear) | 2 | 2 |
| Chemical processing and equipment | 91 | 35 |
| Components (except reactor components) | 90 | 35 |
| Consultants | 77 | 67 |
| Controlled thermonuclear field | 13 | 5 |
| Design and construction of atomic energy facilities | 35 | 45 |
| Electronic systems | 8 | 17 |
| Fuel element fabrication | 15 | 30 |
| General nuclear research and development | 64 | 73 |
| Information services | 15 | 10 |
| Instruments | 29 | 32 |
| Insurance evaluation | 55 | 51 |
| Investment and banking | 2 | 2 |
| Isotope production and utilization | 28 | 34 |
| Legal assistance and accounting | 18 | 18 |
| Machinery | 14 | 16 |
| Ore refining and production of feed materials | 14 | 11 |
| Radiation hazards and effects | 23 | 40 |
| Radioactive waste | 15 | 18 |
| Reactor—Central Station | 80 | 69 |
| Reactor—Components | 21 | 43 |
| Reactor—Heating | 1 | 4 |
| Reactor—Other | 14 | 10 |
| Reactor—Propulsion | 14 | 21 |
| Reactor—Research | 2 | 10 |
| Shield materials | 7 | 13 |
| Special materials | 38 | 39 |
| Surveys for potential use or need | 7 | 15 |
| Training and education | 11 | 12 |
| Transportation and storage | 3 | 4 |
| Weapons and components | 4 | 7 |
| Others (not elsewhere classifiable) | 1 | 29 |
| Total | 811 | 807 |

NOTE.—These figures include permit holders with more than one field of interest, resulting in a total greater than the number of permittees.

***Work Experience Program***

One facet of industrial participation in the atomic energy field is the work experience program. This program was established to provide opportunities for specialized work experience training at AEC facilities for employees of private organizations engaged in civilian applications of atomic energy. It is designed to encourage industrial participation in the development and application of atomic energy for peaceful purposes, to familiarize participants with nuclear processes applicable to specific uses of atomic energy, and to obtain valuable assistance from the industry on AEC programs.

Because of the benefits which flow from this program to both the AEC and industry, during 1964 increased emphasis was placed on informing industry about it advantages.[5]

## THE ATOMIC ENERGY INDUSTRY

As a part of its program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes, the AEC prepares and maintains information pertaining to the development, growth, and state of the private atomic energy industry with the cooperation of other Government agencies and business associations. A summary of this information is presented in the following pages.[5]

### SHIPMENTS OF PRODUCTS

Shipments of atomic energy products, as reported by the Bureau of the Census, increased by more than 10 percent in 1963 [6] over 1962. Tables 3, 4, and 5 summarize these shipments.

In past years, shipments of nuclear instruments have been reported in this survey. Beginning with shipments for 1963, these instruments will be included as a part of a Census Bureau report on "Selected Instruments and Related Products." The 1963 data on nuclear instruments was not available at the time this report was prepared.

This year, for the first time, shipments for AEC use have been reported separately from shipments to other users. The fact that more than 60 percent of the shipments for 1963 went to users other than the AEC is indicative of the broad use of atomic energy in the Nation's economy.

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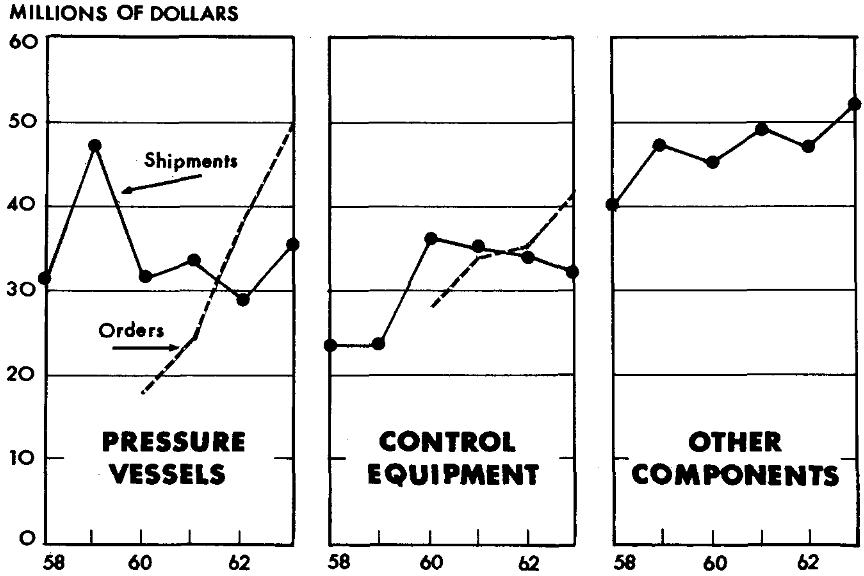
[5] More detailed information can be obtained from the Director, Division of Industrial Participation, U.S. Atomic Energy Commission, Washington, D.C., 20545.

[6] Latest available data.




*Reactor Components.* Charts *above* show the values of shipments made and orders placed, as reported by Bureau of Census for calendar years 1958–63, for nuclear reactor pressure vessels and associated control equipment, and other components going into reactor facilities. It is expected that the trend in the future will be more definitely upward as nuclear reactors become more and more competitive with conventional power generating facilities in certain high-cost areas of the country.

TABLE 3.—VALUE OF NET ORDERS RECEIVED FOR SELECTED ATOMIC ENERGY PRODUCTS: 1963

[In thousands of dollars]

| Product | Net orders received |
|---|---|
| Nuclear reactors | 20, 888 |
| Reactor components and equipment: | |
| Primary vessels and tanks | 14, 664 |
| Control rod drive mechanisms and components for: | |
| Power plant | 20, 323 |
| Propulsion } | 167 |
| Other } | |
| Heat exchangers and condensers | 35, 570 |
| Pressurizers, components, and auxiliary equipment | 6, 537 |
| Valves | 9, 561 |
| Fuel handling equipment | 3, 134 |
| Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor for: | |
| Power plant | 49, 084 |
| Propulsion | 18, 598 |
| Other | 3, 453 |
| Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor | 13, 882 |

TABLE 4.—VALUE OF SHIPMENTS OF ATOMIC ENERGY PRODUCTS: 1961–1963

[In thousands of dollars]

| Product | 1963 | | | | | 1962 | | | 1961 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | To U.S. Government | | Export | Other | Total | U.S. Government agencies | Other including export | Total | U.S. Government agencies | Other including export |
| | | Atomic Energy Commission | Other agencies | | | | | | | | |
| Total (excluding radiation detection and monitoring devices and control and measuring devices containing radioactive isotopes) | 228,185 | [1] 87,127 | [1] 61,736 | [1] 19,901 | [1] 59,421 | 202,054 | 141,208 | [2] 60,846 | 226,430 | 170,806 | [2] 55,624 |
| Total (including radiation detection and monitoring devices and control and measuring devices containing radioactive isotopes) | (NA) | (NA) | (NA) | (NA) | (NA) | 263,764 | 164,478 | 99,286 | 275,850 | 185,335 | 90,515 |
| Nuclear reactors | 2,561 | (D) | (D) | (D) | (D) | 7,884 | 6,469 | 1,415 | 12,296 | 11,625 | 671 |
| Reactor and components and equipment: | | | | | | | | | | | |
| Primary vessels and tanks | 17,163 | 11,185 | 5,746 | 232 | (3) | 12,139 | 10,772 | 1,367 | 14,446 | 11,481 | 2,965 |
| Control rod drive mechanisms and components for— | | | | | | | | | | | |
| Power plant | 7,897 | 699 | 4,982 | 2,216 | (3) | | | | | | |
| Propulsion | 2,979 | (D) | (D) | — | — | 17,996 | 12,811 | 5,185 | 17,369 | 15,196 | 2,173 |
| Other | | (D) | — | — | — | | | | | | |
| Accessory instrumentation for reactor control | 17,674 | 4,316 | 8,750 | 491 | 4,117 | 14,211 | 9,074 | 5,137 | 16,553 | 10,931 | 5,622 |
| Heat exchangers and condensers | 17,832 | 2,258 | 3,811 | 11,763 | (3) | 16,718 | 13,118 | 3,600 | 18,554 | 14,382 | 4,172 |
| Pressurizers, components, and auxiliary equipment | 6,380 | 661 | 2,299 | 3,420 | (3) | 2,585 | 2,289 | 296 | 1,352 | 1,178 | 174 |
| Pumps | 9,477 | 7,901 | (4) | 2,076 | (3) | 17,876 | 14,383 | 3,493 | 20,409 | 15,556 | 4,853 |
| Valves | 20,435 | 3,961 | 14,324 | 571 | 1,579 | 13,015 | 11,703 | 1,312 | 8,238 | 6,663 | 1,575 |
| Fuel handling equipment | 2,968 | 2,229 | (4) | 739 | (3) | 1,715 | 769 | 946 | 1,114 | 751 | 363 |
| Complete reactor fuel elements and control rods shipped directly for installation or use in a reactor for— | | | | | | | | | | | |
| Power plant | 31,572 | 13,980 | (4) | 11,241 | 6,351 | | | | | | |
| Propulsion | 19,683 | 19,683 | — | — | — | 38,966 | 27,804 | 11,162 | 46,155 | 40,185 | 5,970 |
| Other | 2,536 | 1,429 | (4) | 1,107 | (3) | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Partially fabricated reactor fuel element materials and control rods not shipped directly for installation or use in a reactor | 18, 356 | 9, 520 | 1, 595 | 7, 241 | (3) | 15, 908 | 10, 547 | 5, 361 | 19, 267 | 12, 334 | 6, 933 |
| Core structurals (barrels, cans, boxes, plates, etc., not included above) | 3, 219 | 2, 419 | (4) | 800 | (3) | 2, 256 | 1, 898 | 358 | 7, 180 | 7, 076 | 104 |
| Reactor moderators, coolants, and reflectors | 1, 872 | 428 | (D) | (D) | (D) | 1, 312 | 635 | 677 | 4, 201 | 3, 485 | 716 |
| Specialized reactor components and equipment not included elsewhere in this report | 10, 147 | 4, 738 | 1, 859 | 94 | 3, 456 | 10, 089 | 5, 755 | 4, 334 | 7, 309 | 4, 277 | 3, 032 |
| Hot laboratory equipment | 5, 319 | 4, 332 | (4) | 144 | 843 | 2, 585 | 1, 513 | 1, 072 | 3, 389 | 2, 427 | 962 |
| Shielding | 4, 091 | 751 | 1, 590 | 89 | 1, 661 | 6, 166 | 2, 569 | 3, 597 | 6, 636 | 4, 113 | 2, 523 |
| Radioactive isotopes shipped from non-AEC plants producing isotopes | 3, 123 | 351 | (4) | 219 | 2, 553 | 2, 071 | 217 | 1, 854 | 1, 688 | 185 | 1, 503 |
| Radiation sources and other radioactive materials produced from purchased isotopes | 12, 479 | 64 | 1, 807 | 1, 901 | 8, 707 | 6, 078 | 674 | 5, 404 | 4, 559 | 694 | 3, 865 |
| Conversion of enriched uranium metal and compounds (excluding production or conversion of normal and depleted uranium) | 10, 422 (includes commercial irradiation service) | 6, 402 (includes commercial irradiation service) | 649 (includes commercial irradiation service) | (X) | 2, 767 | 3, 584 | 971 | 2, 613 | 3, 688 | 1, 164 | 2, 524 |
| Commercial irradiation service | | | | (X) | 604 | 8, 900 | 7, 237 | 1, 663 | 12, 027 | 7, 103 | 4, 924 |
| Radiation detection and monitoring devices [5] | (NA) | (NA) | (NA) | (NA) | (NA) | 52, 058 | 21, 744 | 30. 314 | 38, 345 | 13, 138 | 25, 207 |
| Control and measuring devices containing radioactive isotopes [5] | (NA) | (NA) | (NA) | (NA) | (NA) | 9, 652 | 1, 526 | 8, 126 | 11, 075 | 1, 391 | 9, 684 |

— Represents zero.

D Withheld to avoid disclosing figures of individual companies.

NA Not available.

(X) Not applicable.

[1] Includes the value of those products for which separate figures are not shown to avoid disclosing figures of individual companies. Also see footnotes 3 and 4.

[2] Exports totaled $13,068 in 1962, and $8,279 in 1961.

[3] Included in export figure.

[4] Included in shipments to AEC.

[5] Data for 1963 for these products will be included in Current Industrial Reports Series M38B "Selected Instruments and Related Products."

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TABLE 5A.—VALUE OF SHIPMENTS OF SELECTED ATOMIC ENERGY PRODUCTS BY GEOGRAPHIC DIVISIONS AND STATES: 1961–1963

[In thousands of dollars]

| Census geographic division and State [1] | 1963 | 1962 | 1961 |
|---|---|---|---|
| United States, total | 228,185 | 202,054 | 226,430 |
| New England, total | 32,332 | 42,679 | 31,633 |
| Massachusetts | 14,354 | 20,524 | 16,899 |
| Rhode Island and Connecticut | 17,978 | 22,155 | 14,734 |
| Middle Atlantic, total | 89,393 | 62,733 | 82,371 |
| New York | 44,895 | 20,904 | 21,399 |
| New Jersey | 5,112 | 3,772 | 5,025 |
| Pennsylvania | 39,386 | 38,057 | 55,947 |
| East North Central, total | 40,837 | 42,450 | 35,361 |
| Ohio | 22,412 | 27,760 | 23,547 |
| Illinois | 3,486 | 4,505 | 3,535 |
| Indiana | 3,842 | } 4,013 (Indiana and Michigan) | 4,516 (Indiana and Michigan) |
| Michigan | 4,603 | | |
| Wisconsin | 6,494 | 6,172 | 3,763 |
| West North Central (Minnesota, Iowa, Missouri, and Kansas) | 6,214 | 5,343 | 5,653 |
| South Atlantic (Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida) | 2,214 | 5,503 | 14,858 |
| East South Central (Kentucky, Tennessee and Alabama) | 11,014 | 3,138 | 9,679 |
| West South Central (Oklahoma and Texas) | 6,767 | 636 | 379 |
| Mountain (Colorado and New Mexico) | 2,112 | 1,639 | 1,146 |
| Pacific (Washington, Oregon, and California) | 37,302 | 37,933 | 45,350 |

[1] Shipments were reported for each State listed during the 1961–1963 period with the following exceptions. In 1963 no shipments were reported in Rhode Island, Kansas, Delaware, North Carolina, and South Carolina.

**TABLE 5B.—VALUE OF SHIPMENTS OF SELECTED ATOMIC ENERGY PRODUCTS BY GEOGRAPHIC DIVISIONS AND STATES: 1958–1962**

[In thousands of dollars. This table includes in addition to the products in table 3A, radiation detection and monitoring devices and control and measuring devices containing radioactive isotopes]

<table>
<tr><th>Census geographic division and State [1]</th><th>1962</th><th>1961</th><th>1960</th><th>1959</th><th>1958</th></tr>
<tr><td>United States, total</td><td>263,764</td><td>275,850</td><td>287,570</td><td>242,009</td><td>161,762</td></tr>
<tr><td>New England, total</td><td>52,665</td><td>38,319</td><td>69,362</td><td>43,053</td><td>41,066</td></tr>
<tr><td>Massachusetts</td><td>27,134</td><td>21,772</td><td>35,319</td><td>21,961</td><td>33,112</td></tr>
<tr><td>Rhode Island and Connecticut</td><td>25,531</td><td>16,547</td><td>34,043</td><td>21,092</td><td>7,954</td></tr>
<tr><td>Middle Atlantic, total</td><td>66,993</td><td>85,641</td><td>89,067</td><td>92,195</td><td>52,090</td></tr>
<tr><td>New York</td><td>23,826</td><td>23,944</td><td>26,762</td><td>21,503</td><td>12,210</td></tr>
<tr><td>New Jersey</td><td>4,401</td><td>5,737</td><td>8,954</td><td>14,019</td><td>11,017</td></tr>
<tr><td>Pennsylvania</td><td>38,766</td><td>55,960</td><td>53,351</td><td>56,673</td><td>28,863</td></tr>
<tr><td>East North Central, total</td><td>80,753</td><td>65,282</td><td>63,057</td><td>56,860</td><td>38,276</td></tr>
<tr><td>Ohio</td><td>45,121</td><td>37,572</td><td>40,126</td><td>36,828</td><td>17,898</td></tr>
<tr><td>Illinois</td><td>21,307</td><td>16,413</td><td>14,848</td><td>16,305</td><td>11,955</td></tr>
<tr><td>Indiana</td><td rowspan="2">5,378</td><td rowspan="2">5,942</td><td>3,906</td><td>1,503</td><td>2,707</td></tr>
<tr><td>Michigan</td><td>2,272</td><td rowspan="2">2,224</td><td rowspan="2">5,716</td></tr>
<tr><td>Wisconsin</td><td>8,947</td><td>5,355</td><td>1,905</td></tr>
<tr><td>West North Central (Minnesota, Iowa, Missouri, and Kansas)</td><td>5,407</td><td>5,693</td><td>5,813</td><td>5,897</td><td>2,478</td></tr>
<tr><td>South Atlantic (Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida)</td><td>5,841</td><td>15,053</td><td>10,445</td><td>6,456</td><td>2,354</td></tr>
<tr><td>East South Central (Kentucky, Tennessee, and Alabama)</td><td>3,660</td><td>11,564</td><td>8,744</td><td>11,841</td><td>10,738</td></tr>
<tr><td>West South Central (Oklahoma and Texas)</td><td>1,254</td><td>743</td><td>299</td><td>400</td><td>693</td></tr>
<tr><td>Mountain (Colorado and New Mexico)</td><td>3,744</td><td>2,572</td><td>2,406</td><td>3,649</td><td>2,689</td></tr>
<tr><td>Pacific (Washington, Oregon, and California)</td><td>43,447</td><td>50,983</td><td>38,377</td><td>21,658</td><td>11,378</td></tr>
</table>

[1] Shipments were reported for each State listed in at least one year during the 1958–1962 period. However, in selected years some of the listed States reported no value of shipments, as follows.
1958—North Carolina, South Carolina, Georgia, Kentucky, Alabama, and Washington.
1959—Delaware, North Carolina, South Carolina, Georgia, and Washington.
1960—South Carolina.

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# STATUS OF INDUSTRY SEGMENTS

The following portion of this report presents highlights on the status of the nuclear industry within each of the eight major industry segments. These segments were established in 1962 in cooperation with industry representatives.[7]

[7] See Appendix 4, pp. 476–479, of Annual Report to Congress for 1962.

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### *Raw Materials (Category 1)*

There were no significant changes in private capability in this category in the past year. Details of this segment of the industry will be found under "Raw Materials" in Part Two.

### *Materials Processing and Fabrication (Category 2)*

*Uranium feed preparation.* Both the AEC's Paduch, Ky., and the privately owned Allied Chemical Corp., Metropolis, Ill., uranium hexafluoride plants ceased operations on June 30, 1964. The Allied plant has been placed in a stand-by status and is ready to produce specifications grade $UF_6$ directly from concentrates, or $UF_4$ from refinery uranium oxides, for either private or Commission needs. Reactivation of the Allied plant and/or the establishment of new private $UF_6$ capability will depend upon the Commission's and private future requirements (both domestic and foreign) for $UF_6$.

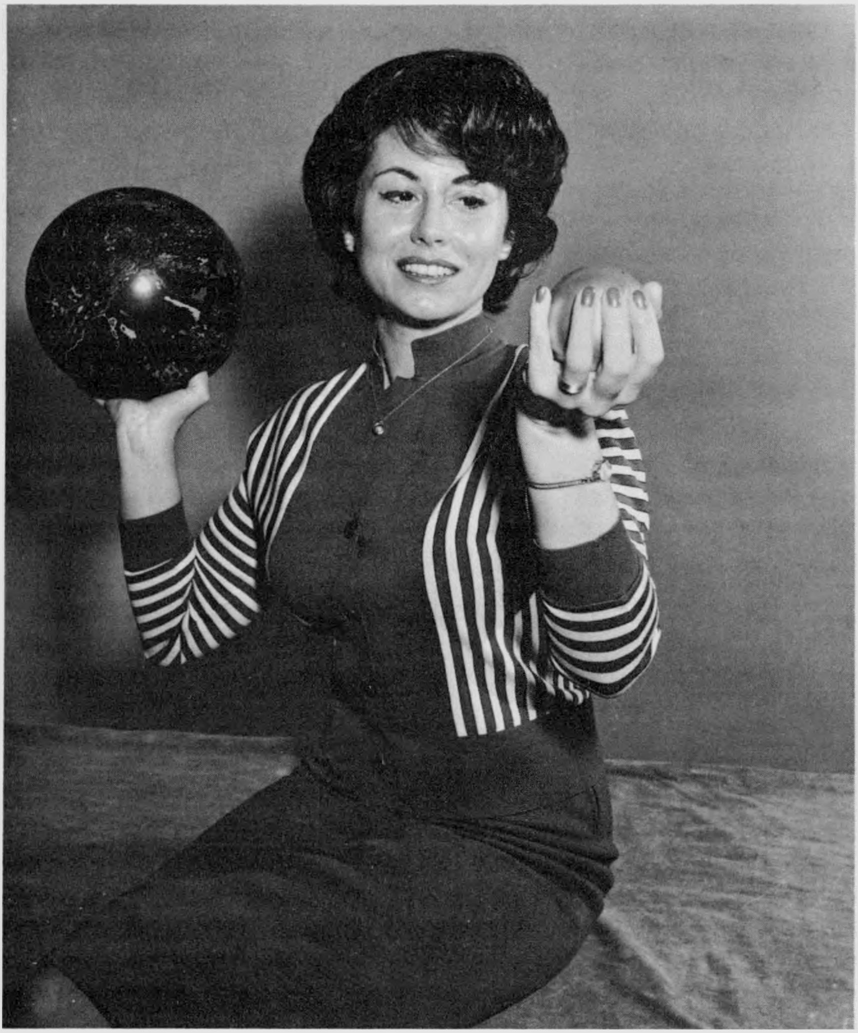
*Uranium enriching.* This continues to be the only portion of the reactor fuel cycle for which a capability has not been established or planned by the private nuclear industry. However, an approach to normal commercial practice is permitted under the private ownership legislation through provision for AEC enrichment of privately owned material.

*Uranium processing.* Adequate industrial capability and competition exists today to convert depleted, normal, or enriched $UF_6$ to any of the required forms for commercial use. The quantities of enriched uranium distributed by the AEC over the years are reflected in Table 6. As noted below, the total quantity of enriched uranium distributed by the AEC in fiscal year 1964 increased slightly as compared to fiscal

TABLE 6.—ENRICHED URANIUM FURNISHED TO INDUSTRY

(Kilograms of uranium)

| Fiscal year | Furnished as $UF_6$ | Furnished in forms other than $UF_6$ | Total |
|---|---|---|---|
| 1956 | 0 | 2, 400 | 2, 400 |
| 1957 | 6, 000 | 4, 000 | 10, 000 |
| 1958 | 24, 000 | 21, 000 | 45, 000 |
| 1959 | 110, 300 | 6, 300 | 116, 600 |
| 1960 | 86, 200 | 3, 400 | 89, 600 |
| 1961 | 118, 400 | 6, 900 | 125, 300 |
| 1962 | 125, 600 | 3, 000 | 128, 600 |
| 1963 | 100, 273 | 3, 916 | 104, 189 |
| 1964 | 116, 401 | 2, 037 | 118, 438 |



*Depleted Uranium.* An employee of Atomics International, Canoga Park, Calif., compares the size of a bowling ball with a dummy uranium casting which would weigh the same. Depleted uranium, a byproduct of nuclear fuel manufacture, is one of the most dense materials known. It makes excellent counterweights and balances for missiles and aircraft. Specialized radiation shields can be made from depleted uranium and it is useful in the manufacture of pigments. Depleted uranium—from which uranium 235 isotopes have been "stripped"— is discharged as a very slightly radioactive waste product from the AEC's uranium enrichment (gaseous diffusion) plants.

year 1963. The increase in total uranium requirements in fiscal year 1964 was due to increase in requirements by AEC programs which were large enough to more than offset sharply reduced foreign requirements.

*Uranium fabrication.* Industrial capability exists to produce various types of fuels and shapes from metal and compounds. No new firms entered this area of activity. During the year, American Radiator and Standard Sanitary Corp. withdrew from this area and assigned all incompleted fuel contracts to Sylvania Electric Products, Inc. AEC orders placed with commercial suppliers for the fabrication of fuel are reflected in Table 7 below.

TABLE 7.—AEC ORDERS FOR FABRICATION OF NUCLEAR FUEL FROM COMMERCIAL SUPPLIERS

(Millions of dollars)

| Fiscal year | Orders placed for— | | Total |
|---|---|---|---|
| | Naval purposes [1] | All other purposes | |
| 1959 | 38. 6 | 2. 8 | 41. 4 |
| 1960 | 48. 6 | 3. 8 | 52. 4 |
| 1961 | 29. 2 | 4. 0 | 33. 2 |
| 1962 | 60. 9 | 4. 5 | 65. 4 |
| 1963 | 36. 8 | 2. 2 | 39. 0 |
| 1964 | 28. 5 | 8. 7 | 37. 2 |

[1] Includes Shippingport (PWR).

Table 7 reflects a substantially higher volume of orders placed in fiscal year 1964 than in any prior year for non-Naval purposes. However, a continuing decrease in the dollar volume of Naval cores ordered resulted in a 1964 total somewhat below 1963. The decrease in Naval dollar value reflects the longer lifetimes now obtainable from nuclear fuel elements plus improved unit production methods.

*Plutonium, thorium, uranium 233.* These materials are currently needed only in limited quantities for research and development purposes. During the year, the Babcock & Wilcox Co. completed a pilot facility at Lynchburg, Va., for developing and testing of thorium and uranium 233 fuel.

### *Nuclear Components and Equipment (Category 3)*

All nuclear components and equipment are available commercially, usually from firms that are not dependent on atomic energy activities for their growth and well-being.

The graph shows shipments of principal reactor components (other than fuel elements and nuclear instruments) as reported by the Bureau of the Census. These components are especially designed for nuclear applications. The relative evenness of shipments over recent years is the most noteworthy feature of this chart. Data on orders received as shown for pressure vessels and control equipment show a clear upward trend.

### *Reactors (Category 4)*

The decision by Jersey Central Power and Light to move ahead with a nuclear plant as a straight economic decision generated a climate of increased optimism during 1964. However, at mid-year the total value of reactors under construction was slightly below the total of a year earlier as shown on Table 8. This is accounted for principally by Consolidated Edison's decision [8] not to go ahead with the Ravenswood nuclear unit.

Nonetheless, the future continues to be viewed with optimism, nuclear plants appear to be competitive with fossil fuel in many sections of the country, and the electric utilities (and their customers) are benefitting from reduced prices and transportation charges for conventional fuels where nuclear plants are being seriously considered.

Tables 8 through 10 summarize information reported to the AEC quarterly. Table 11 summarizes the total of all reactor work on which the AEC has information.

TABLE 8.—DOMESTIC REACTOR PROJECTS UNDER DESIGN OR CONSTRUCTION

| | At June 30, 1963 | | At June 30, 1964 | |
|---|---|---|---|---|
| | Number of projects | Total estimated cost (millions) | Number of projects | Total estimated cost (millions) |
| All projects | 52 | $1, 733. 0 | 41 | $1, 624. 7 |
| Civilian reactor projects | 47 | 1, 407. 6 | 35 | 1, 228. 0 |
| Power prototypes and experiments | 26 | 1, 230. 0 | 20 | 1, 052. 0 |
| Civilian testing | 5 | 85. 5 | 3 | 75. 0 |
| Civilian research | 16 | 92. 1 | 12 | 101. 0 |
| Military reactor projects | 4 | 119. 2 | 5 | 185. 7 |
| Military prototypes, experiments, and field plants | 2 | 103. 9 | 2 | 167. 3 |
| Military testing and research | 2 | 15. 3 | 3 | 18. 4 |
| Materials production reactors | 1 | 206. 2 | 1 | 211. 0 |

[8] See pp. 5, 89, and 363, Annual Report to Congress for 1963.

TABLE 9.—COSTS INCURRED DURING FISCAL YEARS 1963–1964

| | Costs incurred | |
|---|---|---|
| | Fiscal year 1963 (millions) | Fiscal year 1964 (millions) |
| All projects | $216. 5 | $152. 9 |
| Civilian reactor projects | 134. 1 | 108. 1 |
| Power prototypes and experiments | 100. 9 | 70. 2 |
| Civilian testing | 13. 6 | 18. 3 |
| Civilian research | 19. 6 | 19. 6 |
| Military reactor projects | 29. 0 | 30. 2 |
| Military prototypes, experiments, and field plants | 28. 3 | 29. 7 |
| Military testing and research | . 7 | . 5 |
| Materials production reactors | 53. 4 | 14. 6 |

TABLE 10.—COSTS AND ESTIMATES BY SOURCE OF FUNDS

Projects active as of June 30, 1964

| | Costs incurred fiscal year 1964 (millions) | Total estimated costs of projects (millions) | Cumulative costs incurred through June 30, 1964 (millions) | Estimated costs to be incurred after June 30, 1964 (millions) |
|---|---|---|---|---|
| All projects | $152. 9 | $1, 624. 7 | $849. 2 | $775. 5 |
| SOURCE OF FUNDS | | | | |
| Federal Government | 120. 4 | 893. 9 | 633. 6 | 260. 3 |
| Atomic Energy Commission | 109. 7 | 849. 3 | 605. 8 | 243. 5 |
| Department of Defense | 6. 8 | 35. 4 | 22. 3 | 13. 1 |
| Other Federal Agencies | 3. 9 | 9. 2 | 5. 5 | 3. 7 |
| Industry and others | 32. 5 | 730. 8 | 215. 6 | 515. 2 |
| Privately owned utilities | 25. 2 | 618. 0 | 200. 1 | 417. 9 |
| Publicly owned utilities | 3. 5 | 102. 1 | 8. 4 | 93. 7 |
| Manufacturers, universities and States | 3. 8 | 10. 7 | 7. 1 | 3. 6 |

TABLE 11.—TOTAL ESTIMATED COSTS INCURRED FOR ALL REACTOR WORK

| | Fiscal year 1963 (millions) | Fiscal year 1964 (millions) |
|---|---|---|
| Total of projects included in tables 9 through 11 | $216.5 | $152.9 |
| Naval reactors (research and development, nuclear portion of propulsion plants, and propulsion plant fuel) | 196.2 | 219.7 |
| Other military research and development (Army, PLUTO) | 41.1 | 25.0 |
| Space applications (ROVER, SNAP) | 154.1 | 186.6 |
| Other AEC civilian nuclear power research and development | 72.7 | 80.3 |
| All other AEC reactor development work (including nuclear technology and reactor safety) | 126.1 | 140.4 |
| Total—all reactor work | 806.7 | 804.9 |

***Radioisotopes (Category 5)***

The volume of business in the radioisotope field has continued to increase over the years as has the number of individuals and firms licensed to process and utilize byproduct materials. For example, the value of shipments of packaged radioisotopes and radiation sources (as well as shipments of radioisotopes in bulk form) from privately owned plants, as reported by the Bureau of the Census, was $8.0 million in 1962 and $16.0 million in 1963.

Although the packaging and encapsulation of radioisotopes are basically performed by industry, the AEC is still the principal domestic producer and distributor of radioisotopes. In the past year, however, industry has shown an increased interest in, and capability to, produce and distribute radioisotopes. There are now eight principal industrial producers of cyclotron and reactor radioisotopes. Fission product radioisotopes are presently being separated by the AEC from high-level radioactive wastes. The AEC requested bids from industry for construction and operation of a fission product conversion and encapsulation facility for processing long lived fission products that are removed from the Hanford wastes into useful heat and radiation sources. The bid also was to include the operation of the Hanford chemical separations areas. Three bids were received from industry (Dow-Chemical, Martin-Marietta/U.S. Rubber and Monsanto Research/United Nuclear Corp.) and are being evaluated. Tentative planning is for the fission product conversion and encapsulation facility to be operational by 1968. Fission products also could be available, in the future, from commercial firms, such as Nuclear Fuel Services, Inc., who operate chemical processing plants.

Up to now, the AEC has withdrawn from producing and distributing radioisotopes on an *ad hoc* basis. In consultation with the Atomic Industrial Forum's Committee on Radioisotopes the Commission prepared, and had published for comment in the September 15 *Federal Register*, proposed guidelines under which the AEC will withdraw from producing and distributing radioisotopes. It is the intent that these guidelines will furnish a basis on which the Commission can withdraw from this area under established procedures. During 1964, the AEC withdrew from routine distribution of six radioisotopes: chromium 51, iron 55, cobalt 58, cesium 134, cerium 14 and strontium 85.

Industrial interest in radioisotopes has increased steadily in the last few years. Although industry is producing and distributing more radioisotopes each year, AEC sales (distributions outside of AEC) have also increased. Commission sales were $1.2 million in fiscal year 1963 and $1.3 million in fiscal year 1964.

### *Materials Reprocessing (Category 6)*

*Irradiated fuels.* The chemical processing of irradiated fuels in the United States may be divided roughly into three major areas: production loads at AEC sites, power reactor loads, and a variety of highly enriched loads which include Rover, Naval reactors, MTR/ETR/ATR and research reactor fuels.

*Production loads.* The production loads, which are principally normal uranium fuel elements clad with aluminum from reactor operations at Hanford and Savannah River, are processed in AEC facilities. There is substantial overcapacity in this area, and one of the AEC's major installations, the Redox facility at Hanford, is scheduled for shutdown in 1966.

*Power reactor loads.* Capacity for the processing of most power reactor fuel types will be available upon completion of the Nuclear Fuel Services facility at West Valley, N.Y. This plant is expected to begin operations in 1966 with design capacity of one ton of fuel elements per day and is adequate to take over the forecast needs through the early 1970's. Several companies have already shown interest in meeting subsequent projected demands. In August of this year, Dow Chemical Co. and Westinghouse Electric Corp. announced a joint research and development program directed toward advanced methods for processing nuclear fuels. This will include construction in 1965 of a recycle fuels laboratory at an announced cost of $1.7 million. In September, General Electric announced its expectation to build a new facility for processing irradiated nuclear fuel on the West Coast. Construction is to begin in 1967, is expected to cost more than $15 million, and will employ volatility technology.

*Highly enriched loads.* Reprocessing capacity for a number of types of highly enriched fuel is currently available in AEC facilities at Idaho and the Savannah River Plant. In addition, processing capability for highly enriched, aluminum clad fuels will be available from Nuclear Fuel Services. There are large potential loads of highly enriched fuels in the nuclear rocket program for which processing capability does not now exist either in Government or private facilities. Development of new technology for processing these fuels is nearing completion, but plans have not crystallized for full demonstration of these methods or for installation of processing capability for these and other graphite fuels.

*Unirradiated fuels.* Adequate private capability exists to recover enriched uranium from all types and forms of scrap generated within both private and AEC programs. AEC scrap is recovered commercially either as part of a fixed-price fabrication contract or through a scrap recovery program administered by the Oak Ridge Operations Office. Although the total quantity of scrap available for recovery in fiscal year 1964 through the commercial scrap recovery program was greater than that in fiscal year 1963, the dollar value of the awards were about the same ($554,240 in fiscal year 1963 compared to $556,370 in fiscal year 1964). This was due to a slight decrease in unit cost for the recovery of selected lots of material, increased quantity of slightly enriched uranium and a change in the contract terms wherein the AEC assumed responsibility for the shipment of scrap to the commercial recovery sites. Since 1959, contracts totaling $3.9 million have been awarded through the scrap recovery program.

### *Waste Disposal (Category 7)*

*Low-level wastes.* The following information developed from industrial and AEC sources shows the quantity of low-level waste buried in the year ended June 30, 1964, in commercial facilities and the two AEC facilities[9] which formerly accepted off-site shipments from licensees and other sources:

| | *Approximate Quantity Buried (Cubic Feet)* |
|---|---|
| Commercial facilities | 337,500 |
| AEC facilities | 568,400 |

[9] The Oak Ridge National Laboratory in Tennessee and the National Reactor Testing Station in Idaho.

The AEC announced on May 28, 1963, that it would not accept for burial at AEC sites low-level waste shipped from licensees on or after August 12, 1963. Since that date, the AEC has accepted only 487 cubic feet of radioactive waste from commercial organizations or other Government agencies. This was allowed as a special exception to AEC's policy because circumstances made commercial handling impractical. All other materials accepted for burial at the AEC sites after August 12, 1963, were generated on-site or by AEC weapons sites.

The transition from Government operations in the low-level waste burial business to private operations has been smooth. Nuclear Engineering Co. with headquarters at Walnut Creek, Calif., and Nuclear Fuel Services, Inc., of West Valley, N.Y., are now actively engaged in the waste burial business and others are considering going into it. The location of the three commercial burial sites at the present time are: one at Beatty, Nev., one at Morehead, Ky., and one in Cattaraugus County, N.Y. A number of companies are licensed and are operating in the field of receipt, handling, transportation, and delivery of radioactive wastes. At Hanford, Wash., the AEC has leased land to the State for nuclear-related activities.

*High-level wastes.* Currently, high-level wastes are generated and stored only at AEC sites. However, as commercial fuel reprocessing plants come into operation, high-level wastes will be generated at these sites and stored by industrial concerns.

### *Services (Category 8)*

This category covers a broad range of services most of which are common to both nuclear and non-nuclear activities. However, the following areas were of particular interest during 1964:

*Film badge services.* At most AEC sites, operating contractors provide their own film badge services rather than contract for this service with one of some 15 commercial firms supplying this service. A major problem in expanding industrial participation is whether the commercial firms can provide the quality of service desired at prices reasonably close to in-house costs.

The AEC has been working toward a solution of this problem through standardizing film badge specifications and developing testing procedures and standards to provide means of evaluating services provided. An important step during the year was the decision to contract film badge services at the Hanford Plant. Here, the U.S. Testing Co. will buy the Government-owned film badge processing equipment, provide services to the Hanford Plant, and offer film badge services to other commercial users.

*Contaminated laundry services.* A study of commercial decontamination facilities has shown that in two areas where the AEC has heavy loads of contaminated laundry, no commercial decontamination facilities are in existence. Several private companies have indicated interest in the possibility of developing commercial facilities which would use AEC loads as a base and expand into additional nuclear and non-nuclear industrial laundering activity. The AEC is considering the possibility of encouraging establishment of private decontamination laundry operations near its major installations.

## INDUSTRIAL RELATIONS

The Commission's production facilities, research and development centers, test sites are operated primarily by prime cost-type contractors. The Commission's Division of Labor Relations develops AEC-wide policies and standards concerning employment conditions, compensation practices, labor-management relations and disputes settlement, and application of Federal labor law.

## MANPOWER FOR ATOMIC ENERGY

Employment in the atomic energy field totaled about 185,000 in 1964. This represents an increase of some 6,050 persons, or 3.4 percent over 1963.

Employment data in the atomic energy field is compiled and presented in two groups. The first is referred to below as "Industrial Employment" and is based on an annual survey (conducted by the Bureau of Labor Statistics (BLS) for the AEC) of employment as of each January in industrial establishments in the 16 economic segments shown in table 12. These industrial establishments encompass both privately owned, and Government-owned contractor-operated, establishments, including the Commission's major laboratory and research facilities. The second group is referred to as "All Other Employment." It is not surveyed by BLS, but employment estimates are made by the AEC staff. It encompasses the economic segments shown in table 13.

### *Industrial Employment*

The BLS survey shows 1964 employment of 139,492 persons in industrial establishments in the atomic energy field. This is an increase of 3,249, or 2.4 percent over 1963 employment.

A total of 594 establishments was reported in 1964, as compared with 538 in 1963. Employment in 46 Government-owned, contractor-operated establishments (the same number as in 1963) was 103,462 in 1964, an increase of 3.5 percent over 1963. Employment in 548 privately owned establishments was 36,030, in 1964, a decrease of 0.8 percent from 1963.

Table 12 compares, by economic segment, 1963 and 1964 employment in the 594 Government-owned and privately owned industrial establishments covered in the BLS survey.

TABLE 12.—EMPLOYEES IN INDUSTRIAL ESTABLISHMENTS IN ATOMIC ENERGY FIELD BY ECONOMIC SEGMENT AND TYPE OF ESTABLISHMENT OWNERSHIP, JANUARY 1963 AND 1964 [1]

[Preliminary data]

| Economic segment | Number of establishments | | Total employment | | | |
|---|---|---|---|---|---|---|
| | | | 1963 | | 1964 | |
| | Government | Private | Government | Private | Government | Private |
| Commission laboratory and research facilities | 19 | | 44,809 | | 46,739 | |
| Atomic energy defense production facilities | 12 | 7 | 39,258 | 875 | 40,528 | 571 |
| Reactor and reactor component design and manufacture | [2] 2 | 58 | [2] 3,219 | 10,718 | [2] 3,340 | 12,245 |
| Production of feed materials | 6 | 8 | 8,243 | 683 | 7,978 | 643 |
| Nuclear instrument manufacturing | | 115 | | 3,858 | | 3,853 |
| Design and engineering of nuclear facilities | | 42 | | 2,818 | | 2,462 |
| Uranium milling | | 26 | | 2,742 | | 2,255 |
| Private research laboratories [3] | | 50 | | 1,181 | | 1,227 |
| Fuel element fabrication and recovery activities | | 14 | | 2,548 | | 2,236 |
| Production of special materials for reactor use | | 33 | | 1,887 | | 1,757 |
| Particle accelerator manufacturing | | 9 | | 1,200 | | 1,342 |
| Power reactor operation and maintenance | 4 | 10 | 334 | 606 | 360 | 629 |
| Industrial radiography services | | 53 | | 613 | | 600 |
| Processing and packaging radioisotopes | | 22 | | 312 | | 348 |
| Radioactive waste disposal | | 10 | | 50 | | 79 |
| Miscellaneous | 3 | 91 | 4,075 | 6,214 | 4,517 | 5,783 |
| Total | 46 | 548 | 99,938 | 36,305 | 103,462 | 36,030 |

[1] Data for both years based on 1964 survey results.
[2] Data published with consent of employers.
[3] Excludes nonprofit establishments.

Table 13 provides further data from the 1964 BLS survey of employment in industrial establishments. It shows the number of engineers, scientists, technicians, and other employees, as well as the percentage of scientists and engineers who are engaged in research and development, for each economic segment, for Government-owned and privately owned establishments.

### *All Other Employment*

Employment in the atomic energy field, not covered in the BLS survey of industrial establishments, is estimated to have increased from about 42,500 in 1963, to about 45,300 in 1964—an increase of 6.6 percent. Table 14 shows these estimates for 1963 and 1964 (figures for 1963 have been updated from the 1963 Annual Report).

### *Contractor Work Force Composition*

Included in the Government-owned establishments in the atomic energy field are prime contractors engaged in operations, research, development, maintenance, and test activities on a cost-type basis for the Commission.[10]

In November 1964, these contractors numbered 37 and employed a total of 106,735 persons at 56 AEC-controlled or leased installations. About 42 percent of this work force are production and related (blue collar) employees, 25 percent are clerical and related nonmanual, 18 percent are scientists and engineers in nonsupervisory positions, and the remaining 15 percent are executive, administrative, and other professional personnel. In November 1963, contractors classified as above, had employed about 109,000 persons.

## PRODUCTION CUTBACKS AND EMPLOYMENT

Early in 1964, announcement was made of forthcoming cutbacks in production at the gaseous diffusion plants, at the feed materials plants, and at the production reactor facilities, as well as consolidation of facilities in the weapons program. (See Parts One and Two.) It was estimated that these actions, together with various economy measures, would result in reductions of some 6,000 AEC-contractor employees during the period 1964 through 1968.

To conserve the trained and skilled manpower needed in other programs and to alleviate the effects of the layoffs, an employment information program was established. Under the program, an AEC contractor who is recruiting outside of his local area is expected to consider the surplus manpower of other AEC contractors before making selections. Monthly reports of recruitment needs and of surplus manpower are distributed from AEC Headquarters to the contractors. Because of their need for many of the same skills, the surplus manpower reports are also provided to a number of major National Aeronautics and Space Administration contractors.

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[10] See p. 311, Annual Report to Congress for 1963.

TABLE 13.—EMPLOYEES BY OCCUPATIONAL GROUPINGS IN GOVERNMENT AND PRIVATE INDUSTRIAL ESTABLISHMENTS BY ECONOMIC SEGMENT AND TYPE OF ESTABLISHMENT OWNERSHIP, JANUARY 1964

[Preliminary data]

| | Total employees | | Scientists | | Engineers | | Technicians | | All other employees | | Percent S&E in R&D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Government | Private | Government | Private | Government | Private | Government | Private | Government | Private | Government | Private |
| Commission laboratories and research facilities | 46, 739 | ------ | 6, 362 | ------ | 7, 848 | ------ | 9, 535 | ------ | 22, 994 | ------ | 87. 2 | ------ |
| Atomic energy defense production facilities | 40, 528 | 571 | 1, 629 | 6 | 3, 393 | 105 | 3, 877 | 59 | 31, 629 | 401 | 31. 9 | 70. 3 |
| Reactor and reactor component design and manufacture | [1] 3, 340 | 12, 245 | [1] 208 | 766 | [1] 1, 313 | 3, 361 | [1] 671 | 2, 422 | [1] 1, 148 | 5, 696 | [1] 90. 9 | 62. 6 |
| Production of feed materials | 7, 978 | 643 | 419 | 48 | 541 | 31 | 525 | 67 | 6, 493 | 497 | 35. 8 | 20. 3 |
| Nuclear instrument manufacturing | ------ | 3, 853 | ------ | 246 | ------ | 659 | ------ | 884 | ------ | 2, 064 | ------ | 52. 3 |
| Design and engineering of nuclear facilities | ------ | 2, 462 | ------ | 97 | ------ | 833 | ------ | 628 | ------ | 904 | ------ | 8. 5 |
| Uranium milling | ------ | 2, 255 | ------ | 30 | ------ | 136 | ------ | 123 | ------ | 1, 966 | ------ | 10. 2 |
| Private research laboratories [2] | ------ | 1, 227 | ------ | 356 | ------ | 202 | ------ | 349 | ------ | 320 | ------ | 77. 4 |
| Fuel element fabrication and recovery activities | ------ | 2, 236 | ------ | 64 | ------ | 230 | ------ | 429 | ------ | 1, 513 | ------ | 40. 8 |
| Production of special materials for reactor use | ------ | 1, 757 | ------ | 91 | ------ | 267 | ------ | 274 | ------ | 1, 125 | ------ | 61. 2 |
| Particle accelerator manufacturing | ------ | 1, 342 | ------ | 77 | ------ | 256 | ------ | 388 | ------ | 621 | ------ | 48. 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Power reactor operation and maintenance | 360 | 629 | 16 | 10 | 83 | 116 | 66 | 118 | 195 | 385 | ------ | 4. 0 |
| Industrial radiography services | -------- | 600 | ------- | 8 | ------- | 28 | ------- | 546 | ------- | 18 | ------ | 5. 6 |
| Processing and packaging radioisotopes | -------- | 348 | ------- | 113 | ------- | 22 | ------- | 139 | ------- | 74 | ------ | 25. 9 |
| Radioactive waste disposal | -------- | 79 | ------- | 3 | ------- | 5 | ------- | 22 | ------- | 49 | ------ | ------ |
| Miscellaneous | 4, 517 | 5, 783 | 8 | 87 | 93 | 668 | 167 | 485 | 4, 249 | 4, 543 | ------ | 31. 9 |
| Total | 103, 462 | 36, 030 | 8, 642 | 2, 002 | 13, 271 | 6, 919 | 14, 841 | 6, 933 | 66, 708 | 20, 176 | 71. 8 | 50. 0 |

[1] Data published with consent of employers.
[2] Excludes nonprofit establishments.

TABLE 14.—NUMBER OF EMPLOYEES IN ALL OTHER EMPLOYMENT (NOT IN INDUSTRIAL ESTABLISHMENTS) IN ATOMIC ENERGY FIELD, BY ECONOMIC SEGMENT, JANUARY 1963 AND 1964.

| Economic segment | Estimated total employment | |
|---|---|---|
| | 1963 | 1964 |
| Uranium mining | 3, 600 | 3, 400 |
| Uranium mining support personnel | 1, 200 | 1, 100 |
| Private non-profit research and development laboratories | 2, 000 | 2, 500 |
| University research and teaching personnel | 15, 500 | 17, 000 |
| Construction of nuclear facilities | 12, 000 | 13, 000 |
| Federal service | 8, 200 | 8, 300 |
| Total | 42, 500 | 45, 300 |

Source: Estimates by AEC Staff.

This employment information program, which was in operation for the last seven months of 1964, supplements efforts of state employment offices, as well as the normal placement efforts of AEC contractors.

At the Savannah River, S.C., Plant, operated for the AEC by E. I. du Pont de Nemours Co., a reduction of 584 persons occurred between January and July 1964, but with only 30 employees being terminated involuntarily. This was attributable principally to two factors: temporary modification of the contractor's severance pay plan, and several months advance notice of the general effect of the cutback, both of which greatly facilitated relocations, new employments, and other personal adjustments.

## CONTRACTOR EMPLOYEE WORKING CONDITIONS

### *Earnings*

About 36,080 employees of the 37 prime cost-type contractors in AEC installations are exempt from the overtime provisions of the Fair Labor Standards Act. In November 1964, these exempt employees averaged $972 in base monthly earnings—a 4.7 percent increase over November 1963. Earnings of the nonsupervisory scientists and engineers, who represent 54 percent of the "exempt" group, increased 4.2 percent—from $925 to $964. The remainder of the "exempt" group averaged $981 in November 1964, or 5.4 percent higher than the same month of 1963. During this same period, earnings for clerical and related employees increased 3.8 percent, with the November 1964 level averaging $2.98 per hour in straight-time pay. The average hourly straight-time rate for production and related workers was $3.21 in November 1964, compared to the 1963 November average of $3.14—an increase of 2.2 percent.

### *Equal Employment Opportunity*

In accordance with Executive Orders 10925 (1961) and 11114 (1963), as of November 30, 431 equal employment opportunity compliance reviews had been conducted at facilities of companies in which AEC has a predominant interest. At the end of November, the number of contractor facilities in which the AEC is responsible for review of equal employment compliance was approaching 1,000. During the year, 12 complaints of alleged discrimination by contractors where AEC has program responsibility were referred by the President's Committee on Equal Employment Opportunity to AEC for investigation and resolution. Eight have been completed and submitted to the President's Committee. The committee, at year's end, had closed six of these complaints.

### *Collective Bargaining Activities*

The "nonexempt" work force of 37 prime cost-type contractors (excluding construction contractors) totaled 70,600 in November 1964. Of this group, about 32,400 or 45.9 percent are represented by labor unions and are covered by 109 collective bargaining agreements as shown below:

| Union organization | Approximate representation | Percent |
|---|---|---|
| Metal Trades Council (AFL–CIO) | 11, 565 | 35. 3 |
| International Association of Machinists (AFL–CIO) | 7, 010 | 21. 4 |
| Oil, Chemical and Atomic Workers International Union (AFL–CIO) | 3, 255 | 9. 9 |
| Miscellaneous unions (excluding guards, but including crafts) | 7, 460 | 22. 8 |
| Miscellaneous Guard Unions (Independent) | 1, 600 | 4. 9 |
| Office Employees International Union (AFL–CIO) | 1, 850 | 5. 7 |
| Total | 32, 740 | 100. 0 |

During the first 10 months of 1964, 26 of these labor agreements have been involved in negotiations of either renewal of contract terms or modifications as provided in reopening provisions. Under longstanding procedures, the Atomic Energy Labor-Management Relations Panel may intervene in such negotiations in order to promote

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settlement through collective bargaining and to assure continuity of operations.

During the first 10 months of 1964, the Panel intervened in seven disputes, as follows:

(*1*) General Electric Co., Hanford, and Hanford Atomic Metal Trades Council, AFL–CIO;
(*2*) Reynolds Electrical and Engineering Co., Nevada Test Site, and Teamsters Local 631 representing firefighters;
(*3*) Reynolds Electrical and Engineering Co., Nevada Test Site, and Office Employees International Union, AFL–CIO;
(*4*) Mason & Hanger-Silas Mason Co., Inc., Burlington, Iowa, and Craft Group I (various craft unions);
(*5*) Mason & Hanger-Silas Mason Co., Inc., Burlington, Iowa, and Craft Group II (various other craft unions);
(*6*) Reynolds Electrical and Engineering Co., Nevada Test Site, and Culinary Workers and Bartenders Union, AFL–CIO; and
(*7*) Pan American World Airways, Nuclear Rocket Development Station, and Transport Workers Union, AFL–CIO.

In case 1 above, settlement was reached by the parties without Panel participation. In the remaining cases, the Panel's recommendations for settlement were accepted by the parties.

### *Work Stoppages*

Work stoppages during the period January through September 1964 produced 316,777 man-hours of idleness compared with 945,406 man-hours lost in 1963. This amounts to 0.17 percent of the man-hours scheduled for the period. Of this lost time, 215,166 hours, or about 68 percent, are attributed to strikes by employees at the Nevada Test Site (NTS). Both operations and construction are affected by NTS stoppages since the work force is engaged in both activities.

In strikes other than at NTS, 35,295 man-hours were lost in operations, and 66,316 man-hours were lost in construction.

### *Labor Relations at Nevada Test Site*

Efforts were continued to attain labor stability and economy on construction work at the Nevada Test Site, including the joint AEC–NASA Nuclear Rocket Development Station. Review and analysis by expert consultants led to a consensus that collective bargaining agreements, generally based on area conditions but specifically tailored to the site's programs and requirements, would be desirable for all concerned.

A management team of construction contractors, led by a consultant well experienced in the negotiation and administration of labor agreements, was, at year's end, engaged in discussion of such agreements with national and local labor representatives. Also sought was an agreement to be applicable to operations and maintenance work performed by Reynolds Electrical & Engineering Co.

### *Labor Relations Problems in Contractor Replacement at Hanford*

Plans to replace the General Electric Co. as the single operating contractor at Hanford with several new contractors (see Part One) raised problems involving the transfer of personnel and the maintenance of favorable employee relations during a period in which production and employment would be reduced. The objectives are continuity of operations during and after replacement, retention of trained and skilled personnel needed for on-going operations, and protection of employee interests, based on past service, in job retention and in other conditions of employment. At year's end, new contractors were showing a cooperative attitude.

## WORKMEN'S COMPENSATION STANDARDS

Consideration of the question of workmen's compensation in relation to radiation injury gained impetus during the year through Federal and State actions.

### *Federal Activity*

The first three of a series of studies, under the joint sponsorship of AEC and the Labor Department, were initiated during the year. Contracts were let to: (*a*) Woodward & Fondiller, Inc., New York City, for a study of the value and use of radiation exposure records, and of the preferable method of maintaining them for use in the event of injury or death alleged to have resulted from exposure to radiation; (*b*) the University of Wisconsin, Madison, Wis., for a study to identify and analyze ways of improving state workmen's compensation protection against the hazards of nuclear radiation; and (*c*) Georgetown University Law School, Washington, D.C., for a study of the processing of injury claims arising from employee ionizing radiation exposure, including detailed analysis of information obtained from court and administrative agency records and of the experience of Federal and State authorities in processing such claims. All of the studies are to be completed by July 1965.

### *Cooperation With States*

The Council of State Governments' Advisory Committee on Workmen's Compensation, on which an AEC staff member continued to serve, completed work on the procedural provisions for its comprehensive Workmen's Compensation and Rehabilitation Law. The substantive provisions for this proposed law, which were drafted in 1962, meet many of the problems related to radiation but do not treat some (e.g., record keeping) in anticipation of the studies mentioned under "Federal Activity," above. This model law, including the procedural provisions recently completed, will be included in the Council's Suggested State Legisation Program for 1965.

## OPERATIONAL SAFETY

The Atomic Energy Commission has made "safety a way of life" in its activities. This comment [11] came as the AEC completed its 18th year, and is well demonstrated by the maintenance of an accident prevention record comparable to those industries designated by the National Safety Council (NSC) as the top three. During 1964, the overall frequency rate of 1.96 (as of December 1) was well below the all-industrial rate of 6.12 as reported to NSC.

### *Accidents and Property Damage*

Seven deaths in 1964 resulted from industrial type accidents (none from radiation) as compared to nine in 1963. One of the accidents at the Nevada Test Site which resulted in a fatality received considerable publicity when an electrician was killed and four men trapped 1,800 feet below ground. The accident occurred on September 19, 1964, while signal cables were being lowered from spools into a test hole. The spools were jerked from their racks when a hoist rig cable broke, killing one man and slightly injuring three others. The cables fell into the hole, clogging the shaft and trapping four men in a chamber adjacent to the shaft. All were rescued, unharmed, four days later. (A licensee accident fatality is discussed on page 330.)

The AEC property damage ratio of 0.941 cent was well below the AEC 18-year average of 2 cents/$100 of AEC property evaluation. Of the total property damage of $1,300,000 (as of December 31, 1964), eight accidents each resulted in a loss of $50,000 or more. The largest was a $250,000 roof fire at the Aquatic Biology Laboratory at the Hanford Plant on November 3, 1964.

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[11] Made by Howard Pyle, President of the National Safety Council.

***Radiation Incidents***

Among the 65 Type A and B incidents [12] (as of December 31, 1964), there were 13 radiation exposures: 6 internal exposures; 2 exposures to hands, and 5 whole body exposures in excess of 3 *rem* during 1 calendar quarter. Only one of the latter four received more than the maximum average yearly exposure (five *rem*) recommended by the Federal Radiation Council for persons working in atomic energy plants; this one exposure was 8.2 *rem*. The Council, established by law to guide all Federal agencies using or regulating the use of radioactive material, has stated that these limits "represent an appropriate balance between the requirements of health protection and of the beneficial uses of radiation and atomic energy".

One of the incidents, a chemical explosion on June 12, 1964, during a plutonium chip-degreasing process at Dow Chemical Co., Rocky Flats, Colo., resulted in a lost-time injury when the left thumb and index finger of an employee were removed to effect decontamination because small particles of plutonium had become embedded in them.

## WALSH-HEALEY ACT

The Atomic Energy Commission and the Department of Labor (DOL), on May 26, 1964, signed an agreement under which the AEC assumes [13] certain inspection and administrative responsibilities concerning compliance, by AEC contractors in Government-owned or -controlled facilities, with the AEC-prescribed health and safety standards in lieu of the Walsh-Healey Safety and Health Standards for Federal Supply Contracts, CFR Title 41, Part 50–204. The agreement eliminated the possible duplication of inspection effort by AEC and DOL personnel and will effect a considerable saving in both time and manpower required to assure compliance with provisions of the Walsh-Healey Act.

Following a series of discussions with the DOL and representatives of organized labor, the AEC clarified two aspects of its radiation protection policy governing its contractors to eliminate unnecessary differences with the policy in the AEC's Regulatory requirements. They were:

(*1*) AEC contractors operating plants and facilities under a contract, which contains the standard health and safety clause, will be required to post a notice to employees entitled, "U.S. Atomic Energy Commission Radiation Protection Standards."

[12] Type "A" incidents require immediate notification to AEC Headquarters, and Type "B" require reporting within 72 hours. Descriptions of these incidents will be published in TID 5360, Supp. 5. "A Summary of Industrial Accidents in USAEC Facilities (1963–64)," available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[13] Through its Division of Operational Safety.

(2) AEC Field Office Managers will assure that significant radiation safety operating procedures of AEC contractors are periodically (at least once a year) reviewed for adequacy by the AEC.

## NUCLEAR TEST SAFETY

Before every nuclear detonation, an advisory panel of experts carefully weighs all of the factors that insure safety. On the panel are representatives from the fields of public health, medicine, meteorology, fallout phenomenology, blast and thermal effects, etc. In support of the operational procedures to assure safety to the public, there are extensive basic and applied research studies conducted in such fields as meteorology, hydrology and ground motion. These are accomplished by (*a*) cooperation with other Government agencies including the U.S. Weather Bureau, U.S. Public Health Service, U.S. Geological Survey, U.S. Bureau of Mines and U.S. Coast and Geodetic Survey; (*b*) contracts with consulting organizations such as Roland F. Berrs, Inc., Alexandria, Va., Hazleton-Nuclear Science Corp., Palo Alto, Calif., Holmes & Narver, Inc., Los Angeles, Calif., and John A. Blume Associates, Los Angeles; and (*c*) use of services and various laboratories and scientific and technical consultants.

## TEST SITE MONITORING

By agreement with the AEC, off-site radiological monitoring near the Nevada Test Site is conducted by the U.S. Public Health Service. This off-site area extends to a radius of approximately 300 miles.

### *Off-Site Radiation Exposures*

Film badges were issued to approximately 190 persons and placed at 72 stations in areas around the Nevada Test Site. The badges were exchanged about every month. No badge indicated an exposure greater than the lowest detectable limit of 20 milliroentgens. Natural background radiation in these areas is about 10–15 milliroentgens per month, as calculated from gamma dose-rate recorders operated on a continuous basis.

### *Milk Monitoring (Network)*

From January 1, 1964, to June 30, 1964, about 145 routine milk samples were collected from 30 different places around the Nevada Test Site. Of these milk samples, only one was found with an iodine

131 level above the 10 picocuries [14] per liter (1.05 liquid quarts) limit of detection for routine samples. This sample contained 20 picocuries per liter which is comparable to those levels found in other locations within the established network of the U.S. Public Health Service for the same sampling period. These routine samples do not include special samples collected as a result of the Pike event which occurred on March 13, 1964.

### *"Pike" Venting*

The Pike event [15] of March 13, 1964 (see Military Applications, Part Two), which released radioactivity off-site, resulted in detectable levels of iodine 131 activity in milk samples collected in off-site areas. As a result of the Pike event, 450 special milk samples were collected in areas where any deposition of radioactive debris was suspected. These areas were in Nevada, California, New Mexico, Arizona, and Texas.

Although low levels of radioiodine appeared in some samples of milk from individual farms, none were found in commercially available milk at any location sampled. All of the cows in the Las Vegas areas were on dry feed at that time of year. The highest concentration of iodine 131 in milk from cows fed dry feed in Las Vegas was 70 picocuries per liter.

As an experiment, fresh cut green feed (called green chop) was supplied to six animals selected for experimental purposes at two Las Vegas farms. The highest iodine 131 levels in the milk from the experimental cows fed on green chop peaked at 420 picocuries per liter on March 21, 1964. The levels dropped to 70 picocuries per liter by March 31, and to background level by April 4, 1964. If a person were to have drunk the milk containing the highest measured amounts of iodine 131, the total intake of this radioisotope would have been only a small fraction of the Federal Radiation Council's guide even for normal peacetime operations.

The highest potential out-of-doors external gamma radiation exposure at populated areas (based on radiation monitors survey instruments) was about 18 milliroentgens at Cactus Springs, Nev. The next highest was about 6 milliroentgens at Indian Springs, Nev., and the third highest was less than 1 milliroentgen at Las Vegas, Nev. (based on automatic recording instruments).

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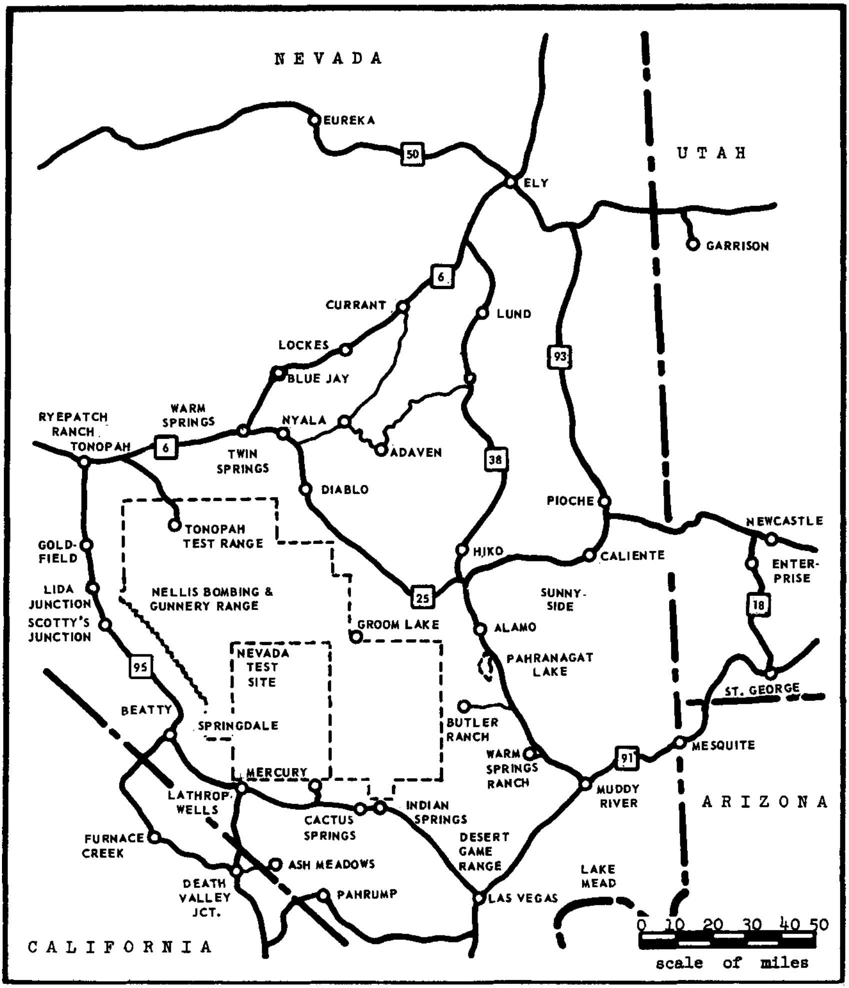
[14] A picocurie is equal in activity to one-millionth of one-millionth of a gram of radium The radiation protection guide established by the Federal Radiation Council for normal peacetime operations is equivalent to the annual ingestion of about 90,000 picocuries of iodine 131 for individuals and about 30,000 picocuries for population groups.

[15] Additional information of this, and other, tests is included in *Radiological Health Data*, Vol. V, No. 8, August 1964; available from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402, at $0.50 per copy.




*Monitoring Stations.* Map shows location of the AEC's Nevada Test Site and communities where monitoring is conducted to detect any off-site radioactivity caused by nuclear weapons tests and other developmental work. Map does not show the new 166-square mile Pahute Mesa area which was added to the test site during the year and which extends out from the northwest corner of NTS.

## *"Eagle" Venting*

Following the Eagle event [16] of December 12, 1963, all instrument readings obtained by aerial and ground monitors off the Nevada Test Site were essentially background. However, filters and charcoal car-

[16] Event was not included in nuclear detonations table, p. 418, of Annual Report for 1963.

tridges on high volume air samplers collected small amounts of short-lived fission products at four of the routine air sampling stations. The highest level of short-lived activity found at any station was 20 picocuries per cubic meter of iodine 133 (extrapolated to end-point of collection) on a filter at Death Valley Junction, Calif., for a 9:30 a.m.–3:50 p.m. collection period on December 12 (iodine 131 was not detected). A charcoal cartridge on an air sampler at the same station collected 15 picocuries per cubic meter of iodine 133 between 9:30 a.m. and 5:05 p.m., December 12 (iodine 131 was not detected).

No fresh fission products (such as iodine 131) were detected in any milk samples.

### *Kiwi Release*

In May 1964, the Kiwi-B4D experimental space propulsion reactor (see Nuclear Reactor Programs, Part Three) was operated at full power at the Nuclear Rocket Development Station in Nevada. Following this reactor run, 76 special milk samples were collected in off-site areas. These samples were in addition to the routine sampling program in the area of collection. Twenty-two of the 76 samples exceeded the detectable level of 20 picocuries per liter of iodine 131 (20 picocuries per liter is the most reliable detection level where the counting time has been reduced to accommodate the large number of samples to be processed). The maximum result was 140 picocuries per liter at Casey Ranch near Adaven, Nev., on May 17. Iodine 131 levels in the milk had dropped to nondetectable quantities by June 2, 1964.

### *Gross Beta Air Activity*

During the 1964 operations at the Nevada Test Site, there were approximately 35 permanent air sampling stations located in populated areas surrounding the Nevada Test Site and operating 24 hours per day. During periods of nuclear testing, this network was supplemented with mobile air samplers placed at other strategic locations. While the gross beta activity in the air has little value in determining radiation doses to persons, the data obtained by air samplers are used by the off-site monitering group as an indication of presence of airborne radioactivity in a specific area and to determine the areas where milk, water and vegetation samples should be collected.

Table 15 summarizes the highest gross beta activity found on a single air particulate sample for each month.

TABLE 15.—HIGHEST AIR PARTICULATE GROSS BETA ACTIVITY IN POPULATED AREAS FOR EACH MONTH

[January 1, 1964–June 30, 1964]

| Month | Location | Collection period (hour/day) | Gross beta (pc/m³) |
|---|---|---|---|
| January | Blue Jay, Nev | 0700/31 to 0700/01 | 9.3EC. |
| February | Eureka, Nev | 0700/27 to 0700/28 | 6.8EC. |
| March | Cactus Springs, Nev | 0840/13 to 1120/13 | 50,000EC. |
| March | Cactus Springs, Nev | 1128/13 to 1503/13 | 9,000EC. |
| March | Cactus Springs, Nev | 1505/13 to 1141/14 | 23EC. |
| April | Hiko, Nev | 0900/24 to 0900/25 | 13.0EC. |
| May | Diablo, Nev | 0715/13 to 1637/13 | 1,500EC. |
| June | Sunnyside, Nev | 2340/17 to 0128/18 | 42.0EC. |

EC—Corrected to end of collection.

### *Water Supplies*

Domestic water supplies are monitored for gross beta radiation in the off-site area around the Nevada Test Site. There are no known surface water supplies for human use in the nearby off-site area, except for Lake Mead, south and east of Las Vegas. A total of 195 routine water samples was taken in 42 areas around the Nevada Test Site, including Lake Mead. The highest levels of gross beta activity in samples taken between January 1, 1964, and June 30, 1964, were all less than 50 picocuries per liter, except for four samples which were 50, 66, 99, and 205 picocuries per liter. These values are generally comparable to those obtained by the U.S. Public Health Service in raw surface water in other areas of the United States.

## CONTRACTING POLICY

### *Small Business*

A determined effort to further increase the percentage of AEC procurement dollars going to small business continued during the year. During the fiscal year 1964, small business received subcontract awards totaling $364.9 million or 47.2 percent of the AEC's $772.8 million total subcontract awards. By comparison, the small business share for the fiscal year 1963 was 45.0 percent and for the period 1951–64 was 41.0 percent.

The best opportunity for substantially increasing the small business share in the buying program—both AEC direct procurement and AEC contract dollars going to subcontractors—appears to be through increased emphasis of the set-aside[17] program. Use of set-asides in AEC procurement was expanded and major cost-type contractors were further encouraged to participate in the set-aside program where such participation would not have the effect of restricting competition or increasing the cost of performance. An agreement with the Small Business Administration was extended to include set-asides for advertised construction contracts between $2,500 and $500,000.

## CLASSIFICATION AND DECLASSIFICATION

### *New Classification Policy*

As part of its dynamic declassification policy which has already helped make possible the establishment of large atomic energy industries, the AEC conducted a further comprehensive study of its reactor classification policy during 1964. As a result, most of its research and development work on reactor materials will be conducted on an unclassified basis.

Following the decision to place four production reactors in standby, the AEC declassified certain information concerning their design and construction. An appreciable amount of additional information concerning the largest graphite-uranium and heavy water-uranium reactors in the United States was thus made available to industry.

The AEC, working with the Department of Defense, has determined that only research and development work on or with lasers or laser systems with a maximum output of $10^{11}$ watts or more and a total energy of $10^3$ joules or more, or application of lasers in the atomic energy or other classified fields may require classification under the espionage laws or the Atomic Energy Act.

### *Document Declassification*

As part of its continuous review of classified documents to declassify as many as possible when changes in classification rules permit, the AEC sends out teams to review the classified holdings of former AEC contractors. These reviews result in making most of the technical information in these files, which has been generated through AEC-sponsored activities, available to industry and to the

[17] "Set-asides" for small business are either partial or total. In a partial set-aside, a portion of the total quantity to be procured is advertised on an unrestricted basis, with both large and small business concerns competing, and the remaining portion is limited to small business concerns who submitted bids within 120 percent of the low bid on the unrestricted part. The price paid on the restricted portion cannot exceed the highest price paid on the unrestricted portion. In the case of a total "set-aside," the entire quantity procured is restricted to small business concerns.

scientific community on an unclassified basis. It also makes possible the reduction or closing of the expensive storage facilities maintained by such contractors. This program was speeded up in 1964 as part of the AEC's overall cost reduction program. During the year, information stored at 14 such facilities was reviewed with the resulting declassification of 5,900 documents. In addition to these former contractor reviews, 17,000 documents were reviewed for declassification during 1964 with 14,500 being declassified to bring the total since the beginning of the declassification program in 1946 to 322,000 documents which have been made available on an unclassified basis to industry and science.

# PUBLIC INFORMATION PROGRAM

The AEC conducts an active public information program to broaden the understanding of the atomic energy field. Activities include distributing news releases, photographs, motion pictures and film footage, and responding to inquiries from the press and the public.

AEC installations provide speakers for groups interested in atomic energy matters, and make arrangements for newsmen to visit AEC sites to observe and to discuss work with scientific personnel. Tours for students to encourage them to consider careers in nuclear energy are arranged at various Commission installations.

## FILMS

Stocked with prints of more than 300 popular and professional-level films during 1964, the AEC's ten domestic film libraries loaned prints for some 100,000 showings which were viewed by an estimated 4,500,000 persons in high schools, colleges and universities, industrial organizations, labor organizations, scientific and engineering groups, service clubs, etc. Television audiences also viewed many of these films through educational and commercial channels. The film libraries and the geographical areas they serve are listed in Appendix 4.

### *International Aspect*

Loans of approximately 170 motion pictures, largely on a professional level, were made from the Commission's liaison offices in London, Tokyo, Brussels, and Buenos Aires, the latter two supplying French and Spanish versions of about 75 of these films. The use of AEC films by foreign scientific, industrial, and educational organizations has greatly increased during the past year.

A depository of atomic energy films, both English and French versions, was established during the year at the National Science Film Library of Canada in Ontario to serve the needs of Canadian scientists, industry, universities, and scientific and educational organizations. The AEC continued to supply films to the American Film Library in The Hague, Holland, the film library of the International Atomic Energy Agency in Vienna, and to the United States Information Service office in Stockholm for use throughout Scandinavia.

### *New Films*

The Commission added 50 films to its motion picture libraries during the year (see Appendix 4). Featured among these motion pictures was an hour-long television film, "Man and The Atom," the story of the AEC's role in developing and guiding the Nation's atomic energy program, a production of National Educational television which was sponsored by the AEC. Also released during the year were nine films of the "Challenge II" series, produced by National Educational Television for the AEC's Argonne National Laboratory. This series, as did the previous Challenge series, explores the work of Argonne scientists.

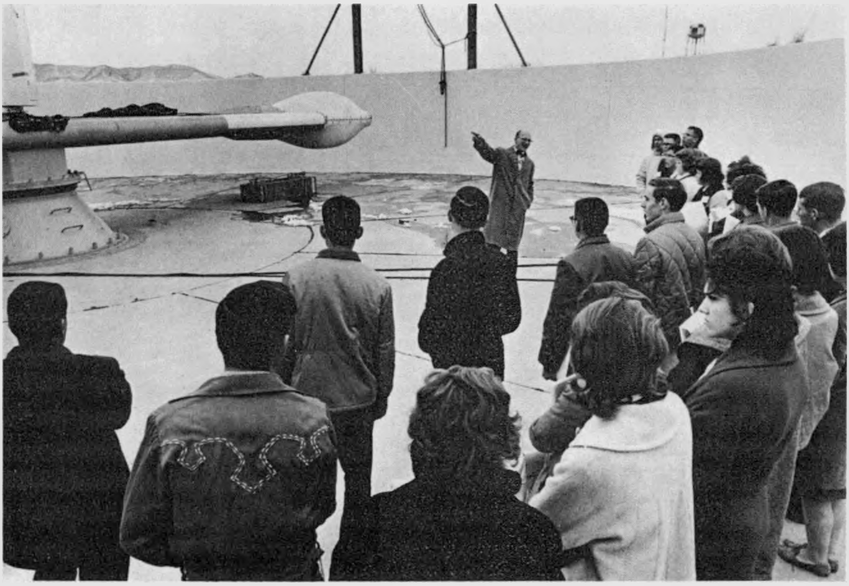
### *Geneva Conference Films*

Twenty-four films were selected for showing at the Third U.N. International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, Switzerland. These films were produced by the AEC's Argonne National Laboratory, Donner Laboratory, Lawrence Radiation Laboratory, and private industry. All had English, French, Spanish, and Russian sound tracks. After the conference they were released to the Commission's film libraries for general distribution to professional level audiences. One of the films, "Fusion Research," produced by Argonne National Laboratory, subsequently won first prize, over 44 finalists from 20 nations, at the Third International Festival of Industrial and Commercial Films at the University of Brussels.

## YOUTH ACTIVITIES

### *Edison Day Tours*

For the eighth consecutive year, the AEC participated in the Thomas Alva Edison Foundation's international "Science Youth Day" commemorating the 117th anniversary of Edison's birth.



*Edison Day Tours.* More than 4,500 students toured AEC's research and development installations as a part of the Thomas Alva Edison Foundation's "Science Youth Day" on February 11. In photo *above,* the operation of Sandia Laboratory's centrifuge, believed to be the largest in the world, is explained to some of the 122 high school students who visited Sandia on the 117th anniversary date of Edison's birthday. The centrifuge is used to test the effect of high accelerations on materials and weapons components. In photo *below,* three Long Island students study a Brookhaven National Laboratory display of the molecular structure of the amino acids which play an important part in the body's building of proteins.

More than 4,500 junior high and high school science students and their teachers visited 12 AEC installations throughout the United States. Participating facilities included Argonne National Laboratory, Argonne, Ill.; Atomic International, Canoga Park, Calif.; Battelle Memorial Institute, Columbus, Ohio; Brookhaven National Laboratory, Upton, Lond Island, N.Y.; the Hanford Plant, Richland, Wash.; Los Alamos Scientific Laboratory, Los Alamos, N. Mex.; Sandia Laboratory, Albuquerque, N. Mex.; Mound Laboratory, Miamisburg, Ohio; Nuclear Rocket Development Station, Nevada; National Reactor Testing Station, Idaho Falls, Idaho; Oak Ridge National Laboratory, Oak Ridge, Tenn.; and the Savannah River Plant, Savannah River, S.C.

## PATENT MATTERS

### *Availability of Patent Information*

In implemention of its program of dissemination of information and data to the public, the AEC has made inventions and patents available through various publications. Abstracts of patents are prepared, listed separately, and distributed as press releases.[18] In turn, technical journals such as "Nuclear Science Abstracts" select those abstracts in their particular field of interest for publication. The Small Business Administration publishes a brochure which includes those patents deemed of interest to small business; and the United States Patent Office, in the weekly "Official Gazette," publishes summaries of recent issued patents as well as periodic listings of AEC patents available for licensing.

### *1964 Issuances*

During the period November 26, 1963–November 24, 1964, the United States Patent Office issued 230 patents to the AEC. As a result, the portfolio of Government-owned United States patents, administered by the AEC and available for licensing, numbers 3,409 domestic patents. In addition, 388 foreign patents issued during this period including 56 British, 43 Belgian, 47 Canadian, 47 French, 52

[18] Listings published as Commission press releases during 1964: No. IN–470 (French Patents), January 6; IN–480 (U.S. Patents), March 17; No. IN–494 (U.S. Patents), June 2; No. IN–499 (U.S. Patents), June 17; No. IN–508 (Japanese Patents) August 10; No. IN–513 (British Patents), September 8; No. IN–516 (U.S. Patents), September 17; No. IN–519 (German Patents), October 1; No. IN–522 (French Patents), October 8; No. IN–526 (U.S. Patents), November 3; No. IN–532 (Canadian Patents), November 12; No. IN–535 (U.S. Patents), November 20; No. IN–549 (Italian Patent), December 30. Copies of these releases are available from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C., 20545.

German, and 40 Japanese. The balance consists of patents issued by 15 other countries.

During 1964, the AEC granted 46 nonexclusive licenses on Government-owned United States patents. At present, 1,049 nonexclusive licenses have been issued on 558 of the 3,409 Government-owned patents administered by the AEC. In addition, 561 nonexclusive licenses have been retained by contractors. Contractors have retained exclusive licenses in fields other than atomic energy on 329 patents. In 397 instances, the title and rights in the patents are vested in the contractors, subject to a nonexclusive license in the Government for governmental purposes.

### *Private Atomic Energy Applications*

In the past year, the Patent Office reported 745 privately owned patent applications under Section 152 of the Atomic Energy Act of 1954, as amended. The AEC filed 28 directives for acquisition of rights under the Atomic Energy Act, bringing the total directives filed under Section 152 since 1954 to 133. The AEC has acquired rights in 69 applications, and in 47 cases, after completion of investigation, the directives were withdrawn without the acquisition of any rights. The remaining 16 cases were pending at year's end, one case having been withdrawn by applicant.

### *Patent Litigation*

After the Commission denied his petition for review, James C. Hobbs, Coral Gables, Fla., brought two proceedings—one in the Court of Claims and the other in the United States Court of Appeals for the Fifth Circuit, New Orleans, La., to review a decision of the Patent Compensation Board denying a claim. The claim sought just compensation and an award for the invention of certain valves used in the production of fissionable material. A motion to dismiss the petition in the Court of Claims, on the ground of lack of jurisdiction of the subject matter and the failure of the petition to state a claim on which relief can be granted, was granted on December 11, 1964.

# NUCLEAR MATERIALS MANAGEMENT

## INVENTORY MANAGEMENT

### *Basic Supply Agreement*

A new arrangement was developed and put into effect August 1, 1964, to enable any contractor making end-products of nuclear materials for the Government to consolidate the separate inventories used under several contracts. Previously each contract required the material for that contract to be isolated. Any converter or fabricator having special nuclear material for various contracts may now pool the material thereby reducing the total inventory. The new arrangement initiates as a major feature a use-charge of 4¾ percent per annum on material held thereunder. Thus, having previously been provided with these materials at no use-charge, industry for the first time now has a financial incentive to optimize its inventories used on Government fixed-price contracts. The arrangements include a plan for use-charge credits to be issued to offset use-charges as appropriate. Savings are anticipated to benefit both the AEC and industry.

### *Electronic Data Processing*

Considerable progress was made during 1964 in a program to apply electronic data processing to nuclear materials management. With the availability of a high speed computer at Oak Ridge, it has become possible to accelerate system changes. The goal is a single, integrated system built upon source data which can be used by any segment of the AEC requiring information concerning source and special nuclear materials.

### *Availability of Special Nuclear Materials*

Section 41b of the Atomic Energy Act of 1954 provides for Presidential determination as to the quantities of special nuclear materials which are to be available for distribution to licensed users within the United States and to nations having agreements for cooperation with the United States. The status of such determinations for 1964 was:

| | Kilograms | | |
|---|---|---|---|
| | $U^{235}$ | Plutonium | $U^{233}$ |
| DOMESTIC LICENSEES | | | |
| Presidential determination of availability | 200, 000 | 207. 5 | 53. 6 |
| AEC commitments | 75, 600 | 92. 2 | 0. 5 |
| Actual distribution | 10, 200 | 82. 1 | 0. 5 |
| FOREIGN NATIONS | | | |
| Presidential determination of availability | 150, 000 | 543. 0 | 45. 0 |
| AEC commitments | 104, 800 | 515. 3 | 35. 3 |
| Actual distribution | 5, 800 | 19. 8 | 4. 5 |

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# TECHNICAL PROGRAMS

### *Selected Measurement Methods*

A 5-year study of analytical methods in atomic energy operations was culminated with the publication of "Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle."[19] The publication outlines 45 analytical methods and discusses various aspects of measurements and has received wide acceptance in domestic and foreign atomic energy organizations.

### *Standard Reference Materials*

With the issuance during August of a plutonium isotopic standard, a total of 19 chemical and isotopic uranium and plutonium standards are now available through the National Bureau of Standards.

Preliminary work has indicated that three plutonium compounds—plutonium sulfate tetrahydrate, anhydrous plutonium sulfate, and dicesium plutonium hexachloride—are sufficiently stable for use as a primary chemical standard of plutonium. Such a standard is intended to supplement or replace the existing plutonium metal standard, which is difficult and costly to prepare and inconvenient to use.

### *Research and Development*

Research and development efforts during 1964 included: (*a*) "state-of-the-art" evaluation of computer programs for calculating the consumption and production of nuclear materials in reactors; (*b*) the development of satisfactory shipping containers and measurement methods for plutonium nitrate and oxide;[20] and (*c*) an investigation of the application of modern mathematical statistics to the existing management and control system.

# FINANCIAL MANAGEMENT[21]

### *New Authorization Requirement*

Amendment of section 261 of the Atomic Energy Act of 1954 by Public Law 88–72 during 1964 requires that any appropriation to the

[19] "Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle," (TID–7029), available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for $3.50.

[20] The Dow Chemical Co. sponsored a 2-day meeting during July at Denver, Colo., at which it presented to industry and other groups the results of its development of satisfactory shipping containers and measurement methods for plutonium nitrate solutions and plutonium oxide.

[21] A summary financial report will be found in Appendix 8.

Atomic Energy Commission be previously authorized by Congressional legislation. Before this amendment, Section 261 had authorized appropriation of sums necessary and appropriate to carry out the provisions and purposes of the Act, except for appropriations for (*a*) acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction or expansion; and (*b*) carrying out certain cooperative programs with persons for the development and construction of reactors.

Under the new authorization requirement, the Joint Committee on Atomic Energy held a total of 60 hours of hearings over a period of 6 weeks beginning on January 22, 1964, reviewing the AEC request for authorization of both the "Operating expenses" and the "Plant and capital equipment" appropriations to the Commission for fiscal year 1965. This resulted in legislation (Public Law 88–332, dated June 30, 1964) authorizing appropriation to the Commission of $2,636,577,000, which included $2,298,467,000 for "Operating expenses" and $338,110,-000 for "Plant and capital equipment."

### *Property Management*

The AEC continues to utilize increasing amounts of excess property available from other Federal agencies. As shown by the following 3-year summary, almost $40 million worth of excess materials and equipment were utilized in fiscal year 1964. The 232 percent increase in fiscal year 1964 over fiscal year 1961 is directly attributable to the long-term emphasis throughout the AEC on making maximum use of property already owned by the Government.

*Excess Property Utilized by Transfer from Other Federal Agencies*

[Dollars in millions]

| Fiscal year 1961 | Fiscal year 1962 | | Fiscal year 1963 | | Fiscal year 1964 | | |
|---|---|---|---|---|---|---|---|
| Amount | Amount | Percent of increase over 1961 | Amount | Percent of increase over 1962 | Amount | Percent of increase over 1963 | Percent of increase over 1961 |
| $12 | $18 | 50 | $32. 9 | 83 | $39. 9 | 21 | 232 |

### *Records Management*

During fiscal year 1964, the Commission and its principal cost-type contractors disposed of 174,000 cubic feet of records having no further value. This volume is equivalent to the capacity of 23,200 five-drawer file cabinets. More than 256,000 cubic feet of records having continuing value (about 40 percent of the total holdings) were economically housed in low-cost storage facilities instead of in office space.

# ORGANIZATION AND PERSONNEL

## ORGANIZATIONAL CHANGES

The major organizational changes within the Atomic Energy Commission during the January–December 1964 reporting period were:

### REGULATORY PROGRAM

Effective March 30, 1964, the Division of Licensing and Regulation and the Division of Radiation Protection Standards were abolished. The functions of those two divisions were assigned to four new divisions: the Division of Reactor Licensing, the Division of Safety Standards, the Division of Materials Licensing and the Division of State and Licensee Relations. The organization and functions of the Division of Compliance were not changed by the reorganization. All of these divisions report to the Director of Regulation and reflect the growth of the private nuclear industry and the resulting increased volume of AEC licensing and other regulatory activities. The new divisional functions are:

*Division of Reactor Licensing* performs the detailed safety evaluation of applications for licenses and authorizations to construct and operate nuclear reactors; licenses facility operators; evaluates nuclear safety aspects of AEC-owned and Department of Defense-owned reactors which are exempt from licensing; and maintains liaison with the Commission's Advisory Committee on Reactor Safeguards.

*Division of Safety Standards* develops and recommends to the Commission, nuclear safety standards to protect employees and the public, including standards for the design, location, construction and operation of reactors and other nuclear facilities; provides technical advice and assistance to other AEC divisions, Federal agencies and other organizations; provides staff assistance to the Commission in matters involving the Federal Radiation Council; and participates in nuclear safety research programs.

*Division of Materials Licensing* reviews license applications and issues licenses for the use of radioactive isotopes, the source materials uranium and thorium, and the fissionable materials uranium 233, uranium 235, and plutonium. It also handles applications for facility licenses for reprocessing irradiated sources and special nuclear material.

*Division of State and Licensee Relations*, in addition to its responsibilities for developing agreement with the States for the transfer of certain AEC regulatory authority, conducts the AEC's programs for indemnification of AEC licensees, enforcement, and the licensing of export of radioactive materials and nuclear facilities.

## OFFICE OF ECONOMIC IMPACT AND CONVERSION

The Office of Economic Impact and Conversion, reporting to the Assistant General Manager for Operations, was established on May 6, 1964. The office was created to coordinate the analysis and review of management activities designed to cope with the broad economic impact resulting from program cutbacks and with AEC program adjustments connected with cutbacks (see Part One of this report). This responsibility includes participation in the planning associated with potential program adjustments, conducting studies to determine the magnitude of economic impacts, the transferring current General Electric Co. project functions at Hanford to other contractors, and analyzing of current and projected programs to evaluate possible use of facilities affected by cutbacks. The office is the focal point within AEC Headquarters for intergovernmental activities relating to economic impact matters.

## BOARD OF CONTRACT APPEALS

Effective August 25, the Commission approved the establishment of an AEC Board of Contract Appeals under the supervision of a chairman, who reports directly to the Commission.

The Board of Contract Appeals considers and finally decides appeals from findings of fact or decisions of contracting officers in disputes arising under AEC prime contracts containing a disputes provision and certain subcontracts containing such a provision. The rules of practice of the Board were published in the *Federal Register* on September 11, 1964, and will be codified as Part 3 of Title 10, Code of Federal Regulations. The new rules became effective 60 days after publication in the *Federal Register*. Appeals filed prior to that date will be handled under the procedures and delegations of authority in effect on the date the appeal is filed, unless the appellant requests the application of Part 3.

## THE REACTOR DEVELOPMENT PROGRAM

Effective December 1, 1964, the reactor development activities were reorganized in recognition of the size and complexity of these activities and the progress that had been made in developing nuclear power applications. There was established an Assistant General Manager for Reactors responsible for all nuclear reactor development programs. The functions of the former Division of Reactor Development were divided into three major organizations, the Division of Reactor Development and Technology, the Division of Naval Reactors, and the Space Nuclear Propulsion Office, all reporting to the Assistant General Manager for Reactors.

## OTHER MAJOR ORGANIZATIONAL CHANGES

Effective October 5, 1964, the Directors of the Division of Public Information and Special Projects began reporting to the Assistant General Manager for Administration rather than to the Office of the General Manager and the Assistant General Manager for International Activities, respectively.

Effective December 1, 1964, the Director of the Division of Peaceful Nuclear Explosives began reporting to the Assistant General Manager for Research and Development rather than to the Assistant General Manager for Plans and Production.

### PERSONNEL CHANGES

During the January–December 1964 reporting period, the following major personnel changes took place:

Robert E. Wilson retired as Commissioner because of ill health effective February 1, 1964. (He died in Geneva, Switzerland, on September 1.)

Mary I. Bunting, President, Radcliffe College, was appointed as Commissioner by the President, confirmed by the Senate, and sworn in June 29, 1964, for the unexpired term of the late former Commissioner Wilson which will end June 30, 1965. Dr. Bunting was granted a year's leave of absence by Radcliffe College to accept the appointment.

General A. R. Luedecke, formerly General Manager, resigned effective July 31, 1964, to accept the position of Deputy Director, Jet Propulsion Laboratory of the California Institute of Technology.

Robert E. Hollingsworth, formerly Deputy General Manager, was appointed General Manager (vice Gen. A. R. Luedecke), effective August 11, 1964.

Edward J. Bloch, formerly Assistant General Manager for Operations, was appointed Deputy General Manager (vice Robert E. Hollingsworth), effective October 28, 1964.

Harry S. Traynor, formerly Assistant General Manager for Administration, was appointed Assistant to the General Manager, effective October 5, 1964.

Howard C. Brown, formerly Executive Assistant to the Chairman, was appointed Assistant General Manager for Administration (vice Harry S. Traynor), effective October 5, 1964.

Arnold R. Fritsch, formerly Technical Assistant to the Chairman, was appointed Special Assistant to the Chairman, effective October 5, 1964.

John A. Hall, who transferred to International Atomic Energy Agency in December 1961, was reemployed in his former AEC position of Assistant General Manager for International Activities, effective October 6, 1964.

John A. Erlewine, formerly Senior Representative, Brussels, Belgium, and more recently the Director of Congressional Relations, was appointed Assistant General Manager for Operations (vice Edward J. Bloch), effective December 15, 1964.

Frank K. Pittman, formerly Director, Division of Reactor Development, resigned effective December 22, 1964.

John V. Vinciguerra, formerly Director, Division of Contracts, was appointed Executive Assistant to the General Manager, effective December 15, 1964.

Paul H. Gantt, formerly Chairman of the Department of Interior's Board of Contract Appeals, was appointed Chairman, AEC Board of Contract Appeals, effective October 17, 1964.

John A. Swartout, formerly Deputy Director of the Oak Ridge National Laboratory, was appointed Assistant General Manager for Reactors, effective December 1, 1964.

Allen J. Vander Weyden, formerly Deputy Director, Division of Reactor Development, was appointed Deputy Assistant General Manager for Reactors, effective December 1, 1964.

Allan M. Labowitz, formerly Assistant to the Director, Division of Reactor Development, was appointed Special Assistant for Disarmament to the General Manager, effective February 12, 1964.

Clarence C. Ohlke, formerly Special Assistant to the Assistant General Manager for Operations, was appointed Director, Office of Economic Impact and Conversion, effective May 6, 1964.

Algie A. Wells, formerly Director, Division of International Affairs, and Acting Assistant General Manager for International Activities, transferred to International Atomic Energy Agency in Vienna, Austria, effective September 30, 1964.

Myron B. Kratzer, formerly Deputy Director, Division of International Affairs, was appointed Director, Division of International Affairs (vice Algie A. Wells), effective August 19, 1964.

Maj. Gen. A. W. Betts, formerly Director, Division of Military Application, was reassigned by the Department of the Army effective February 14, 1964.

Brig. Gen. Delmar L. Crowson, formerly Deputy Director, Division of Military Application, was appointed Director, Division of Military Application (vice Maj. Gen. A. W. Betts), effective February 17, 1964.

Robert Lowenstein, formerly Director, Division of Licensing and Regulation, was appointed Assistant Director of Regulation, effective March 30, 1964.

Richard L. Doan, a former Manager, Atomic Energy Division, Phillips Petroleum Co., was appointed Director, Division of Reactor Licensing, effective June 15, 1964.

Eber R. Price, formerly Assistant Director, Division of Licensing and Regulation, was appointed Director, Division of State and Licensee Relations, effective March 30, 1964.

Vice Adm. H. G. Rickover, formerly Manager, Naval Reactors, was appointed Director, Division of Naval Reactors, effective December 1, 1964.

Milton Shaw, formerly Technical Assistant to the Assistant Secretary of the Navy for Research and Development, was appointed Director, Division of Reactor Development and Technology, effective December 1, 1964.

Kenner F. Hertford, formerly Manager, Albuquerque Operations Office, retired effective July 31, 1964.

Lawrence P. Gise, formerly Deputy Manager, Albuquerque Operations Office, was appointed Manager, Albuquerque Operations Office (vice Kenner F. Hertford), effective August 1, 1964.

William L. Ginkel, formerly Acting Manager, Idaho Operations Office, was appointed Manager, Idaho Operations Office, effective March 31, 1964.

Joseph C. Clarke, formerly Manager, New York Operations Office, retired effective January 17, 1964.

Wesley M. Johnson, formerly Deputy Manager, New York Operations Office, was appointed Manager, New York Operations Office (vice Joseph C. Clarke), effective January 19, 1964.

Charles F. Schank, formerly Deputy Manager, San Francisco Operations Office, was appointed AEC Senior Representative, Brussels, Belgium (vice John A. Erlewine), effective August 2, 1964.

Lester R. Rogers, formerly Assistant Director for Materials, Division of Safety Standards, was appointed AEC Scientific Representative, Buenos Aires, Argentina, effective July 5, 1964.

L. R. Hafstad, member of the General Advisory Committee since September 1962, was elected Chairman of the Committee.

Herbert J. C. Kouts, member of the Advisory Committee on Reactor Safeguards since February 1962, was elected Chairman of the Committee effective January 1, 1964. William D. Manly was elected vice-chairman to complete the unexpired term of John C. Geyer who resigned from the committee in October.

# Part Six

# Regulatory Activities

The Commission's regulatory program is aimed toward assuring that the utilization, transportation, and disposition of radioactive materials and the operation of reactors and other facilities are conducted in a manner consistent with public health and safety and the common defense and security. The Director of Regulation and his staff are organizationally separate from the operational and promotional staff of the Commission.

# THE REGULATORY PROGRAM

The year 1964 marked the closing of the first decade of operations under the 1954 Atomic Energy Act authorizing the civilian use of nuclear reactors and entrusting the Atomic Energy Commission with greatly expanded regulatory responsibilities.

### *Regulatory Landmarks*

While the Commission's regulatory function is relatively new, it is growing apace along with the growth of the nuclear industry. For example, in 1954 less than 5,000 kilowatts of electrical power had been installed. At the end of 1964 the number had been increased to about 1 million kilowatts, and it is estimated that by 1974 the total will lie between 15 million and 20 million kilowatts. It is anticipated that in the next century nuclear power may well furnish over half of the Nation's energy. These statistics and predictions place in some perspective the growth of the Commission's regulatory task of protecting the public health and safety.

Noteworthy regulatory events in the first decade of the "civilian program" included the following:

- In 1955, the first research reactor license was granted to North Carolina State College, Raleigh, N.C. Today, a total of 68 research reactors have been licensed.
- In 1956, the first two construction permits for power reactors were issued: to the Consolidated Edison Co. for its Indian Point, N.Y., plant, and to the Commonwealth Edison Co. for its Dresden, Ill., plant. By the end of 1964, construction permits issued for power reactors totaled 20.
- In 1957, the Price-Anderson legislation was enacted to provide indemnity against public liability claims in the event of a nuclear incident. As of December 31, 1964, no claims had been made under licensee indemnity agreements.
- In 1959, legislation was enacted to provide for the transfer of certain materials licensing authority to States with which the Commission enters into effective agreements. Today, nine states have such agreements, 22 others have enacted enabling legislation, and several are actively developing programs for assumption of regulatory authority.

• In 1961, recognizing the increasing regulatory activities and responsibilities, the Commission established the Office of the Director of Regulation, thereby separating at the staff level the AEC's regulatory from its promotional and operational functions.[1] In 1964 the regulatory staff was reorganized to permit more efficient handling of its expanding activities.

• In 1963 came authorization for construction of the first privately owned facility for the processing of irradiated reactor fuels.

## HIGHLIGHTS OF 1964

During 1964 the regulatory effort was marked by the following significant events:

- A major reorganization of the regulatory staff to keep pace with the rapid growth of the nuclear industry. (See chart; details are under Organization and Personnel section, Part Five.)
- Issuance of a provisional construction permit to Jersey Central Power and Light Co. for a proposed 515,000 net electrical kilowatt reactor at Oyster Creek, N.J.; the Jersey Central application was a substantial factor prompting consideration of a finding of practical value. (See "Broad Commission Actions and Decisions" Section, Part One.)
- Review of nuclear power reactor applications from Niagara Mohawk Corp. for a proposed 500,000 net electrical kilowatt reactor near Oswego, N.Y.; and Los Angeles Department of Water and Power to construct and operate a 490,000 gross electrical kilowatt reactor plant at Coral Canyon, Malibu Beach, Calif.
- Issuance of construction permits to Southern California Edison for a 375,000 net electrical kilowatt reactor at Camp Pendleton, Calif., and to Connecticut Yankee Atomic Power Co. for a 462,600 net electrical kilowatt reactor at Haddam, Conn.
- Withdrawal of the Consolidated Edison Ravenswood Station (New York City) reactor application, and withdrawal of Pacific Gas and Electric Co.'s application to construct and operate a boiling water reactor at Bodega Bay, Calif.
- Signing of agreements with Florida, North Carolina, and Kansas for the transfer to each of these States of certain of the AEC's regulatory authority for the control of byproduct material, source material, and special nuclear material in quantities not sufficient to form a critical mass. This brought to nine the number of agreement States.

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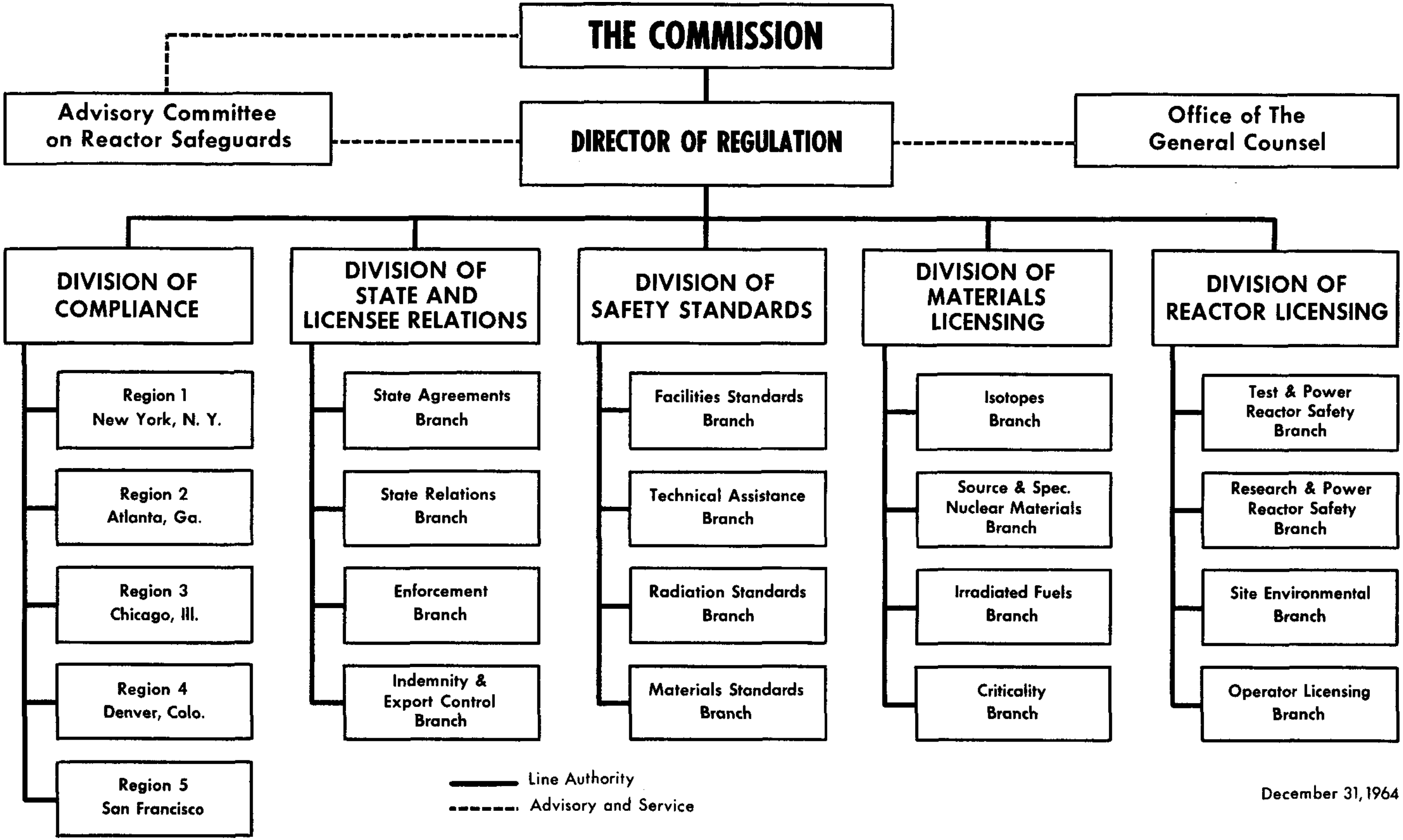
[1] In June, 1963, the regulatory staff was moved from the AEC Headquarters building at Germantown, Md., to new offices in Bethesda, Md.

# THE AEC REGULATORY ORGANIZATION




December 31, 1964

- *Licensing of the U.S. Coast Guard to use 225,000 curies of strontium 90 in a SNAP–7B device powering an unmanned lighthouse near the entrance to Baltimore Harbor.*
- Licensing of two large (750,000- and 275,000-curie) irradiators for sterilization of products by intense gamma radiation by Ethicon Inc., at Summerville, N.J., and by the Department of the Interior Marine Products Development Laboratory at Gloucester, Mass.
- Processing of over 8,000 materials licensing applications by the AEC, even though the nine agreement States exercise authority, transferred by the AEC, over 30 percent of the total materials licenses outstanding—an indication of continued growth of the industry.

## REACTOR LICENSING

In the licensing of power reactors in the United States, primary reliance for the protection of public health and safety has been placed upon design, construction and operation of reactors in a manner which reduces the possibility of occurrence of an accident to an exceedingly low level. Isolation of reactors from heavily populated areas and carefully engineered containment are added safeguards. The Commission's "Reactor Site Criteria," 10 CFR Part 100, incorporate basic site considerations. The guidelines set forth in this regulation recognize that when proven engineered safeguards are incorporated into a facility a lesser isolation distance than would otherwise be required may be acceptable.

The question of whether engineered safeguards can be substituted completely for the distance factor was presented by the application of Consolidated Edison Co. for a 1 million electrical kilowatt plant at its Ravenswood site in New York City. No final decision on this application was made, since it was withdrawn in January 1964 when the company decided to use another means of expanding its generating capacity.

### *Construction Permits Issued*

*San Onofre.* Following a public hearing before an atomic safety and licensing board,[2] a provisional construction permit for the San Onofre Nuclear Generating Station was issued to Southern California

[2] The Atomic Energy Act of 1954 was amended in 1962 to authorize the Commission to establish such boards to conduct public hearings for proceedings involving the granting, suspending, revoking, or amending of licenses for authorizations. The three-member boards are drawn from a panel of AEC Hearing Examiners, AEC-contractor employees, and private citizens (see pp. 426–427, Annual Report to Congress for 1962).

Edison Co., San Diego Gas & Electric Co., Bechtel Corp., and Westinghouse Electric Corp., on February 29, 1964. The plant is being constructed on an 84-acre site within the Marine Corps' Camp Pendleton, Calif., base about half-way between Long Beach and San Diego and will have an initial capacity of approximately 375,000 net electrical kilowatts.

*Connecticut Yankee.* Issuance of a provisional construction permit to Connecticut Yankee Atomic Power Co. followed a public hearing held April 1–2, 1964, at Middletown, Conn., before an atomic safety and licensing board. The plant is being constructed at Haddam, Conn., approximately 21 miles southeast of Hartford and will have an initial net electrical capacity of 462,600 kilowatts.

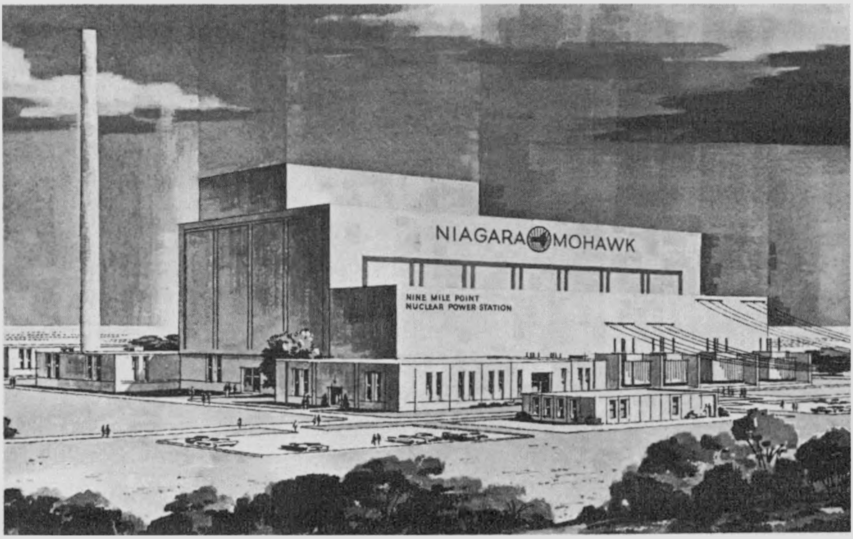
*Oyster Creek.* Jersey Central Power & Light Co. applied on March 26, 1964, to the Commission for a permit to construct a 515,000 net electrical kilowatt nuclear power reactor at its Oyster Creek site in Ocean County, N.J., approximately 35 miles north of Atlantic City. Following a public hearing on the application held on October 14–16, 1964, at Toms River, N.J., and upon an initial decision of an atomic safety and licensing board dated December 4, 1964, a provisional construction permit was issued December 15, 1964, which was to become final on January 5, 1965, if no motions for review were made. On December 24, the AEC staff petitioned for Commission review of the board's initial decision because of certain conditions included by the board.

### *Power Reactor Applications*

*Malibu.* The application by the Department of Water and Power of the city of Los Angeles to build a 490,000 gross electrical kilowatt reactor in the Malibu area was reviewed by the regulatory staff, and considered by the Advisory Committee on Reactor Safeguards in December. A public hearing is planned for early 1965.

*Nine Mile Point.* Niagara Mohawk Power Corp. applied for a permit to construct a 500,000 net electrical kilowatt reactor at its Nine Mile Point site on the southeast shore of Lake Ontario, seven miles northeast of Oswego, N.Y. A pre-hearing conference was held on December 15 at Oswego, N.Y., and an atomic safety and licensing board scheduled a public hearing on the matter for January 19, 1965, at Oswego.

*Bodega Bay.* The regulatory staff and the AEC's Advisory Committee on Reactor Safeguards (ACRS) completed their independent reviews of Pacific Gas & Electric Co.'s application to build a 325,000 electrical kilowatt nuclear plant at Bodega Bay, north of San Francisco. The separate reports, made public October 27, 1964, presented




*"Nine-Mile Point" Plant.* At year's end, the AEC had under consideration the application of the Niagara Mohawk Power Corp. for construction of a 500,000 net electrical kilowatt, boiling water nuclear power plant. General Electric would be the nuclear components and turbogenerator contractor for the plant which would be built on the shores of Lake Ontario, about 6 miles from Oswego, N.Y. Niagara Mohawk is not seeking AEC financial or research and development assistance for construction of the plant. Operation is planned for 1968.

different conclusions. The ACRS concluded that there was reasonable assurance that the proposed reactor could be constructed and operated at Bodega Bay without undue hazard to public health and safety. The AEC regulatory staff felt that there was such reasonable assurance in all respects except one. That exception was the uncertainty associated with the effects of a major earthquake involving substantial shear movement of the foundation rock. The company withdrew its application on November 4, 1964.

### *New Reactor Licenses and Authorizations*

*Pathfinder.* A provisional operating license authorizing Northern States Power Co. to operate its Pathfinder reactor at power levels up to 1 megawatt thermal was issued on March 12, 1964. The reactor, which is located near Sioux Falls, S. Dak., has a design capacity of 58,500 net electrical kilowatts.

*BONUS.* On April 2, 1964, a provisional operating authorization was issued to General Nuclear Engineering Corporation (GNEC) and the Puerto Rico Water Resources Authority (PRWRA) for operation of the 16,300 net electrical kilowatt BONUS reactor at Punta Higuera, Puerto Rico. At the request of GNEC, and with the consent of PRWRA, an amendment was subsequently issued to transfer operating authorization to Combustion Engineering, Inc., and PRWRA in view of the September 1, 1964, merger of GNEC with Combustion Engineering, Inc., its parent company.

*Hallam and Piqua.* The provisional operating authorization previously issued to North American Aviation, Inc., for the Hallam reactor was transferred to the Consumers Public Power District of Lincoln, Nebr., on February 5, 1964. The assumption of operating responsibility by the utility followed completion of North American's construction and initial check out of the 75,000 electrical kilowatt reactor located at Hallam, Nebr., and a review by the Commission of the technical qualifications and experience of the utility's organization. Similarly, on August 10, 1964, the provisional authorization previously issued to North American Aviation, Inc., was transferred to the City of Piqua, Ohio, for the AEC–owned reactor at Piqua, which has a rated capacity of 11,400 kilowatts electrical.

*Big Rock Point and Saxton.* Full term operating licenses, replacing provisional licenses, were issued to Consumers Power Co. of Michigan on May 1, 1964, for its Big Rock Point reactor, and to Saxton Nuclear Experimental Corp. on February 29, 1964, for its reactor located 20 miles southeast of Altoona, Pa.

### Test Reactors

*Babcock & Wilcox Co.* An operating license was issued on January 25, 1964, to the Babcock & Wilcox Co. for its test reactor located near Lynchburg, Va.

*National Bureau of Standards.* On October 2, 1964, the Hearing Examiner issued an initial decision ordering that the provisional construction permit issued on April 22, 1963, to the National Bureau of Standards (NBS) for a test reactor at Gaithersburg, Md., be modified. The proceeding had been reopened for receipt of further evidence on specified issues, including population density and anticipated population growth, in accordance with a Commission Order issued May 9, 1963. The modification ordered would require the addition by NBS of a stack gas continuous monitor to measure the rates and levels of radioactive iodines that might be released in the event of a maximum credible accident.

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On October 22, a petition for review of the initial decision was filed by NBS and on November 9, the regulatory staff filed an answer to the petition for review.

### NS *Savannah*

The NS *Savannah* is operated as a joint project of the AEC and the Maritime Administration of the U.S. Department of Commerce, with American Export Isbrandtsen Lines, Inc., as general agent.

Following review and approval by the regulatory staff of each proposed port visit, the nuclear merchant ship NS *Savannah* completed its first visits to foreign ports. During 1964, four trips to Europe were made, including stops in England, Ireland, Norway, Sweden,

*New York Reception.* Escorted by a flotilla of tugs, small craft and fireboats spouting their traditional greetings, the Nuclear Ship *Savannah* moves majestically up the Hudson River in the Port of New York. New York is serving as the *Savannah's* operating headquarters during her 1964–65 transatlantic cruise schedule. She will make goodwill calls at European and U.S. Ports through March of 1965. The cargo-passenger liner is carrying passengers on all her voyages. American Export Isbrandtsen Lines, Inc., is the *Savannah's* General Operating Agent. The *Savannah* is a joint project of the Maritime Administration, U.S. Department of Commerce, and the Atomic Energy Commission. In December, the Maritime Administration requested a 25-year license to operate the ship.

Denmark, Germany, The Netherlands, Belgium, France, Portugal, Spain, and Italy. Late in 1964, American Export proposed that the *Savannah* be operated on a regular schedule between New York and the Far East when the present series of goodwill visits to foreign ports is completed. In December, the Maritime Administration filed an application for an operating license for the *Savannah.*

### *Operator Licensing*

Reactor operators (i.e., persons who manipulate or direct the manipulation of reactor controls) are licensed under 10 CFR Part 55. A category of licensed senior operators was established by a 1963 amendment to the regulation.

During the 12 months ending November 30, 1964, 317 operator licenses and 326 senior operator licenses were issued. These included 496 new licenses, nine amended licenses, and 138 renewed licenses. Including previously issued licenses, there were in effect on that date 1,036 operator and 513 senior operator licenses.

## ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Concurrent with the regulatory staff's technical evaluation of an application for a construction permit or a reactor operating license for power and test reactors, the Commission's Advisory Committee on Reactor Safeguards (ACRS) independently reviews the application. During 1964, the ACRS held 11 meetings of the full committee and 38 subcommittee meetings. It furnished to the Commission 35 reports concerning 10 privately- or municipally-owned, 13 Commissioned-owned, and four reactor projects owned by other agencies of the Federal Government. The ACRS also submitted a report on engineered safeguards.

## MATERIALS LICENSING

The scope of the AEC's materials licensing activities ranges from small quantities of materials such as those used in medical diagnosis to facilities for the chemical processing of irradiated fuels. In addition to the considerable diversity in the types of activities licensed and the health and safety considerations involved, there has been a substantial increase in the volume of applications received. During the 12-month period ending November 30, 1964, a total of 8,118 applications were filed with the Commission's regulatory staff. As of that date, there were in effect 568 special nuclear material licenses, 475 source material licenses, and 8,018 byproduct material licenses, plus one construction

*Advisory Committee.* The AEC's Advisory Committee on Reactor Safeguards (ACRS) reviews facility license applications and advises the Commission with regard to the hazards of proposed or existing reactor facilities. Members of the ACRS are, reading *left to right:* (seated) Dr. David Okrent, Argonne National Laboratory; Nunzio J. Palladino, Pennsylvania State University; Dr. Franklin A. Gifford, U.S. Weather Bureau Laboratory, Oak Ridge, Tenn.; Dr. Leslie Silverman, Harvard University; and Dr. Henry W. Newson, Duke University. Standing (*left to right*) are: Dr. Theos J. Thompson, Massachusetts Institute of Technology; Dr. David B. Hall, Los Alamos Scientific Laboratory; Col. Reuel B. Stratton, Hartford, Conn.; Dr. Herbert J. C. Kouts, Brookhaven National Laboratory, *Chairman;* Donald A. Rogers, Morristown, N.J.; and William D. Manly, Union Carbide Corp., New York City, *Vice-Chairman.* Missing from the picture is Kenneth R. Osborn, Allied Chemical Corp., Morristown, N.J. During the November meeting in Washington, D.C., at which this photo was taken, Mr. Manly was elected Chairman of the ACRS for 1965 and Dr. Okrent was elected Vice-Chairman.

permit authorizing construction of a plant for the chemical processing of irradiated fuels.

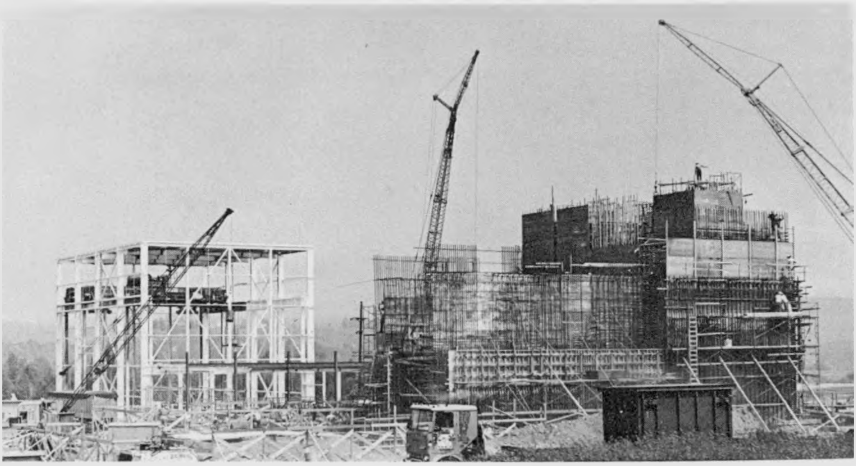
Contributing to the increase in applications for materials licenses are recent changes in the Commission's rules and policies requiring certain Commission contractors and subcontractors, not previously licensed to obtain licenses.

### *Irradiated Fuel Shipping Casks*

Along with the growth of research and power reactors there has been an increase in the number of applications for AEC licenses which, in effect, approve the design of shipping casks and the procedures for their use in shipping irradiated reactor fuel from reactor sites to fuel reprocessing facilities. During the 12 months ending November 30, 1964, reviews were completed of six cask designs and 17 licensing actions were taken authorizing their use. In addition, the regulatory staff reviewed and offered advice concerning the design of seven other casks to be used by organizations in foreign countries for shipment of irradiated fuel to the United States.

### *Chemical Processing Plant*

Construction of the Nuclear Fuel Services, Inc., chemical processing plant at the Western New York Nuclear Service Center is proceeding. A permit was issued in April 1963 authorizing construction of this plant, which is designed to process a variety of irradiated fuels, primarily from reactors licensed or owned by the Commission. Data submitted by the applicant in support of its request for an operating license are under review by the regulatory staff and, separately, by the ACRS. Completion of construction and check-out operations is scheduled for mid-1965.



*NFS Fuel Processing Plant.* Construction of a plant for processing irradiated reactor fuels by Nuclear Fuel Services, Inc., is well along, with completion scheduled by late spring of 1965. The storage pool for "spent" fuels is expected to be ready to receive fuel from customers by mid-February. Construction of the private facility, costing upwards of $25 million, is being performed by the Bechtel Corp. at a New York State-owned site at West Valley, 32 miles south of Buffalo. The New York State Atomic and Space Development Authority will lease a part of the Western New York Nuclear Service Center to NFS and assume responsibility for perpetual care of the radioactive wastes generated by the plant. Capable of processing nine types of fuel, the plant is expected to recover fuel at rates up to 1,000 kilograms of enriched uranium per day. The AEC had issued a construction permit for the facility in the spring of 1963. (Photo courtesy of Buffalo Courier-Express.)



*Unmanned Lighthouse.* Historic "Baltimore Light," built in 1908, became the first unmanned lighthouse to have its electricity supplied by a nuclear generator on May 20. Photo *above* shows the 4,600-pound SNAP-7B generator being hoisted into the lighthouse from the deck of the U.S. Coast Guard buoy tender *White Pine.* The 60-watt, strontium 90-fueled generator was developed for the AEC by the Martin Co. The license for the Coast Guard to possess the generator was issued by the AEC on March 28. Map at *left* shows location of the nuclear-powered light just north of the Chesapeake Bay Bridge.

### *SNAP Devices*

On March 28, 1964, an AEC license was issued to the U.S. Coast Guard authorizing the possession of 225,000 curies of strontium 90 for use in the generation of electricity by the SNAP–7B device installed in an unmanned lighthouse near the entrance to Baltimore Harbor.

Discussions with industry representatives indicate that an expanding commercial and governmental market is developing for the use of isotopic-powered SNAP devices. It is anticipated that there will be a substantial number of applications requesting AEC licenses for their use.

### *Irradiators*

Licenses have been issued authorizing the operation of two large irradiators for the sterilization of products by intense gamma radiation. The radiation facility of Ethicon, Inc., at Somerville, N.J., the largest in any commercial installation in the United States, is designed to utilize 750,000 curies of cobalt 60 and was initially loaded with approximately 500,000 curies.

The irradiator installed by the Department of Interior Marine Products Development Laboratory, Gloucester, Mass., uses the radiation from 275,000 curies of cobalt 60 for the preservation of marine food products (see Isotopes Development Section, Part Four). This facility is similar in operation to that of Ethicon.

## SAFETY STANDARDS

A systematic program of regulatory standards development is essential to the orderly, consistent and effective administration of the Commission's licensing program. Such a program involves the establishment, by regulation or guides, of the conditions and criteria under which licenses will be issued and of performance standards which will be required. A substantial body of information pertaining to the effects of radiation, the handling and use of radioactive materials, and to a somewhat lesser extent the operation of nuclear reactors, has been generated. The development and modification of appropriate standards is, in part, dependent on the compilation and evaluation of such information. To that end, the regulatory staff participated in activities of the Federal Radiation Council, other Federal agencies, and other national and international standards organizations, and within the AEC, cooperated with those operational divisions concerned with the handling of radioactive materials and the nuclear safety research program.

### *Existing Standards*

The Commission's regulation, 10 CFR Part 20, "Standards for Protection Against Radiation," which was originally published in 1955 as a proposed regulation, has undergone a number of revisions of varying degrees of significance. Compliance with 10 CFR Part 20 is a condition of each license issued by the AEC. Other Commission regulations reflecting standards development include those relating to the licensing of byproduct materials, source materials and special nuclear materials; radiation safety requirements for radiographic operations; protection against accidental conditions of criticality in the shipment of special nuclear materials and protection against radiation in the shipment of irradiated fuel elements; and guidelines identifying a number of factors important to the question of acceptability of proposed reactor sites. Every effort is made to assure, insofar as possible, that these regulations are kept current with the advancing technology.

### *Licensing Guides*

Appendix 7 lists the licensing guides which are currently available for use as aids in the preparation of applications for AEC licenses. Also listed are those draft guides which have been distributed to interested persons for comment.

### *Standards Applicable to Radiation Exposures to Persons*

There were no changes during the year in the guides recommended by the Federal Radiation Council for limiting radiation doses received by radiation workers and the public as a result of normal peacetime operations. The AEC revised concentration limits of some radioisotopes in air and water to reflect guidance that had been developed by the FRC. Further revision to increase the number of radioisotopes for which concentration limits are provided is under study by the AEC.

### *Standards Applicable to Uses of Materials*

Amendments to AEC regulations applicable to the possession, use and transfer of materials subject to licensing which were published for comment or made effective during 1964 are listed in Appendix 7.

A major effort, not reflected in the Appendix, was made, in cooperation with Federal agencies and international groups, toward the development of more adequate safety standards applicable to the transportation of irradiated reactor fuels and other fissile materials.

Continued effort was devoted to identification of conditions under which materials, subject to licensing, may be used or transferred without detailed regulatory supervision. In this connection, guides and specifications which are presently being prepared for use both by the regulatory staff and by licensees are designed to facilitate the regulatory process by providing minimum acceptable performance criteria. Emphasis during the year was on the following areas: (*a*) the systematic evaluation of commercial dosimetry services using photographic films; (*b*) the use of respirators for protection against airborne radioactive materials; (*c*) criteria for the approval of the use of radioactive materials in consumer products; and (*d*) research by Commission contractors relative to (1) assuring adequate containment of radioactive materials used as sources of radiation in industrial devices and for other purposes and (2) the preparation of design requirements for containers to be used in the transport of nuclear materials.

### *Progress in Technical Specifications*

During the past year, a task force on reactor technical specifications, consisting of ten reactor experts from both within and outside the AEC, made substantial progress in defining vital areas of reactor safety that should be covered by the technical specifications accompanying a reactor license. The task force has focused on simplification of the specifications to provide a well defined safety framework within which the licensee may conduct his operations responsibly with minimum regulatory interference on details.

Factors involved in revising the technical specifications guidelines were discussed with representatives of the Atomic Industrial Forum in December, and additional meetings will be held in early 1965.

The guidelines also should facilitate identification of the vital safety areas that must be covered in considering a proposed reactor facility at the construction permit stage, as well as determination of the scope and detail of information that should be required in those areas.

In another move to reduce review time at the permit stage, the regulatory staff at year's end offered to make informal safety evaluation of commercial reactor systems or major components in advance of the formal filing of construction permit applications. Extension of this pre-application review practice, long offered for proposed facility sites, may help to expedite the overall delivery schedules of plants where "package" reactor systems are involved.

### *Nuclear Safety Research Program*

Liaison with the Commission's nuclear safety research program during the year emphasized the interests of the regulatory staff in program objectives and the results of (*a*) the planned major accident tests of a reactor, and (*b*) the pressure vessel material irradiation effects program. These activities, popularly referred to as SPERT, CSE, LOFT, SNAPTRAN, etc., are described under "Nuclear Safety Program" of Part Three of this Report.

## COMPLIANCE AND ENFORCEMENT ACTIVITIES

The regulatory staff is responsible for determing whether licensees are complying with the requirements of their licenses and with AEC rules, regulations and orders. By inspection of the premises, records, and activities of licensees, the Division of Compliance determines the status of compliance and identifies any nuclear safety problems which need correction. More than 200 inspections are conducted each month. The division investigates all accidents which involve materials or facilities subject to licensing.

### *Headquarters and Regional Offices*

A headquarters staff in Washington directs the overall program of inspection and investigation. A field staff of 66 professionals, distributed among five regional offices,[3] conducts individual inspections and investigations in accordance with the general policies, standards and procedures established by the headquarters staff. This decentralization of the compliance program permits prompt correction of most cases of noncompliance by local action, facilitates communications between licensees and the Division of Compliance, and reduces the travel cost of the inspection program.

### *Inspection of Reactors*

The frequency of reactor inspections depends on such safety factors as the allowable fission product inventory for the facility, the nature of operations, and the complexity of the facility itself. Operating power and test reactors were inspected about every 2 months during 1964, while the typical research reactor at a university was inspected once or twice during the year. Each power reactor currently under construction was inspected an average of four times during 1964. Although it is not a licensed facility, the NS *Savannah* was inspected 17 times as part of the special procedures which the Commission has adopted for assuring safe operation of the ship. In addition, the

[3] Compliance Regional Offices are located in New York, Atlanta, Chicago, Denver, and San Francisco.

Nuclear Fuel Services processing plant for spent fuel, now under construction in New York State, was inspected nine times during 1964. This facility is treated similarly to power or test reactors for regulatory purposes.

### *Inspection of Materials Licenses*

The number of specific materials licenses subject to inspection increased from 8,866 on November 30, 1963, to 9,061 on November 30, 1964. This increase occurred despite the fact that three more States assumed responsibility in 1964 for regulation of source materials, byproduct materials, and small quantities of special nuclear materials. The compliance staff inspected operations being conducted under 2,277 materials licenses during the 12-month period ending November 30, 1964. Selection of these operations for inspection was based on consideration of the amount and kind of material held under the license, the nature of the licensed operations, and the licensee's history of compliance with regulatory requirements.

### *Investigations of Licensee Radiation Incidents*

Licensees are required by the AEC's regulation 10 CFR Part 20, "Standards for Protection Against Radiation", to report radiation incidents to the Commission. All significant incidents reported by licensees are investigated.[4] During the 12-month period ending November 30, 1964, 11 such incidents were investigated by the AEC.

One of these incidents caused the first nuclear fatality in a licensed operation (discussed in following section). Five other incidents involved radiation exposures to six persons; four incidents occurred in radiography operations, and one occurred during the handling of a radioactive pharmaceutical. The maximum exposure involved in any one of these latter ten incidents was 5,000 rem to the hands and five rem to the whole body of a radiographer.

Licensees reported four incidents involving losses of operating time in excess of 24 hours. One resulted from a fire in an electric oven used for drying tissue specimens; two were caused by the accidental release of radioactive materials within, and confined to, restricted areas; and the fourth involved failure of a teletherapy source to retract to its shielded container following use. A fire causing damage in excess of $1,000 was reported at a decommissioned uranium ore processing mill. None of these incidents caused significant radiation exposure to personnel.

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[4] Reports on such incidents are on file for public inspection in the AEC's Public Document Room, 1717 H Street NW., Washington, D.C.

There were seven instances in which a radioactive source became detached from logging gear during oil well logging operations. In four of the instances the source was subsequently retrieved from the well. In the other three instances the source could not be recovered: one source remained buried under 45 feet of water in soft mud and well cuttings; another source was submerged under 200 feet of water; and a third source was lost at a depth of 7,800 feet. In the third instance, the well containing the source was sealed off.

Eighteen other licensees reported lost radioactive sources; in eight of the instances the missing material was subsequently recovered. In five cases where the radioactive material was not recovered, it appeared that the material had been inadvertently disposed of through normal refuse channels and that no significant hazard would result. In the five remaining instances, where the ultimate disposition has not been established, no significant radiation hazard was apparent owing to circumstances of the loss and amounts of material involved.

### *First Radiation Fatality in Licensed Operations*

On July 24, 1964, the first nuclear fatality in a licensed operation occurred as a result of a nuclear criticality accident at the United Nuclear Corp.'s recovery plant for enriched uranium scrap near Charleston, R.I. The employee, who later died, received an exposure initially estimated to be about 8,000 rem when he poured a solution of enriched uranyl nitrate of unknown concentration from a geometrically safe bottle into a process vessel of unsafe geometry. Film badges of three other employees showed exposures of 50, 3.5, and 2.5 rem respectively.

In keeping with established Commission procedures, the Director of Regulation appointed a technical review committee to review and evaluate the information assembled by the regulatory staff. The committee report, made public on November 16, analyzed the nature and possible causes of the accident and the measures which should be considered in order to minimize or preclude similar accidents. The committee concluded that no single factor appeared to be solely responsible for the accident, but that it resulted from a combination of several technical and plant procedural circumstances. The report noted that the event posed no threat to the surrounding population, and if viewed in this light alone, should be regarded on the same basis as other industrial accidents. However, the committee added, "it has been appropriate to consider this accident in some detail, to aid in implementing the high standards needed in the nuclear industry for protecting employees as well as the public."

## STATE AND LICENSEE RELATIONS

The Commission is authorized [5] to enter into agreements with the States for the transfer of certain AEC regulatory authority and to provide assistance to the States in developing a program and competence to assume such authority.

### *State Agreements*

During 1964, the States of Florida, North Carolina, and Kansas entered into agreements with the Commission for the transfer of certain of the AEC's regulatory authority for the control of byproduct material, source material, and special nuclear material in quantities not sufficient to form a critical mass. The following nine States now have effective agreements:

| States | Effective date | Number of current State material licenses |
|---|---|---|
| Kentucky | Mar. 26, 1962 | 126 |
| Mississippi | July 1, 1962 | 105 |
| California | Sept. 1, 1962 | 1,049 |
| New York | Oct. 15, 1962 | 1,267 |
| Texas | Mar. 1, 1963 | 735 |
| Arkansas | July 1, 1963 | 73 |
| Florida | July 1, 1964 | 239 |
| North Carolina | Aug. 1, 1964 | 159 |
| Kansas | Jan. 1, 1965 | 128 |

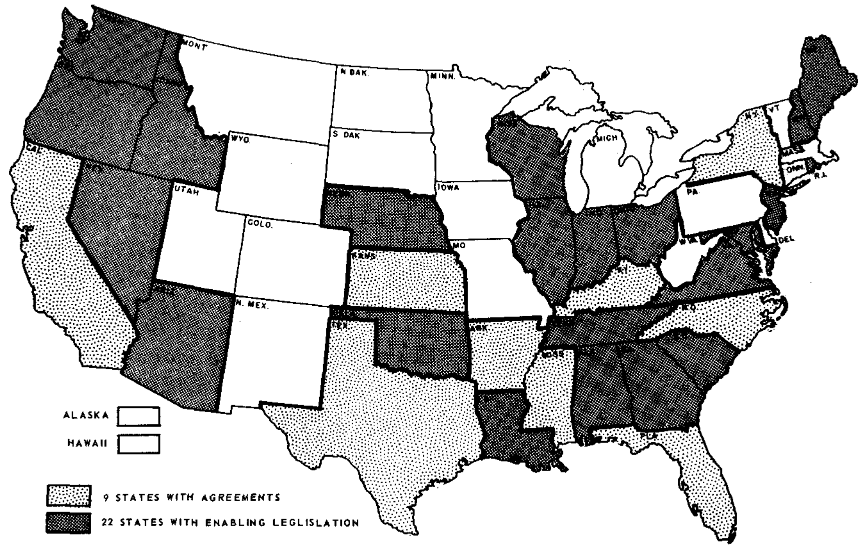
Of the total number of current effective licenses for byproduct, source, and special nuclear material, 30 percent have been issued by agreement States and 70 percent by the AEC.

### *States Preparing for Agreements*

Arizona, Georgia, Rhode Island, and Virginia adopted enabling legislation in 1964 authorizing their respective Governors to enter into agreements with the AEC, bringing the total to 31 States which either have enacted enabling legislation authorizing an agreement, or have already entered into such an agreement with the Commission. Ari-

[5] Public Law 86–373, effective September 23, 1959, added Section 274 to the Atomic Energy Act of 1954, as amended. See pp. 266–267, Annual Report to Congress for 1959; pp. 375–376, Annual Report for 1961.

STATUS OF STATES WITH AGREEMENTS AND WITH ENABLING LEGISLATION




zona, Indiana, Louisiana, Nebraska, New Hampshire, New Jersey, Oregon, and Tennessee are considering programs for assumption of regulatory authority.

The Commission staff, upon request, assists States in the development of their enabling legislation and participates in formal State legislative hearings concerned with proposed State radiation control acts.

## COOPERATION WITH AGREEMENT STATES

In the interest of maintaining compatible programs, the AEC staff conducts semiannual meetings with individual agreement States on licensing, inspection, enforcement, and other aspects of regulatory programs of the States and the Commission. In addition to such meetings with individual States, the AEC met twice in 1964 with representatives of all agreement States. These meetings, while serving as a medium for the exchange of information, also provided a forum for discussion of matters of interest to all regulatory agencies, serving as a medium for the exchange of information, also provided a forum for discussion of matters of interest to all regulatory agencies, such as jurisdiction, reciprocal recognition of licenses, proposals regarding the AEC-State cooperative program, and other matters of procedure or policy of mutual interest.

To supplement the information which is exchanged during meetings with States, the AEC has developed a procedure for the routine exchange of information through correspondence. The system provides for the exchange of copies of licenses; license back-up data; licensing guides and criteria; reports, papers and publications; licensing and enforcement data; and other information of mutual interest. In addition to the information routinely supplied, the AEC responds each month to an average of 20 specific requests from the agreement States for technical advice or information.

### *A Typical Case History*

The agreement between the State of North Carolina and the Commission was signed on July 21, 1964, in Raleigh by Governor Terry Sanford and Commissioner James T. Ramey. The cooperation and assistance provided to North Carolina and its officials by the Commission are typical of the assistance available to other States. A brief summary of the North Carolina experience follows:

*Initial meetings.* Commencing in June 1960, meetings at frequent intervals were held with North Carolina officials to discuss the program for State assumption of regulatory responsibility. The meetings, which were held both in Raleigh and in Washington, included the Governor and his staff, the Governor's Atomic Energy Advisory Committee, the Deputy Attorney General, the Commissioner of Health and his staff, and State legislative leaders.

*Training courses.* In order to develop a pool of technical talent, the University of North Carolina conducted a course in the fundamentals of radiation and radiation protection during 1962–63. The course was financed by the Commission. A total of 48 State and local government agency personnel attended the course. Other training provided by the AEC for North Carolina State officials included the 10-week health physics course at Oak Ridge, a 3-week orientation course on the regulatory policies and practices of the Commission at AEC Headquarters, and the 3-week course in applied health physics at Oak Ridge. In addition, State officials visited the AEC Region II Compliance Office in Atlanta for 2 days of orientation in inspection procedures, reports, records, etc.

*Regulations drafted.* More than a year before the Governor submitted a formal request for the transfer of regulatory authority, the State

*North Carolina Signing.* North Carolina became the eighth State to enter into agreement with the AEC to assume certain regulatory authority for control of radioactive materials on July 21. Photo shows AEC Commissioner James T. Ramey signing the agreement as Governor Terry Sanford and former Congressman Carl T. Durham look on. The signing had historical significance in that Congressman Durham, as Chairman and Vice-Chairman of the Joint Committee on Atomic Energy (JCAE) during the period of 1956–59 had been a strong backer of the legislation (passed in 1959) which made possible the AEC's transfer of regulatory functions to the States. During the same period, Commissioner Ramey was serving as Executive Director of the JCAE staff.

Board of Health submitted draft regulations to the Commission's staff for informal review. A number of discussions with AEC were held concerning the draft.

*Agreement Signed.* Following Commission approval of the Governor's request for the transfer of authority, the agreement to this effect was signed on July 21 and the authority was formally transferred as of August 1.

*Municipal meetings.* Staff members of the State Board of Health and the AEC met with officials in Charlotte, Durham, Greensboro, Raleigh, and Winston-Salem to provide background on the Commission's program, to discuss the transfer of authority, and to assist in the planning for cooperative working relationships between the State and the cities in radiation matters.

***Training Assistance***

As part of its program of assisting States to assume responsibility for the regulation of atomic energy materials, the Commission continues to encourage participation of State and local personnel in formal training courses sponsored by the AEC.

The 10-week Health Physics course given by the Oak Ridge Institute of Nuclear Studies in cooperation with the Oak Ridge National Laboratory, offered each fall, provides training for State and local personnel who will participate in licensing and inspection programs. Academic-year courses in health physics at local universities equivalent to the 10-week Oak Ridge course and consisting of weekly sessions of lectures and of laboratory sessions given in the late afternoon and evening, make it possible for students to be trained with minimum absence from their regular duties. During the academic year 1963–64, such courses were presented at Loyola College, Baltimore; the University of Denver, Oregon State University, and the University of South Carolina. These 4 courses averaged 21 students each. During the 1964–65 academic year, a similar course is being conducted by the Medical College of Virginia in Richmond.

An orientation course on the regulatory policies and practices of the Commission is conducted twice a year at AEC Headquarters.

The first session of a 3-week course in applied health physics was held at Oak Ridge in May and June 1964, and similar sessions

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are expected to be conducted annually in the spring of each year. A total of 11 students from 9 States attended the first session. This course is designed to provide practical experience for State personnel engaged in radiation control programs.

In October 1964, a 2-week health physics course, sponsored by the AEC in cooperation with the Puerto Rico Nuclear Center, was conducted for staff members of the Puerto Rico Department of Labor. Twenty-one students attended. The course was held at the PRNC facilities at Mayaguez.

In addition to offering formal training courses, the AEC staff invites personnel from interested State governments to accompany inspectors on visits to observe AEC inspection techniques and procedures.

### *Municipal and Local Activities*

In cooperation with State Municipal Leagues, the AEC participated in atomic energy seminars for local officials in Colorado, Massachusetts, and New Jersey during 1964. At the invitation of the American Municipal Association, the AEC was represented at the association's annual meeting in July at Miami Beach. The exhibit, "Your State—Your City—and the Atom," was displayed at each of the meetings, which were attended by approximately 2,500 local officials.

### *Suggested State Regulations for Control of Radiation*

Amendments to update the publication of the Council of State Governments, "Suggested State Regulations for Control of Radiation," were developed by the AEC staff in cooperation with the U.S. Public Health Service and the Council of State Governments, and recommended to the Council for adoption. As a result, the first revised version of the Suggested State Regulations was issued in October 1964.

### *Cooperation With Other Federal Agencies*

In April 1964, a hearing was conducted by the U.S. Department of Labor on radiation safety and health standards promulgated under the Walsh-Healey Act. At the hearing, the agreement States contended that the Walsh-Healy regulations, which contain an exemption for employers who possess or use atomic materials under an AEC license, should also contain a similar exemption applicable to licensees of agreement States. The AEC supported this position and urged the Department of Labor to amend its regulations so that an employer in an agreement State shall be deemed to be in compliance with the Walsh-Healey radiation safety regulations if the employer possesses or uses atomic energy materials under an agreement State license and in accordance with the requirements of the regulatory program of that State. The matter is under consideration by the Department of Labor.

On April 6, the Director of Regulation and the Administrator of the Wage and Hour and Public Contracts Division of the Department of Labor signed an agreement concerning AEC licensees which is intended to avoid unnecessary duplication of effort by the two agencies with respect to radiation health and safety matters, such as the conduct of compliance investigations.

### *Cooperation With the Southern Interstate Nuclear Board*

During 1964, the AEC entered into a contract with the Southern Interstate Nuclear Board under which the Board conducted a study of radiation safety training experience and training requirements in the State health departments and other State regulatory agencies in the 17 States eligible for membership on the Southern Interstate Nuclear Board. The study is expected to prove helpful to the AEC in developing information on the training needs of the several States.

## INDEMNIFICATION

Section 170 of the Atomic Energy Act of 1954, as amended, provides a means of protecting against a third-party liability resulting from a nuclear incident arising out of the operation of certain licensed nuclear facilities in the event that the total loss exceeds the amount of required financial protection. This is done through indemnification agreements between the AEC and licensees. These agreements provide public liability protection up to $500 million for each incident over and above the amount of financial protection required.

Except for nonprofit educational institutions and Federal agencies, the operator of a licensed nuclear facility is required to provide financial protection in order to qualify for the indemnification. The exact amount of financial protection, which is usually in the form of liability insurance, depends on the purpose for which the reactor is operated, the location in terms of population density, and the power level. The maximum insurance presently available from the private insurance industry is $60 million.

### *Coverage for Chemical Processing Facilities*

In May 1964, the Commission published in the *Federal Register* a notice requesting public comment concerning the development of generally applicable criteria for determining amounts of financial protection and indemnity fees for spent reactor fuel processing facilities. The notice also invited comment on a proposed interim level of financial protection and an interim indemnity for the Nuclear Fuel Services, Inc., irradiated reactor fuel processing facility currently under construction in New York State. In settling the proposed amount for the NFS facility, the Commission considered the factors specifically designated in the Act for establishing financial protection levels. and took into account the amounts of nuclear liability insurance carried by fabricators of unirradiated fuel and the amounts of liability insurance carried by a substantial number of firms engaged in potentially hazardous non-nuclear operations. At the close of the year, the Commission's staff was reviewing the public comments received in response to this notice.

### *Indemnity Agreements*

As of December 31, 1964, there were 77 indemnity agreements in effect covering the operation of 11 power reactors, four test reactors, 68 research reactors, 17 critical experiment facilities, and four for storage only of nuclear fuel at a reactor site.

For indemnity protection, AEC charges $30 per thermal megawatt of authorized reactor power, subject to a minimum annual charge of $100.

Nuclear energy liability insurance premiums of the two underwriting syndicates were reduced for some reactors effective January 1, 1964. The premium reduction applied to reactors operating at high power levels and averaged approximately 14 percent. Under these revised rates, for example, a large power reactor for which the annual premium formerly was $312,000 received a reduction to $266,550. To date, there have been no claims under licensee indemnity agreements.

A listing of the reactor licensees with whom the AEC has indemnity agreements is shown in Appendix 6.

### *Clarifying Legislation*

Under the Price-Anderson Amendments to the Atomic Energy Act, Government indemnity applies to licenses issued prior to August 1, 1967, and covers public liability arising out of, or in connection with, the licensed activity. During the past year the Jersey Central Power and Light Co. raised the question of whether operation of a facility can be indemnified under the present statute if a construction permit is issued prior to August 1, 1967, but the license to operate the facility is not issued until after that date. The Commission's General Counsel, in an opinion, answered the question affirmatively, after concluding that the word "licenses," as used in the Act, includes construction permits within its scope, and that the "licensed activity" covered by an indemnity agreement includes all licensed activities which are to be carried on at a facility.

Nevertheless, Jersey Central requested clarifying legislation, which the Commission included in the 1964 Omnibus Bill submitted to Congress. Section 170 was amended on August 1, 1964, to make clear that Government indemnity extends to any license issued for a facility for which a construction permit is issued prior to August 1, 1967.

## RULES AND REGULATIONS

A description of each of the amendments and proposed amendments to the Commission's regulations published in the *Federal Register* during 1964 is given in Appendix 7.

# APPENDIX 1

## ORGANIZATION AND PRINCIPAL STAFF OF U.S. ATOMIC ENERGY COMMISSION

### COMMISSIONERS

| | |
|---|---|
| Atomic Energy Commission | GLENN T. SEABORG, *Chairman* |
| | ARNOLD R. FRITSCH, *Special Assistant* |
| | MARY I. BUNTING |
| | RICHARD X. DONOVAN, *Special Assistant* |
| | JAMES T. RAMEY |
| | JAMES R. YORE, *Special Assistant* |
| | JOHN G. PALFREY |
| | HARRIET S. SHAPIRO, *Special Assistant* |
| | GERALD F. TAPE |
| | WILLIAM C. BARTELS, *Technical Assistant* |
| Secretary to the Commission | W. B. MCCOOL |
| Chief Hearing Examiner | SAMUEL W. JENSCH |
| Chairman, AEC Board of Contract Appeals | PAUL H. GANTT |
| Controller | JOHN P. ABBADESSA |
| General Counsel | JOSEPH F. HENNESSEY |

### OPERATING AND PROMOTIONAL FUNCTIONS

| | |
|---|---|
| General Manager | ROBERT E. HOLLINGSWORTH |
| Executive Assistant to General Manager | JOHN V. VINCIGUERRA |
| Assistant to the General Manager | HARRY S. TRAYNOR |
| Deputy General Manager | EDWARD J. BLOCH |
| Assistant General Manager | DWIGHT A. INK |
| Assistant General Manager for Operations | JOHN A. ERLEWINE |
| Director, Office of Enonomic Impact and Conversion | CLARENCE C. OHLKE |
| Director, Division of Construction | JOHN A. DERRY |
| Director, Division of Contracts | (Vacant) |
| Director, Division of Labor Relations | OSCAR S. SMITH |
| Director, Division of Operational Safety | NATHAN H. WOODRUFF |
| Assistant General Manager for Research and Development | SPOFFORD G. ENGLISH |
| Director, Division of Biology and Medicine | CHARLES L. DUNHAM, M.D. |
| Director, Division of Isotopes Development | PAUL C. AEBERSOLD |
| Director, Division of Research | PAUL W. MCDANIEL |

| | |
|---|---|
| Assistant General Manager for Research and Development—Continued | |
| Director, Division of Nuclear Education and Training | RUSSELL S. POOR |
| Director, Division of Peaceful Nuclear Explosives | JOHN S. KELLY |
| Assistant General Manager for Plans and Production | GEORGE F. QUINN |
| Director, Division of Operations Analysis and Forecasting | PAUL C. FINE |
| Director, Division of Plans and Reports | WILLIAM H. SLATON |
| Director, Division of Production | F. P. BARANOWSKI |
| Director, Division of Raw Materials | RAFFORD L. FAULKNER |
| Assistant General Manager for Reactors | JOHN A. SWARTOUT |
| Director, Division of Naval Reactors | Vice Adm. H. G. RICKOVER |
| Director, Division of Reactor Development and Technology | MILTON SHAW |
| Manager, Space Nuclear Propulsion Office | HAROLD B. FINGER |
| Assistant General Manager for International Activities | JOHN A. HALL |
| Director, Division of International Affairs | MYRON B. KRATZER |
| Assistant General Manager for Administration | HOWARD C. BROWN |
| Director, Division of Classification | C. L. MARSHALL |
| Director, Division of Headquarters Services | EDWARD H. GLADE |
| Director, Division of Intelligence | C. H. REICHARDT |
| Director, Division of Nuclear Materials Management. | DOUGLAS E. GEORGE |
| Director, Division of Personnel | ARTHUR L. TACKMAN |
| Director, Division of Public Information | DUNCAN C. CLARK |
| Director, Division of Security | JOHN A. WATERS, Jr. |
| Director, Division of Special Projects | EDWARD R. GARDNER |
| Director, Division of Technical Information | EDWARD J. BRUNENKANT, Jr. |
| Director, Division of Military Application | Brig. Gen. DELMAR L. CROWSON |
| Controller, Office of the Controller | JOHN P. ABBADESSA |
| General Counsel, Office of the General Counsel | JOSEPH F. HENNESSEY |
| Director, Division of Industrial Participation | ERNEST B. TREMMEL |
| Director, Division of Inspection | CURTIS A. NELSON |
| Director, Office of Congressional Relations | JOHN J. BURKE |

## LICENSING AND REGULATORY FUNCTIONS

| | |
|---|---|
| Director of Regulation | HAROLD L. PRICE |
| Deputy Director | CLIFFORD K. BECK |
| Assistant Director | ROBERT LOWENSTEIN |
| Assistant Director for Nuclear Safety | M. M. MANN |
| Assistant Director for Administration | C. L. HENDERSON |
| Director, Division of Compliance | LAWRENCE D. LOW |
| Director, Division of Reactor Licensing | RICHARD L. DOAN |
| Director, Division of Safety Standards | FORREST WESTERN |
| Director, Division of Materials Licensing | LYALL E. JOHNSON, *Acting* |
| Director, Division of State and Licensee Relations | EBER R. PRICE |

## MANAGERS OF FIELD OFFICES

| | |
|---|---|
| Albuquerque (N. Mex.) Operations Office | LAWRENCE P. GISE |
| 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 | CHARLES C. CAMPBELL |
| Pinellas (Fla.) Area | HENRY A. NOWAK |
| Rocky Flats (Colo.) Area | SETH R. WOODRUFF, Jr. |
| San Antonio (Tex.) Area | H. JACK BLACKWELL |
| Sandia (N. Mex.) Area | LADDIE W. OTOSKI |
| South Albuquerque (N. Mex.) Area | WALTER W. STAGG |
| Brookhaven (Upton, N.Y.) Office | E. L. VAN HORN |
| Chicago (Ill.) Operations Office | KENNETH A. DUNBAR |
| Canoga Park (Calif.) Area | JOEL V. LEVY |
| Grand Junction (Colo.) Office | ALLAN E. JONES |
| Idaho (Idaho Falls) Operations Office | WILLIAM L. GINKEL |
| Nevada (Las Vegas) Operations Office | JAMES E. REEVES |
| New York (N.Y.) Operations Office | WESLEY M. JOHNSON |
| Health and Safety Laboratory (New York City) | DR. JOHN HARLEY |
| Oak Ridge (Tenn.) Operations Office | S. R. SAPIRIE |
| Cincinnati (Ohio) Area | CLARENCE L. KARL |
| New Brunswick (N.J.) Area | C. J. RODDEN |
| Paducah (Ky.) Area | BERNARD N. STILLER |
| Portsmouth (Ohio) Area | ROY V. ANDERSON |
| Puerto Rico (San Juan) Area | FLOYD P. TRENT |
| St. Louis (Mo.) Area | FRED H. BELCHER |
| Pittsburgh (Pa.) Naval Reactors Office | LAWTON D. GEIGER |
| Richland (Wash.) Operations Office | J. E. TRAVIS |
| San Francisco (Calif.) Operations Office | ELLISON C. SHUTE |
| Palo Alto (Calif.) Area | LAWRENCE G. MOHR |
| Savannah River (Aiken, S.C.) Operations Office | ROBERT C. BLAIR |
| Schenectady (N.Y.) Naval Reactors Office | STANLEY W. NITZMAN |

## DIRECTORS OF COMPLIANCE FIELD ORGANIZATIONS

| | |
|---|---|
| Region I (New York) | ROBERT W. KIRKMAN |
| Region II (Atlanta) | JOHN G. DAVIS |
| Region III (Chicago) | ROY C. HAGEMAN |
| Region IV (Denver) | DONALD I. WALKER |
| Region V (San Francisco) | RICHARD W. SMITH |

## AEC REPRESENTATIVES IN FOREIGN OFFICES

| | |
|---|---|
| Brussels, Belgium | CHARLES F. SCHANK, *Senior Representative* |
| Buenos Aires, Argentina | LESTER R. ROGERS |
| Chalk River, Ontario, Canada | MILLER N. HUDSON, JR. |
| London, England | SAMUEL G. NORDLINGER |
| Paris, France | ABRAHAM S. FRIEDMAN |
| Tokyo, Japan | PETER A. MORRIS |

# APPENDIX 2

## MEMBERSHIP OF COMMITTEES DURING 1964

### STATUTORY COMMITTEES AND BOARDS

### Joint Committee on Atomic Energy—88th Congress

This Committee was established by the Atomic Energy Act of 1946, and continued under the Atomic Energy Act of 1954, to make "continuing studies of the activities of the Atomic Energy Commission and of problems relating to the development, use, and control of atomic energy." The Committee is kept fully and currently informed with respect to the Commission's activities. Legislation relating primarily to the Commission or to atomic energy matters is referred to the committee. The Committee's membership is composed of nine Members of the Senate and nine Members of the House of Representatives. During 1964, the Committee was composed of:

Senator JOHN O. PASTORE (Rhode Island), *Chairman.*[1]
Representative CHET HOLIFIELD (California), *Vice Chairman.*[1]
Senator RICHARD B. RUSSELL (Georgia).
Senator CLINTON P. ANDERSON (New Mexico).
Senator ALBERT GORE (Tennessee).
Senator HENRY M. JACKSON (Washington).
Senator BOURKE B. HICKENLOOPER (Iowa).
Senator GEORGE D. AIKEN (Vermont).
Senator WALLACE F. BENNETT (Utah).
Senator CARL T. CURTIS (Nebraska).
Representative MELVIN PRICE (Illinois).
Representative WAYNE N. ASPINALL (Colorado).
Representative ALBERT THOMAS (Texas).
Representative THOMAS G. MORRIS (New Mexico).
Representative CRAIG HOSMER (California).
Representative WILLIAM H. BATES (Massachusetts).
Representative JACK WESTLAND (Washington).[2]
Representative JOHN B. ANDERSON (Illinois).
JOHN T. CONWAY, *Executive Director.*

### Military Liaison Committee

Under section 27 of the Atomic Energy Act of 1954, "there is hereby established a Military Liaison Committee consisting of (*a*) a Chairman, who shall be the head thereof and who shall be appointed by the President, by and with the advice and consent of the Senate, who shall serve at the pleasure of the President, and who shall receive compensation at the rate prescribed for an Assistant Secretary

[1] Under Section 203 of the Atomic Energy Act of 1954, as amended, the Chairmanship alternates between the Senate and the House with each Congress; Representative Holifield is expected to be the Chairman and Senator Pastore the Vice-Chairman for the 89th Congress.

[2] Representative Westland was defeated in the November 1964 election; seat on Committee was vacant as of January 4, 1965.

of Defense; and (*b*) a representative or representatives from each of the Departments of the Army, Navy, and Air Force, in equal numbers as determined by the Secretary of Defense, to be assigned from each Department by the Secretary thereof, and who will serve without additional compensation. The Chairman of the Committee may designate one of the members of the Committee as Acting Chairman to act during his absence. The Commission shall advise and consult with the Department of Defense, through the Committee, on all atomic energy matters which the Department of Defense deems to relate to military applications of atomic weapons or atomic energy including the development, manufacture, use, and storage of atomic weapons; the allocation of special nuclear material for military research, and the control of information relating to the manufacture or utilization of atomic weapons; and shall keep the Department of Defense, through the Committee, fully and currently informed of all such matters before the Commission. The Department of Defense, through the Committee, shall keep the Commission fully and currently informed on all matters within the Department of Defense which the Commission deems to relate to the development or application of atomic energy. The Department of Defense, through the Committee, shall have the authority to make written recommendations to the Commission from time to time on matters relating to military applications of atomic energy as the Department of Defense may deem appropriate. If the Department of Defense at any time concludes that any request, action, proposed action, or failure to act on the part of the Commission is adverse to the responsibilities of the Department of Defense, the Secretary of Defense shall refer the matter to the President whose decision shall be final."

Hon. W. J. HOWARD, *Chairman.*
Maj. Gen. ARTHUR C. AGAN, Jr., United States Air Force.
Maj. Gen. AUSTIN W. BETTS, United States Army.
Maj. Gen. ANDREW J. KINNEY, United States Air Force.
Maj. Gen. LLOYD E. FELLENZ, United States Army.
RAdm. THOMAS F. CONNOLLY, United States Navy.
Capt. HARRY B. HAHN, United States Navy.

## General Advisory Committee

This committee was established by the Atomic Energy Act of 1946, and is continued by the Atomic Energy Act of 1954. The nine civilian members are appointed by the President to advise the Commission on scientific and technical matters relating to materials, production, and research and development. Under the Atomic Energy Act, the committee shall meet at least four times in every calendar year.

Dr. L. R. HAFSTAD, *Chairman;* Vice President, Research Laboratories, General Motors Corp., Warren, Mich.
Dr. MANSON BENEDICT, Professor of Nuclear Engineering, Massachusetts Institute of Technology, Cambridge, Mass.
Dr. JOHN C. BUGHER, Director, Puerto Nuclear Center, San Juan, Puerto Rico.
Dr. DAROL FROMAN, Retired, Espanola, N. Mex.
Dr. STEPHEN LAWROSKI, Associate Laboratory Director, Argonne National Laboratory, Argonne, Ill.
Dr. KENNETH S. PITZER, President, Rice University, Houston, Tex.
Dr. NORMAN F. RAMSEY, Professor of Physics, Harvard University, Cambridge, Mass.
WILLIAM WEBSTER, President, New England Electric System, Boston, Mass.

Dr. JOHN H. WILLIAMS, Professor of Physics, University of Minnesota, Minneapolis, Minn.

DUANE C. SEWELL, *Scientific Officer*; Lawrence Radiation Laboratory, University of California, Livermore, Calif.

ANTHONY A. TOMEI, *Secretary*; U.S. Atomic Energy Commission, Washington, D.C.

The committee met in January, April, July, and October 1964.

## Patent Compensation Board

This Board was established in April 1949 pursuant to section 11 of the Atomic Energy Act of 1946, and is the Board designated under section 157a of the Atomic Energy Act of 1954. Section 157 provides that upon application for just compensation or awards or for the determination of a reasonable royalty fee, certain proceedings shall be held before such a Board.

ROBERT C. WATSON, *Chairman*; firm of Watson, Cole, Grindle & Watson, Washington, D.C.

DOUGLAS MCLEOD COOMBS, Simmonds Precision Products, Inc., Tarrytown, N.Y.

MALCOLM W. FRASER, Attorney of Patent Law, Toledo, Ohio.

HERMAN I. HERSH, firm of McDougall, Hersh & Scott, Chicago, Ill.

LAWRENCE C. KINGSLAND, firm of Kingsland, Rogers, Ezell, Eilers & Robbins, St. Louis, Mo.

The board met twice in 1964, on March 8–9, and September 18.

## Advisory Committee on Reactor Safeguards

The committee reviews safety studies and facility license applications referred to it and makes reports thereon, advises the Commission with regard to the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and performs such other duties as the Commission may request. The committee's reports on applications for facility licenses become a part of the record of the application and available to the public, except for security material. Members are appointed by the Commission for a term of four years each, and one member is designated by the committee as its chairman. This statutory committee replaced the former Advisory Committee on Reactor Safeguards in 1957.

Dr. HERBERT J. C. KOUTS, *Chairman;* Nuclear Engineering Department, Brookhaven National Laboratory, Upton, N.Y.

WILLIAM D. MANLY, *Vice-Chairman;* Director of Technology, Stellite Division, Union Carbide Corp., New York, N.Y.

Dr. FRANKLIN A. GIFFORD, Jr., Director, Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge, Tenn.

Dr. DAVID B. HALL, Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. HENRY W. NEWSON, Professor of Physics, Duke University, Durham, N.C.

Dr. DAVID OKRENT, Physicist, Argonne National Laboratory, Argonne, Ill.

KENNETH OSBORN, Director, Industrial Development, General Chemical Division, Allied Chemical Corp., Morristown, N.J.

NUNZIO J. PALLADINO, Professor and Head, Nuclear Engineering Department, Pennsylvania State University, University Park, Pa.

DONALD A. ROGERS, Consultant, Morristown, N.J.

Dr. LESLIE SILVERMAN, Professor of Engineering in Environmental Hygiene and Director of Radiological Hygiene Program, Harvard University, Boston, Mass.

REUEL C. STRATTON, Consulting Engineer, Hartford, Conn.

Dr. THEOS J. THOMPSON, Director, MIT Nuclear Reactor, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. CHARLES R. WILLIAMS, Assistant Vice-President, Liberty Mutual Insurance Co., Boston, Mass.

R. F. FRALEY, *Executive Secretary;* U.S. Atomic Emergy Commission, Washington, D.C.

Dr. DICK DUFFY, *Technical Secretary;* University of Maryland, College Park, Md.

The Committee met 11 times during 1964, on January 9–10, February 13–15, and 24, April 2–4, and 17, May 7–9, July 9–11, August 24–26, October 7–10, November 12–14, and December 10–12.

## Atomic Safety and Licensing Boards

Public Law 87–615 of the 87th Congress, which became law on August 29, 1962, adopted certain amendments to the Atomic Energy Act of 1954 authorizing, in addition to other matters, the Commission to establish one or more atomic safety and licensing boards. Each board would be composed of three members, two of whom are to be technically qualified and one of whom is to be qualified in the conduct of administrative proceedings. The boards conduct such hearings as the Commission may direct and make such intermediate or final decisions as it may authorize in proceedings with respect to granting, suspending, revoking, or amending licenses or authorizations. The Commission has appointed the following panel to serve on atomic safety and licensing boards as assigned:

J. D. BOND, Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

DIXON CALLIHAN, Oak Ridge National Laboratory, Post Office Box Y, Oak Ridge, Tenn.

ROBERT M. EVANS, Albuquerque, N. Mex.

Dr. EUGENE GRUELING, Professor of Physics, Duke University, Durham, N.C.

PATRICK W. HOWE, Head, Health Chemical Department, University of California, Lawrence Radiation Laboratory, Berkeley, Calif.

SAMUEL W. JENSCH, Chief Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ALBERT J. KIRSCHBAUM, Lawrence Radiation Laboratory, Livermore, Calif.

E. RIGGS MCCONNELL, Hearing Examiner, U.S. Atomic Energy Commission, Washington, D.C.

ARTHUR W. MURPHY, Baer, Marks, Friedman & Berliner, New York, N.Y.

WARREN E. NYER, Assistant Manager, Atomic Energy Division, Phillips Petroleum Co., Idaho Falls, Idaho.

HUGH PAXTON, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. THOMAS H. PIGFORD, Professor of Nuclear Engineering, University of California, Berkeley, Calif.

Dr. LAWRENCE R. QUARLES, Dean, School of Engineering and Applied Science, University of Virginia, Charlottesville, Va.

Dr. Charles E. Winters, Union Carbide, Parma Research Center, Cleveland, Ohio.

Dr. Abel Wolman, Head, Department of Sanitary Engineering and Water Resources, the Johns Hopkins University, Baltimore, Md.

Three boards were drawn from the panel during 1964.

## ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

### Atomic Energy Labor-Management Advisory Committee

This committee was established in March 1962 for the purpose of bringing together representatives of organized labor with representatives of management and the AEC to discuss general problems, procedures, and requirements in connection with the radiological aspects of industrial safety. Its charter was expanded in 1963 to permit consideration of questions other than those concerned with the radiological aspects of industrial safety.

Oscar S. Smith, *Chairman;* Director, Division of Labor Relations, U.S. Atomic Energy Commission, Washington, D.C.

Robert L. Lowenstein, *Vice Chairman;* Assistant Director of Regulation, U.S. Atomic Energy Commission, Washington, D.C.

Andrew J. Biemiller, Legislative Representative, AFL–CIO, Washington, D.C.

Roger J. Coe, Vice President, Yankee Atomic Electric Co., Boston, Mass.

Logan B. Emlet, Executive Vice President, Union Carbide Nuclear Co., New York, N.Y.

Harold Fidler, Associate Director, Lawrence Radiation Laboratory, University of California, Berkeley, Calif.

Gordon M. Freeman, President, International Brotherhood of Electrical Workers, Washington, D.C.

Charles D. Harrington, Vice President, United Nuclear Corp., Centreville, Md.

Albert J. Hayes, President, International Association of Machinists, Washington, D.C.

Homer Myers, Vice President, Spindletop Research Center, Lexington, Ky.

Peter T. Schoemann, President, United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada, Washington, D.C.

Elwood Swisher, Vice President, Oil, Chemical and Atomic Workers International Union, Denver, Colo.

The committee met twice in 1964, on March 16 and September 28.

### 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. Fred J. Hodges, *Chairman;* Professor and Chairman of Radiology, University of Michigan Medical Center, Ann Arbor, Mich.

Dr. James H. Sterner, *Vice Chairman;* Medical Director, Eastman Kodak Co., Rochester, N.Y.

Dr. WILLIAM F. BALE, Professor, Radiation Biology, Department of Radiation Biology and Atomic Energy Project, University of Rochester School of Medicine and Dentistry, Rochester, N.Y.

Dr. PHILIP P. COHEN, Professor and Chairman, Department of Physiological Chemistry, University of Wisconsin School of Medicine, Madison, Wis.

Dr. EARL L. GREEN, Director, the Jackson Laboratory, Bar Harbor, Maine.

Dr. ROBERT F. LOEB, Bard Professor of Medicine, Columbia University, New York, N.Y.

Dr. CARL V. MOORE, Professor of Medicine, Department of Internal Medicine, Washington University, School of Medicine, Barnes and Wohl Hospitals, St. Louis, Mo.

Dr. MORELL B. RUSSELL, Associate Director, Agricultural Experiment Station, University of Illinois, Urbana, Ill.

Dr. HARVEY M. PATT, *Scientific Secretary;* Director, Radiological Laboratory, University of California Medical Center, San Francisco, Calif.

ROSEMARY ELMO, *Executive Secretary;* U.S. Atomic Energy Commission, Washington, D.C.

The committee held five meetings during 1964, on January 10–11, March 13–14, May 7–9, September 24–25, and November 13–14.

## Historical Advisory Committee

The Historical Advisory Committee was established by the Commission in February 1958 to advise the Commission and its historical staff on matters relating to the preparation of the history of the Atomic Energy Commission.

Dr. JAMES P. BAXTER, III, *Chairman;* Senior Fellow, Council on Foreign Relations, Inc., New York, N.Y.

Dr. JAMES L. CATE, Professor of History, University of Chicago, Chicago, Ill.

Dr. CONSTANCE McL. GREEN, Washington, D.C.

Dr. RALPH W. HIDY, Professor of Business History, Graduate School of Business Administration, Harvard University, Cambridge, Mass.

Dr. GEORGE E. MOWRY, Professor of History and Dean, Department of Social Sciences, University of California, Los Angeles, Calif.

Dr. ISADORE PERLMAN, Associate Director, Lawrence Radiation Laboratory, University of California, Berkeley, Calif.

DON K. PRICE, Jr., Dean, Graduate School of Public Administration, Harvard University, Cambridge, Mass.

Dr. ROBERT R. WILSON, Director, Laboratory of Nuclear Studies, Cornell University, Ithaca, N.Y.

Dr. RICHARD G. HEWLETT, AEC representative, Chief Historian, U.S. Atomic Energy Commission, Washington, D.C.

The committee met once during 1964, on August 11–12.

## Advisory Committee on Isotopes and Radiation Development

This committee was established by the Commission in July 1958 to advise on means of encouraging wide-scale industrial use of radioisotopes and nuclear radiation.

Dr. LAUCHLIN M. CURRIE, *Chairman,* Mamaroneck, N.Y.

Dr. PAUL C. AEBERSOLD, *Vice Chairman;* Director, Division of Isotopes Development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. JAMES F. BLACK, Senior Research Associate, Products Research Division, Esso Research & Engineering Co., Linden, N.J.

Dr. JOHN C. BRANTLEY, Director of Research, Nuclear Division, Union Carbide Nuclear Corp., Tuxedo, N.Y.

E. ALFRED BURRILL, Vice President, High Voltage Engineering Corp., Burlington, Mass.

Dr. WILLARD P. CONNER, Technical Assistant to the Director, Research Center Hercules Powder Co., Wilmington, Del.

JOSEPH J. FITZGERALD, President and Director, Iso/Serve, Inc., Cambridge, Mass.

BEARDSLEY GRAHAM, President, Spindletop Research Center, Lexington, Ky.

Dr. MOSES A. GREENFIELD, Department of Radiology, School of Medicine, University of California, Los Angeles, Calif.

Dr. WILLIAM KOCH, Chief, Radiation Physics Division, National Bureau of Standards, Washington, D.C.

JOHN L. KURANZ, Vice President, Nuclear-Chicago Corp., Des Plaines, Ill.

Dr. JOHN W. LANDIS, Manager, Babcock & Wilcox Co., Atomic Energy Division, Lynchburg, Va.

Dr. JAMES R. MAXFIELD, Jr., Maxfield Clinic-Hospital, Dallas, Tex.

Dr. WAYNE MEINKE, Head, Analytical Division, National Bureau of Standards, Washington, D.C.

Dr. EUNICE MOORE, Chief Chemist, Electric Utilities Co., LaSalle, Ill.

HOWARD K. MASON, President, Monsanto Research Corp., St. Louis, Mo.

Dr. LEONARD REIFFEL, Vice President, IIT Research Institute, Chicago, Ill.

Dr. MARVIN G. SCHORR, President, Technical Operations, Inc., Burlington, Mass.

Dr. RODMAN S. SHARP, President, Sharp Laboratories Division, Beckman Instruments, Inc., La Jolla, Calif.

Dr. CHAUNCEY STARR, Atomics International, A Division of North American Aviation, Inc., Canoga Park, Calif.

Dr. ERNST STUHLINGER, Army Ballistic Missile Agency, Marshall Space Flight Center, Huntsville, Ala.

OLIVER H. TOWNSEND, Director, Office of Atomic Development, State of New York, New York, N.Y.

Dr. WALTER M. URBAIN, Director, Engineering Research & Development Dept., Swift and Co., Chicago, Ill.

JAMES F. YOUNG, General Manager, Atomics Product Division, General Electric Co., Palo Alto, Calif.

The committee met twice in 1964, on May 11–13 and October 5–6.

## Advisory Committee on Medical Uses of Isotopes

The committee was established in 1958 and replaced the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution. The committee will advise the Commission on policies and standards for the regulation and licensing of medical uses of radioisotopes in humans.

Dr. WALLACE D. ARMSTRONG, Professor, Department of Biochemistry, University of Minnesota Medical School, Minneapolis, Minn.

Dr. REYNOLD S. BROWN, 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, Dean of Sciences, Northwestern University Medical School, Chicago, Ill.
Dr. LEE EDWARD FARR, Professor of Nuclear and Environmental Medicine and Chief, Section of Nuclear Medicine, M.D., Anderson Hospital and Tumor Institute, University of Texas, Houston, Tex.
Dr. ROBERT H. GREENLAW, Associate Professor of Radiology, University of Kentucky, Lexington, Ky.
Dr. E. RICHARD KING, Professor of Radiology, Medical College of Virginia, Richmond, Va.
Dr. GEORGE V. LEROY, Professor of Medicine, Division of Biological Sciences, University of Chicago, Chicago, Ill.
Dr. EDITH H. QUIMBY, Professor Emeritus, Department of Radiology, Columbia University, New York, N.Y.
Dr. RULON W. RAWSON, Attending Physician and Chairman, Memorial Hospital, New York, N.Y.
Dr. HARALD ROSSI, Professor of Radiology, College of Physicians and Surgeons, Columbia University, New York, N.Y.

The committee met twice in 1964, on May 10–11 and December 4.

## Plowshare Advisory Committee

The Plowshare Advisory Committee was established in September 1959. The committee's function is to advise the Commission and the General Manager on selecting and carrying out particular Plowshare projects; developing and making available various applications of Plowshare; and determining the general orientation and policies of the Plowshare program.

Dr. SPOFFORD G. ENGLISH, *Chairman*, Assistant General Manager for Research and Development, U.S. Atomic Energy Commission, Washington, D.C.
WILLARD BASCOM, President, Ocean Science & Engineering, Inc., Washington, D.C.
Lt. Gen. JAMES H. DOOLITTLE, Space Technology Laboratories, Inc., Redondo Beach, Calif.
Dr. LOUIS H. HEMPELMANN, Professor, Experimental Radiology, Strong Memorial Hospital, University of Rochester, Rochester, N.Y.
Dr. RICHARD LATTER, Research Council, the RAND Corp., Santa Monica, Calif.
Dr. WILLARD F. LIBBY, Director, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Calif.
Dr. W. RANDOLPH LOVELACE II, Director, Lovelace Foundation, Albuquerque, N. Mex.
Dr. DONALD H. MCLAUGHLIN, Chairman of the Board, Homestake Mining Co., San Francisco, Calif.
Dr. PHILIP C. RUTLEDGE, Partner, Mueser, Rutledge, Wentworth & Johnston, New York, N.Y.
Dr. PAUL B. SEARS, Professor Emeritus and former Chairman, Conservation Program, Yale University, New Haven, Conn.

The Committee met once in 1964, on April 14.

## Advisory Committee on Reactor Physics

This committee was established in 1951 to consider the status of the development of reactor physics information required for the development of reactor

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concepts and the design and construction of reactors. Nuclear physics data and reactor physics studies required for the design and development of reactors are reviewed and evaluated. The committee's recommendations and advice are used in planning research and development work in the field of reactor physics.

Dr. IRA F. ZARTMAN, *Chairman;* Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ROBERT AVERY, Director, Reactor Physics Division, Argonne National Laboratory, Argonne, Ill.

JACK CHERNICK, Associate Head, Reactor Physics Division, Brookhaven National Laboratory, Upton, N.Y.

Dr. E. RICHARD COHEN, Associate Director, North American Aviation Science Center, Canoga Park, Calif.

Dr. FRANK G. DAWSON, Jr., Manager, Reactor Physics, Hanford Laboratories, General Electric Co., Richland, Wash.

Dr. GERHARD DESSAUER, Director, Physics Section, E. I. duPont de Nemours & Co., Inc., Aiken, S.C.

Dr. MILTON EDLUND, Manager, Physics and Mathematics Department, Babcock & Wilcox Co., Lynchburg, Va.

Dr. RICHARD EHRLICH, Manager, Advanced Development Activity, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N.Y.

Dr. REX FLUHARTY, Manager, Nuclear Physics Branch, Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. E. R. GAERTTNER, Rensselaer Polytechnic Institute, Troy, N.Y.

Dr. GORDON HANSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

PHILIP B. HEMMIG, Division of Reactor Development, U.S. Atomic Energy Commission, Washington, D.C.

Dr. IRVING KAPLAN, Professor, Department of Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. SIDNEY KRASIK, Vice President, Astronuclear Laboratory, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. F. C. MAIENSCHEIN, Associate Director, Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. MARK NELKIN, Professor, Nuclear Reactor Laboratory, Cornell University, Ithaca, N.Y.

Dr. LORTHAR W. NORDHEIM, Chairman, Theoretical Physics Department, General Atomic, San Diego, Calif.

Dr. THOMA M. SNYDER, Manager, Physics—APED, Vallecitos Atomic Laboratory, General Electric Co., Pleasanton, Calif.

JOHN J. TAYLOR, Manager, Reactor Development and Analysis Department, Bettis Atomic Power Division, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. ALVIN RADKOWSKY, *Secretary,* Division of Naval Reactors, U.S. Atomic Energy Commission, Washington, D.C.

The committee met twice during 1964: April 22–24 and October 15–16 at Oak Ridge, Tenn.

## Advisory Committee for Standard Reference Materials and Methods of Measurement

The committee was originally established by the Commission in March 1956, as the Committee for Uranium Isotopic Standards. The Commission approved its reconstitution in January 1958, under its present title, to reflect the broadened scope of its activities. The committee reviews, evaluates, and recommends means for providing standard reference materials (i.e., certified chemical and isotopic standards for uranium, plutonium, etc.) and approved methods of measurement for materials of special importance to atomic energy activities.

- Dr. SAMUEL C. T. McDOWELL, *Chairman;* Assistant Director for Control, Division of Nuclear Materials Management, U.S. Atomic Energy Commission, Washington, D.C.
- JOHN L. HAGUE, Chief, Analytical Standards Coordinator, Analytical Chemistry Division, National Bureau of Standards, Department of Commerce, Washington, D.C.
- RALPH J. JONES, Chief, Survey and Appraisal Branch, Division of Nuclear Materials Management, U.S. Atomic Energy Commission, Washington, D.C.
- Dr. CHARLES F. METZ, Group Leader, Chemical and Instrumental Analysis, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
- Dr. HORACE W. NORTON, III, Professor of Statistical Design and Analysis, University of Illinois, Urbana, Ill.
- Dr. LEONARD P. PEPKOWITZ, Vice President, Nuclear Materials & Equipment Corp., Apolla, Pa.
- C. J. RODDEN, Area Manager, New Brunswick Area Office, U.S. Atomic Energy Commission, New Brunswick, N.J.
- CHARLES M. STEVENS, Special Materials and Services, Argonne National Labratory, Argonne, Ill.
- C. D. W. THORNTON, International Telephone & Telegraph Corp., New York, N.Y.
- Dr. EDWARD WICHERS, National Academy of Sciences, Washington, D.C.
- Dr. J. ERNEST WILKINS, General Atomic, San Diego, Calif.

The committee met once in 1964, on October 1–2.

## 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. In 1960 its function was enlarged to furnish guidance in the implementation of the Commission's program of cooperation with States. At the same time, its membership was broadened to provide a larger cross section of views consistent with its additional functions.

- JOHN B. BRECKENRIDGE, Director, Kentucky Atomic Energy and Space Authority, Frankfort, Ky.
- Dr. BERNARD BUCOVE, Director of Health, State Department of Public Health, Seattle, Wash.
- Dr. R. L. CLEERE, Executive Director, State Department of Public Health, Denver, Colo.
- CARL FRASURE, Committee of State Officials on Suggested State Legislation, West Virginia University, Morgantown, W. Va.
- ROBERT H. GIFFORD, Executive Director, Southern Interstate Nuclear Board, Atlanta, Ga.
- Dr. ALBERT E. HEUSTIS, Commissioner of Health, Michigan Department of Health, Lansing, Mich.
- C. W. KLASSEN, Chief Sanitary Engineer, Department of Public Health, Springfield, Ill.
- Dr. MORRIS KLEINFELD, Director, Division of Industrial Hygiene, Department of Labor, New York, N.Y.

W. T. LINTON, Executive Director, Water Pollution Control Authority, South Carolina State Board of Health, Columbia, S.C.

HENRY M. MARX, Coordinator, Atomic Development Activities, Greenwich, Conn.

KARL M. MASON, Director, Bureau of Environmental Health, Pennsylvania Department of Health, Harrisburg, Pa.

Dr. JAMES E. PEAVY, Commissioner of Health, State Department of Health, Austin, Tex.

WILLIAM J. PIERCE, National Conference of Commissioners on Uniform Laws, University of Michigan Law School, Ann Arbor, Mich.

B. A. POOLE, Director Bureau of Environmental Sanitation, Indiana State Board of Health, Indianapolis, Ind.

D. P. ROBERTS, Chief Industrial Hygiene Section, Tennessee Department of Health, Nashville, Tenn.

OLIVER H. TOWNSEND, Director, Office of Atomic Development, New York, N.Y.

The committee did not meet during 1964.

## Advisory Committee on Technical Information

This committee was established during 1961, replacing the Advisory Committee on Industrial Information, formed in 1949. The committee advises and assists in the planning and execution of the AEC's technical information program.

EDWARD J. BRUNENKANT, Jr., *Chairman;* Director, Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C.

HERBERT S. BAILEY, Jr., Director, Princeton University Press, Princeton, N.J.

JOHN E. DOBBIN, Project Director, Educational Testing Service, Princeton, N.J.

Dr. HAYLANDE YOUNG FAILEY, Chicago, Ill.

BERNARD M. FRY, Director, Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va.

JAMES L. GAYLORD, Senior Partner of James L. Gaylord Associates, Santa Monica, Calif.

Dr. ALLEN G. GRAY, Editor, "Metal Progress," American Society for Metals, Metals Park, Ohio

NORMAN H. JACOBSON, Managing Editor, "Atomics," the Technical Publishing Co., Barrington, Ill.

JOHN W. LANDIS, Manager, Atomic Energy Division, the Babcock & Wilcox Co., Lynchburg, Va., representing American Nuclear Society, Chicago, Ill.

Dr. FRED P. PETERS, Vice President, Reinhold Publishing Co., New York, N.Y.

KARL T. SCHWARTZWALDER, Director of Research, A–C Spark Plug Division, General Motors Corp., Flint, Mich., representing the American Ceramic Society, Inc., Columbus, Ohio.

OLIVER H. TOWNSEND, Director, Office of Atomic Development, New York, N.Y.

JOHN W. WIGHT, Vice President, McGraw-Hill Book Co., Inc., New York, N.Y.

The committee met once during 1964, on March 31.

## Committee of Senior Reviewers

The Committee of Senior Reviewers studies the major technical activities of the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect to the rules and guides for the control of scientific and technical information. The committee consists of eight members each of whom is appointed for a one-year term.

Dr. ALVIN C. GRAVES, *Chairman;* J Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. EUGENE EYSTER, Alternate GMX Division Leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. A. C. HAUSSMANN, A Division Leader, Lawrence Radiation Laboratory, University of California, Livermore, Calif.

Dr. JOHN P. HOWE, Professor of Engineering, Cornell University, Ithaca, N.Y.

Dr. FRANK C. HOYT, Missiles System Division, Lockheed Aircraft Corp., Palo Alto, Calif.

Dr. WARREN C. JOHNSON, Vice President, University of Chicago, Chicago, Ill.

Dr. WINSTON M. MANNING, Director, Chemistry Division, Argonne National Laboratory, Argonne, Ill. (Term ended October 31, 1964.)

Dr. J. REGINALD RICHARDSON, Professor of Physics, University of California at Los Angeles, Calif.

The committee met three times during 1964, on February 4–6, May 20–22, and August 12–13.

## Mathematics and Computer Sciences Research Advisory Committee

The Mathematics and Computer Sciences Research Advisory Committee was established in 1960 as an advisory board to the Division of Research of the AEC to make recommendations on computer research and development programs and provide advice and guidance on problems in this field.

Prof. ABRAHAM H. TAUB, *Chairman;* Computer Center, University of California, Berkeley, Calif.

SAMUEL N. ALEXANDER, Data Processing Systems Division, National Bureau of Standards, Washington, D.C.

Dr. ALSTON S. HOUSEHOLDER, Oak Ridge National Laboratory, Oak Ridge, Tenn..

Dr. MARIO JUNCOSA, The Rand Corp., Santa Monica, Calif.

Dr. WILLIAM F. MILLER, Argonne National Laboratory, Argonne, Ill.

JAMES H. RICHARDSON, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. NORMAN R. SCOTT, Department of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

Dr. CHARLES V. L. SMITH, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

Dr. JOHN R. PASTA, *Secretary;* Digital Computer Laboratory, University of Illinois, Urbana, Ill.

The committee met three times in 1964, on April 20, July 7, and December 4.

## Nuclear Cross Sections Advisory Group

This group, appointed on a yearly basis, provides consultation and guidance for the Commission's program of nuclear cross-section measurements. Information from this program is of fundamental importance to many activities of the Commission.

Prof. HERBERT GOLDSTEIN, *Chairman;* Columbia University, New York, N.Y.

Dr. LOUIS ROSEN, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

HARRY PALEVSKY, Brookhaven National Laboratory, Upton, Long Island, N.Y.

Prof. HENRY W. NEWSON, Department of Physics, Duke University, Durham, N.C.

Dr. H. WILLIAM KOCH, National Bureau of Standards, Washington, D.C.

Dr. HERMAN J. DONNERT, U.S. Army Chemical Corps, Nuclear Defense Laboratory, Edgewood Arsenal, Md.

Dr. GERALD C. PHILLIPS, Department of Physics Chairman, Rice University, Houston, Tex.

Dr. GEORGE L. ROGOSA, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

Dr. M. S. MOORE, Atomic Energy Division, Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. PAUL H. STELSON, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Prof. JAMES E. RUSSELL, Rensselaer Polytechnic Institute, Troy, N.Y.

Dr. IRA L. ZARTMAN, Division of Reactor Development and Technology, U.S. Atomic Energy Commission, Washington, D.C.

Dr. ALAN B. SMITH, *secretary;* Argonne National Laboratory, Argonne, Ill.

*Ex-Officio Members*

Dr. WILLIAM W. HAVENS, Jr., Department of Physics, Columbia University, New York, N.Y.

Dr. GEORGE A. KOLSTAD, Division of Research, U.S. Atomic Energy Commission, Washington, D.C.

Dr. RICHARD F. TASCHEK, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

*Official Observers*

CHARLES GOTTSCHALK, Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C.

Dr. JOHN R. STEHN, Brookhaven National Laboratory, Upton, Long Island, N.Y.

The group met three times in 1964, on January 28–30, June 4–5, and October 13–14.

## 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.
JOHN J. WILSON, firm of Whiteford, Hart, Carmody & Wilson, Washington, D.C.
LOUIS A. TURNER, Princeton University, Princeton, N.J.

The Board met twice during 1964, on March 9 and on October 28.

## Technical Information Panel

The panel was established in 1948 to advise and assist the AEC in the planning, testing, development, and execution of the Commission's technical information program, primarily on matters of interest to the National Laboratories and major operating contractors.

EDWARD J. BRUNENKANT, Jr., *Chairman;* Director, Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C.
H. S. ALLEN, Chief, Information Services, Atomic Energy Division, Babcock & Wilcox Co., Lynchburg, Va.
BREWER F. BOARDMAN, Director, Technical Information, Phillips Petroleum Co., Idaho Falls, Idaho.
Dr. THOMAS S. CHAPMAN, Technical Information Officer, Dow Rocky Flats, Golden, Colo.
C. L. CHASE, Manager, Technical Information, General Electric Co., Nuclear Materials and Propulsion Operation, Cincinnati, Ohio.
W. E. DREESZEN, Administrative Aide to Director, Ames Laboratory, Ames, Iowa.
DOUGLAS DUPEN, Technical Information Department, Stanford Linear Accelerator Center, Stanford University, Stanford, Calif.
W. L. HARWELL, Head, Legal and Information Control Department, Union Carbide Corp., Oak Ridge, Tenn.
Dr. C. P. KEIM, Director, Technical Information Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.
MAX K. LINN, Director, Technical Information and Publications, Sandia Corp., Sandia Base, Albuquerque, N. Mex.
FRANK R. LONG, General Supervisor, Information Services, Atomic International, Canoga Park, Calif.
JOHN H. MARTENS, Director, Technical Publications Department, Argonne National Laboratory, Argonne, Ill.
W. A. MINKLER, Supervisor, Bettis Technical Information, Westinghouse Electric Corp., Pittsburgh, Pa.
Dr. J. W. MORRIS, Director, Separations and Services Section, Savannah River Laboratory, Aiken, S.C.
Dr. JUDD C. NEVENZEL, University of California, Laboratory of Nuclear Medicine, Los Angeles, Calif.
DENNIS PULESTON, Head, Information Division, Brookhaven National Laboratory, Upton, Long Island, N.Y.
HELEN REDMAN, Librarian, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. ARCHIE E. RUEHLE, Assistant Technical Director, Uranium Division, Mallinckrodt Chemical Works, St. Charles, Mo.
Dr. HOWARD W. RUSSELL, Technical Director, Battelle Memorial Institute, Columbus, Ohio.

Frank D. Shearin, Technical Editor, Monsanto Research Corp., Mound Laboratory, Miamisburg, Ohio.

C. G. Stevenson, Manager, Technical Information Operation, General Electric Co., Richland, Wash.

Dr. Stuart Sturges, Knolls Atomic Power Laboratory, Schenectady, N.Y.

Charles D. Tabor, Superintendent, Works Laboratory, Goodyear Atomic Corp., Piketon, Ohio.

Joseph W. Votaw, Assistant to Technical Director, National Lead Co. of Ohio, Cincinnati, Ohio.

Dr. Raymond K. Wakerling, Chief, Technical Information Division, Lawrence Radiation Laboratory, Berkeley, Calif.

Robert L. Shannon, Secretary; Ext. Manager, Division of Technical Information Extension, U.S. Atomic Energy Commission, Oak Ridge, Tenn.

# APPENDIX 3

## PRINCIPAL AEC-OWNED, CONTRACTOR-OPERATED INSTALLATIONS

*Ames Laboratory* (Iowa State University of Science and Technology, contractor), Ames, Iowa

Director — Dr. Frank H. Spedding
Deputy Director — Dr. Morton Smutz
Associate Director — Dr. H. A. Wilhelm
Assistant Director — Dr. Adolf F. Voigt
Business Manager — Alex E. Edwards

*Argonne Cancer Research Hospital* (University of Chicago, contractor), Chicago, Ill.

Director — Dr. Leon O. Jacobson
Associate Director — Dr. P. V. Harper
Assistant Director for Administration — Cyril W. Kupferberg

*Argonne National Laboratory* (University of Chicago, contractor), Argonne, Ill.

Director — Dr. Albert V. Crewe
Associate Director — Dr. Stephen Lawroski
Associate Director for High Energy Physics — Dr. Robert G. Sachs
Associate Director for Education — Dr. Frank E. Myers
Assistant Director — Dr. James R. Gilbreath

*Bettis Atomic Power Laboratory* (Westinghouse Electric Corp., contractor), Pittsburgh, Pa.

General Manager — Philip N. Ross
Executive Assistant to the General Manager — W. A. Brecht
Manager, Operations — A. P. Zechella
Manager, Naval Reactor Facility (NRTS), Idaho — D. C. Spencer

*Boiling Reactor Nuclear Superheat Project* (BONUS plant), (Puerto Rico Water Resources Authority, contractor), Punta Higuera, P.R.

Executive Director, PRWRA — Rafael V. Urrutia
Assistant Executive Director — Rafael R. Ramirez
Plant Superintendent — J. Hernando Fragoso
Assistant Plant Superintendent — Manuel M. Rivera

*Brookhaven National Laboratory (Associated Universities, Inc., contractor)*, Upton, Long Island, N.Y.

Chairman, Board of Trustees ---------- Dr. CARL F. FLOE
President, AUI ---------- THEODORE P. WRIGHT
Laboratory Director ---------- Dr. MAURICE GOLDHABER
Deputy Director ---------- Dr. CLARKE WILLIAMS
Associate Director ---------- Dr. CHARLES FALK

The participating institutions are:

Columbia University
Cornell University
Harvard University
The Johns Hopkins University
Massachusetts Institute of Technology
Princeton University
University of Pennsylvania
University of Rochester
Yale University

*Burlington AEC Plant* (Mason & Hanger-Silas Mason Co., Inc., contractor), Burlington, Iowa

Contract Manager (Vice President) ---------- R. B. JEWELL
Plant Manager ---------- D. E. HEFFELBOWER
Program Planning Manager ---------- A. S. PETER, Jr.
Administrative Assistant ---------- B. W. CALVIT

*Clarkesville Facility* (Mason & Hanger-Silas Mason Co., Inc., contractor), Fort Campbell, Ky.

Branch Manager ---------- R. J. IHNE
Program Planning ---------- J. R. VINSON
Security ---------- H. H. PHILLIPS
Safety ---------- E. L. BAKER

*Connecticut Aircraft Nuclear Engineering Laboratory* (CANEL) (Pratt & Whitney Aircraft Division, contractor), Middletown, Conn.

General Manager ---------- WALTER DOLL

*Elk River Reactor* (Rural Cooperative Power Association, contractor), Elk River, Minn.

General Manager ---------- EDWARD E. WOLTER
Manager, Nuclear Contract and Engineering Department ---------- ELDEN J. WELSH
Manager, Nuclear Plant ---------- ROBERT CAMPBELL
Manager, Radiological Physics Department ---------- DUANE HALL

*Evendale Plant* (General Electric Co., contractor), Cincinnati, Ohio

Manager ---------- WILLIAM H. LONG

*Feed Materials Production Center* (National Lead Co. of Ohio, contractor), Fernald, Ohio

Vice President ---------- GEORGE WUNDER
Manager ---------- JAMES H. NOYES
Assistant Manager ---------- M. S. NELSON

*Hallam Nuclear Power Facility* (Consumers Public Power District, contractor), Hallam, Nebr.

| | |
|---|---|
| General Manager | D. W. Hill |
| Consultant | Dr. Emerson Jones |
| Power Supply Manager | R. S. Kamber |
| Plant Superintendent | J. D. Cochran |

*Hanford Atomic Products Operation* (General Electric Co., contractor), Richland, Wash.

| | |
|---|---|
| General Manager, HAPO | W. E. Johnson |
| Manager, Plant Operations | A. B. Greninger |
| General Manager, N Reactor Department | R. L. Dickeman |
| General Manager, Chemical Processing Department | J. H. Warren |
| Acting General Manager, Irradiation Processing Department | O. C. Schroeder |
| Manager, Hanford Laboratories [1] | H. M. Parker |

*Kansas City Plant* (The Bendix Corp., Kansas City Division, contractor), Kansas City, Mo.

| | |
|---|---|
| General Manager | E. E. Evans |
| Assistant General Manager | R. J. Quirk |
| Director, Production Management | V. L. Ritter |
| Director, Manufacturing | A. J. Raymo |

*Knolls Atomic Power Laboratory* (General Electric Co., contractor), Schenectady, N.Y.

| | |
|---|---|
| General Manager | K. A. Kesselring |
| Manager, S5G Project | H. E. Stone |
| Manager, D1G Project | W. E. Bruggeman |
| Manager, SAR Project | E. C. Rumbaugh |

*LaCrosse Boiling Water Reactor* (under construction), (Dairyland Power Cooperative, contractor), LaCrosse, Wis.

| | |
|---|---|
| President | John E. Olson |
| General Manager | John P. Madgett |
| Chief Engineer | N. W. Moser |
| Plant Superintendent | R. E. Shimshak |

*Los Alamos Scientific Laboratory* (University of California, contractor), Los Alamos, N. Mex.

| | |
|---|---|
| Director | Dr. Norris E. Bradbury |
| Technical Associate Director | Dr. Raemer E. Schreiber |
| Assistant Director | Dr. Jane H. Hall |
| Assistant Director, Production | Dr. Max F. Roy |

[1] The name of the Hanford Laboratories, which have been contractor-operated for the AEC by General Electric, will be changed to "Pacific Northwest Laboratory" when Battelle Memorial Institute of Columbus, Ohio, becomes the AEC's operating contractor for the research facility in 1965; Dr. S. L. Fawcett will be the Director.

*Medina Facility* (Mason & Hanger-Silas Mason Co., Inc., contractor), San Antonio, Tex.

| | |
|---|---|
| Contract Manager | JOSEPH M. HIGGINS |
| Administrative Assistant | JAMES E. OBERMILLER |
| Division Superintendent, Production | THOMAS R. WIGGINS |
| Fiscal Manager | BENJAMIN A. JAMES |

*Mound Laboratory* (Monsanto Research Corp., contractor), Miamisburg, Ohio

| | |
|---|---|
| Project Director (president, Monsanto Research Corp.) | H. K. NASON |
| Plant Manager (vice president, Monsanto Research Corp.) | DAVID L. SCOTT |
| Technical Coordinator | Dr. JOHN F. EICHELBERGER |
| Director, Production | J. E. BRADLEY |

*Nuclear Rocket Development Station* (Pan American World Airways, Guided Missile Range Div., NRDS Project, contractor), Jackass Flats, Nev.

| | |
|---|---|
| Project Manager | R. L. YORDY |
| Manager, Operations | D. I. WALLACE |

*National Reactor Testing Station* (NRTS), Idaho Falls, Idaho (two contractors):

*Phillips Petroleum Co., Atomic Energy Division, Idaho Falls*

| | |
|---|---|
| Project Manager | J. P. LYON |
| Assistant Manager, Operations | M. H. BARTZ |
| Assistant Manager, Nuclear and Chemical Technology | B. R. DEBOISBLANC |
| Assistant Manager, Nuclear Safety Technology | W. E. NYER |
| Assistant Manger, Engineering | L. J. WEBER |
| Assistant Manager, Administration | L. L. LEEDY |

*Aerojet General Corp. and Aerojet-General Nucleonics, San Ramon, Calif.*

| | |
|---|---|
| Program Manager, Army Gas Colled Reactor Systems | R. H. CHESWORTH |
| Manager, NRTS Operations | W. D. WAYNE |
| Assistant Manager, NRTS Operations | N. K. SOWARDS |
| Administrative Superviser, NRTS Operations | N. D. ZIPKIN |

*Naval Reactors Facility* (Combustion Engineering, Inc., contractor), Windsor, Conn.

*Nevada Test Site* (Reynolds Electrical & Engineering Co., Inc., contractor), Mercury, Nev.

| | |
|---|---|
| General Manager | J. R. CROCKETT |
| Deputy General Manager | R. W. KIEHN |
| Assistant Project Manager, Construction | W. A. STEVENS |
| Assistant Project Manager, Engineering | R. D. CUNNINGHAM |
| Assistant Project Manager, Logistics | R. R. SAUNDERS |

*Notre Dame Radiation Laboratory* (University of Notre Dame, contractor), Notre Dame, Ind.

Director — Dr. MILTON BURTON
Associate Director — Dr. JOHN L. MAGEE
Assistant Director, Administration — J. J. RISSER

*Oak Ridge Research and Development and Production Facilities* (Union Carbide Corp., contractor), Oak Ridge, Tenn., and Paducah, Ky.

General Manager — Dr. C. E. LARSON

*Oak Ridge Production Facilities*

Manager of Production — CLARK E. CENTER

*Y-12 Plant*

Superintendent — R. F. HIBBS

*Oak Ridge Gaseous Diffusion Plant*

Superintendent — ROBERT G. JORDAN

*Paducah Gaseous Diffusion Plant*

Superintendent — ROBERT A. WINKEL

*Oak Ridge National Laboratory*

Director — Dr. ALVIN M. WEINBERG
Deputy Director — H. G. MACPHERSON

*Agricultural Research Laboratory* (University of Tennessee, contractor), Oak Ridge, Tenn.

Project Leader — Dr. JOHN A. EWING
Laboratory Director — Dr. NATHAN S. HALL

*Oak Ridge Institute of Nuclear Studies* (contractor), Oak Ridge, Tenn.

President — Dr. PAUL M. GROSS
Executive Director — Dr. WILLIAM G. POLLARD
Deputy Director — Dr. VINCENT E. PARKER

The sponsoring universities of the institute are:

Auburn University
Catholic University of America
Clemson University
Duke University
Emory University
Fisk University
Florida State University
Georgia Institute of Technology
Louisiana State University
Medical College of Virginia
Meharry Medical College
Mississippi State College
North Carolina State College
Tuskegee Institute
University of Alabama
University of Arkansas
University of Florida
University of Georgia
University of Kentucky
University of Louisville
University of Maryland
University of Miami
University of Mississippi
University of North Carolina
University of Oklahoma
University of Puerto Rico

The sponsoring universities of the institute are—Continued

| | |
|---|---|
| North Texas State College | University of South Carolina |
| Rice Institute | University of Tennessee |
| Southern Methodist University | University of Texas |
| Texas A. and M. University | University of Virginia |
| Texas Christian University | Vanderbilt University |
| Texas Woman's University | Virginia Polytechnic Institute |
| Tulane University | West Virginia University |

*Pantex Plant* (Mason & Hanger-Silas Mason Co., Inc., contractor), Amarillo, Tex.

Contract Manager (Vice President) ---------- R. B. Jewell
Plant Manager ---------- John C. Drummond
Chief Engineer ---------- Marion L. Ott
Production Manager ---------- Robert B. Carroll

*Pinellas Peninsula Plant* (General Electric Co., contractor), St. Petersburg, Fla.

General Manager ---------- R. J. Schier
Plant Manager ---------- A. F. Persons
Manager, Production Engineering ---------- G. P. Petersen
Manager, Manufacturing ---------- C. T. Kimball

*Piqua Nuclear Power Facility* (City of Piqua, contractor), Piqua, Ohio

City Manager ---------- Robert M. Hance, Jr.
Reactor Supervisor ---------- Dennis L. Ziemann
Utilities Director ---------- John P. Gallagher
Director of Finance ---------- Edgar I. Gerhard

*Portsmouth Gaseous Diffusion Plant* (Goodyear Atomic Corp., contractor), Piketon, Ohio

General Manager ---------- C. H. Reynolds
Deputy General Manager ---------- C. R. Milone

*Puerto Rico Nuclear Center* (University of Puerto Rico, contractor), San Juan and Mayaguez, P.R.

Director ---------- Dr. John C. Bugher
Deputy Director ---------- Dr. Henry J. Gomberg

*Rocky Flats Plant* (Dow Chemical Co., contractor), Rocky Flats, Colo.

General Manager ---------- Dr. Lloyd M. Joshel
General Services Manager ---------- Robert R. Harrison
Director of Research and Development ---------- Lorne A. Matheson
Product Manager ---------- Edward J. Walko

*Sandia Laboratory* (Sandia Corp., contractor), Sandia Base, Albuquerque, N. Mex.

President ---------- S. P. Schwartz
Vice President, Weapons Programs ---------- R. W. Henderson
Vice President, Development ---------- E. H. Draper
Vice President, Engineering for Manufacture ---------- R. A. Bice
Vice President, Administration ---------- C. W. Campbell
Vice President, Research ---------- R. C. Fletcher
Vice President, Development ---------- G. A. Fowler

*Sandia—Livermore Laboratory* (Sandia Corp., contractor), Livermore, Calif.

Vice President — B. S. BIGGS

*Savannah River Laboratory* (E. I. du Pont de Nemours & Co., contractor), Aiken, S.C.

Director — W. P. OVERBECK
Assistant Director — A. A. JOHNSON
Section Director—Physics Sections — G. DESSAUER
Section Director—Pile Engineering and Materials Section — J. W. MORRIS
Section Director—Separations and Services Section — C. H. ICE

*Savannah River Plant* (E. I. du Pont de Nemours & Co., contractor), Aiken, S.C.

Plant Manager — JULIAN D. ELLETT
Assistant Plant Manager — J. A. MONIER, Jr.
General Superintendent, Technical Department — W. P. BEBBINGTON
General Superintendent, Production — FREDERICK H. ENDORF

*Shippingport Atomic Power Station* (Duquesne Light Co., contractor), Shippingport, Pa.

Station Superintendent — G. M. OLDHAM

*Sodium Reactor Experiment* (Atomics International Division, North American Aviation, Inc., contractor), Santa Susana, Calif.

President — CHAUNCEY STARR
Executive Vice President — J. J. FLAHERTY
Vice President — S. SIEGEL
Vice President — A. B. MARTIN

*South Albuquerque Works* (ACF Industries, Inc., contractor), Albuquerque, N. Mex.

Vice President and General Manager — W. J. JACKEL
Plant Manager — J. C. O'HARA
Director, Engineering — W. T. GEYER
Director, Applied Research and Development — C. R. GARR

*University of California at Los Angeles, Laboratory of Nuclear Medicine and Radiation Biology* (University of California, contractor), Los Angeles, Calif.

Director — Dr. JOSEPH F. ROSS
Assistant Director — T. G. HENNESSY
Project Manager — CLINTON LONGWILL

*University of California Medical Center, Radiological Laboratory* (University of California, contractor), San Francisco, Calif.

Director — Dr. HARVEY M. PATT
Associate Director — Dr. GAIL D. ADAMS

*University of California E. O. Lawrence Radiation Laboratory* (University of California, contractor), Berkeley and Livermore, Calif.

| | |
|---|---|
| Director | Dr. EDWIN M. MCMILLAN |
| Associate Director and Director, Livermore Laboratory | Dr. JOHN S. FOSTER, Jr. |
| Associate Director and Director, Donner Laboratory | Dr. JOHN H. LAWRENCE |
| Business Manager and Managing Engineer | WALLACE B. REYNOLDS |

*University of Rochester Atomic Energy Project* (University of Rochester, contractor), Rochester, N.Y.

| | |
|---|---|
| Director | Dr. HENRY A. BLAIR |
| Business Manager | C. S. THOMPSON |

*Uranium Ore and Concentrate Servicing Center* (Lucius Pitkin, Inc., contractor), Grand Junction, Colo.

| | |
|---|---|
| Project Manager | MARTIN N. GAINES |
| Assistant Project Manager | J. N. LATIMER |

*Weldon Spring Feed Materials Plant* (Mallinckrodt Chemical Works, contractor), Weldon Spring, Mo.

| | |
|---|---|
| Vice President and General Manager of Operations Division | S. H. ANONSEN |
| Manager, Uranium Division | WILLIAM J. SHELLEY |

# APPENDIX 4

## NEW AEC FILMS MADE AVAILABLE TO PUBLIC DURING 1964

### PROFESSIONAL LEVEL

PROJECT GNOME TECHNICAL REPORT: 19 minutes, color, produced by AEC's Lawrence Radiation Laboratory. Presents the technical aspects of the first experiment of the Commission's Plowshare program to study the peaceful applications of nuclear explosives.

NEUTRON ACTIVATION ANALYSIS: 40 minutes, color, produced for AEC by the General Atomic Division, General Dynamics. Deals with the nature, potentialities, and applications of neutron activation analysis, a highly sensitive analytical technique being used today in scientific crime detection, geology and geochemistry, agriculture, medicine, and petroleum, chemical and semiconductor industries.

FUNDAMENTALS OF MECHANICAL VIBRATION: 29 minutes, color, produced for the AEC by the Sandia Corp. A technical film for engineers and engineering students discussing the simple systems of mechanical vibration.

FABRICATION OF SNAP—7D FUEL SOURCES: 12 minutes, color, produced by AEC's Oak Ridge National Laboratory. A semi-technical film describing the fabrication of strontium 90 fuel capsules for the SNAP–7D generator which powers an unmanned Navy Weather Station in the Gulf of Mexico.

AIR AND GAS CLEANING FOR NUCLEAR ENERGY: 30 minutes, color, produced by AEC's Oak Ridge National Laboratory. Portrays the need for, and the development of, high efficiency filters for the nuclear energy industry.

VELA PROGRAM: SATELLITE DETECTION SYSTEM: 17 minutes, color, produced by the Sandia Corp. for the Advanced Research Projects Agency of the Department of Defense. A technical film which discusses a satellite-borne system for the detection of nuclear detonations.

(*The following 24 films were presented at the Third United Nations International Conference on the Peaceful Uses of Atomic Energy.*)

POWER REACTOR EXPERIENCE IN THE UNITED STATES: 30 minutes, color, produced by AEC's Argonne National Laboratory. A survey of the current status of power reactor development in the United States with emphasis on economic aspects and the development of a privately owned nuclear power industry.

FAST REACTOR DEVELOPMENT: 17 minutes, color, produced by AEC's Argonne National Laboratory. A film report on sodium-cooled fast breeder reactors: the Experimental Breeder Reactor II, and the Enrico Fermi Atomic Power Plant.

EBR II FUEL FACILITY: 13 minutes, color, produced by AEC's Argonne National Laboratory. Explains the facility which disassembles, reprocesses, and fabricates radioactive fuel from the Experimental Breeder Reactor II.

PLUTONIUM RECYCLE: 17 minutes, color, produced by AEC's Argonne National Laboratory. Discusses the fuel element technology, reactor use, and chemical reprocessing associated with mixed oxides of plutonium and uranium in thermal reactors.



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THORIUM—U-233 UTILIZATION: 13 minutes, color, produced by AEC's Argonne National Laboratory. Reports on the use of thorium 232 and uranium 233 as fertile material for power reactors.

HIGH ACTIVITY WASTE: 17 minutes, color, produced by AEC's Argonne National Laboratory. Describes new methods for solidifying high activity wastes, reducing their volume by a factor of 10 into solids that are almost chemically inert.

REACTOR SAFETY RESEARCH: 15 minutes, color, produced by AEC's Argonne National Laboratory. Explains reactor safety research which also provides a basis for improvement in design features and reduction of costs.

OPERATING EXPERIENCE—DRESDEN: 10 minutes, color, produced by General Electric Co. for the AEC. A film report on the day-to-day operation of the boiling water nuclear-electric power station.

OPERATING EXPERIENCE—INDIAN POINT: 10 minutes, color, produced by Babcock & Wilcox Co. for the AEC. The design, construction, and operation of the world's first central station using thorium as a fertile material.

OPERATING EXPERIENCE—YANKEE: 10 minutes, color, produced by Westinghouse Electric Corp. for the AEC. Relates various design features and performance data on this nuclear power station which has been in operation more than three years.

OPERATING EXPERIENCE—HALLAM: 10 minutes, color, produced by Atomics International for the AEC. Depicts the operation of the United States' first central station generating plant powered by a sodium-graphite reactor.

ADVANCED TEST REACTOR: 9 minutes, color, produced by Ebasco Services, Inc., Babcock & Wilcox Co., and Phillips Petroleum Co. for the AEC. An animated description of the design and theory of operation of AEC's 250-mwt Advanced Test Reactor.

THE NUCLEAR SHIP "*Savannah*": 10 minutes, color, produced by Babcock & Wilcox Co. for the AEC. An account of the experience with the design, construction and operation of the nuclear power plant for the world's first nuclear-powered cargo-passenger ship.

NUCLEAR REACTOR SPACE POWER SYSTEMS: 8 minutes, color, produced by Atomics International for the AEC. Summarizes the program to develop nuclear power reactor supplies for large space vehicles.

HIGH ENERGY PHYSICS RESEARCH: 23 minutes, color, produced by AEC's Argonne National Laboratory. Indicates current understanding of subnuclear particles, nuclear forces; and surveys the status of high energy physics research in the United States.

FUSION RESEARCH: 22 minutes, color, produced by AEC's Argonne National Laboratory. Describes the nature of controlled thermonuclear research as illustrated by many of the current investigations of plasma production and confinement.

DIAGNOSIS AND THERAPY WITH RADIATION: 32 minutes, color, produced by AEC's Argonne National Laboratory. Describes the radiation techniques of diagnosis and therapy which have become standard medical tools in the United States.

RADIATION EFFECTS IN CHEMISTRY: 13 minutes, color, produced by AEC's Argonne National Laboratory. Describes the investigation of the wide variety of chemical reactions initiated by radiation.

NEUTRON DIFFRACTION: 9 minutes, color, produced by AEC's Argonne National Laboratory. Describes the principles of neutron diffraction, and indicates new fields of investigation which were previously considered not feasible.

NEUTRON ACTIVATION: 9 minutes, color, produced by AEC's Argonne National Laboratory with film footage from General Atomic, Division of General Dynamics. Describes the general techniques, applications, and sensitivity of this new powerful analytical tool.

CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES—1964: 12 minutes, color, produced by AEC's Lawrence Radiation Laboratory. Outlines the technical progress made in developing scientific and industrial applications for nuclear explosives.

COUNTING WHOLE-BODY RADIOACTIVITY: 10 minutes, color, produced by AEC's Donner Laboratory and Lawrence Radiation Laboratory. Describes the Donner Laboratory whole body counter and outlines its program of use.

THE SCINTILLATION CAMERA: 10 minutes, color, produced by AEC's Donner Laboratory and Lawrence Radiation Laboratory. Describes the scintillation camera and its use for studying thyroid disorders and kidney function.

HEAVY PARTICLE BEAMS IN MEDICINE: 10 minutes, color, produced by AEC's Donner Laboratory and Lawrence Radiation Laboratory. Gives a brief historical development of the medical uses of cyclotrons and shows the unique properties of accelerator-produced heavy particles both in investigative studies and radiation therapy.

## PROFESSIONAL AND POPULAR LEVEL

LIVING WITH A GLOVED BOX: 15 minutes, color, produced by AEC's Lawrence Radiation Laboratory. Explains the principles and techniques of working with a gloved-box—an enclosure designed for handling radioactive materials of low activity which present a hazard primarily through inhalation or ingestion.

ENVIRONMENTAL TESTING AT SANDIA: 28 minutes, color, produced by the Sandia Corp. for the AEC. Discusses the environments, both natural and induced, which weapon components and systems may experience, and how environmental testing is used to insure reliability.

UNDERSTANDING THE ATOM: RADIOISOTOPE APPLICATIONS IN INDUSTRY: 26 minutes, black and white, produced by Educational Broadcasting Corp., under the joint direction of AEC's Divisions of Isotopes Development and Nuclear Education and Training. Discusses some of the practical, simple, and easily understood methods of putting radioisotopes to work in industry. The eighth film in a series.[1]

UNDERSTANDING THE ATOM: RADIOISOTOPES IN BIOLOGY AND AGRICULTURE: 26 minutes, black and white, produced by the Educational Broadcasting Corp., under the joint direction of AEC's Divisions of Isotopes Dèvelopment, and Nuclear Education and Training. Dr. Howard J. Curtis of Brookhaven National Laboratory lectures on the uses of radioisotopes in biological and agricultural research. The ninth film in a series.[1]

UNDERSTANDING THE ATOM: RADIOISOTOPE APPLICATIONS IN MEDICINE: 26 minutes, black and white, produced by the Educational Broadcasting Corp., under the joint direction of AEC's Divisions of Isotopes Development, and Nuclear Education and Training. A lecture by Dr. John Cooper of Northwestern University on the application of radioisotopes in medical diagnosis and therapy. The tenth film in a series.[1]

UNDERSTANDING THE ATOM: THE ATOM IN PHYSICAL SCIENCE: 26 minutes, black and white, produced by the Educational Broadcasting Corp., under the direction of the AEC's Division of Nuclear Education and Training. Dr. Glenn T. Seaborg, Chairman of the AEC, discusses the role of the atom in physical science today. The eleventh film in a series.[1]

## POPULAR LEVEL

HANDLE WITH CARE: THE SAFE HANDLING OF RADIOISOTOPES: 21½ minutes, black and white, produced by the National Film Board of Canada for the Inter-

[1] See p. 428, Annual Report to Congress for 1963, and pp. 354–355, Annual Report to Congress for 1962, for previous films of this series.

national Atomic Energy Agency. Covers some of the methods of safe handling of radioisotopes in a laboratory.

THE ATOMIC FINGERPRINT: 12½ minutes, color, produced by Handel Film Corp. Explains the technique of neutron activation analysis and demonstrates some of its many applications.

PROJECT SHOAL: 17½ minutes, color, produced by AEC's Nevada Operations Office. Describes the preparation and firing of an underground nuclear detonation, one of a series of AEC-Department of Defense experiments to improve means of detecting, locating, and identifying underground nuclear explosions.

TOMORROW'S POWER TODAY: 5½ minutes, color, produced by AEC's Argonne National Laboratory. Briefly explains the principle of atomic power production, states the need for its continued development while showing that it is already in use in many locations across the country.

THE NUCLEAR SHIP "*Savannah*": 28½ minutes, color, produced for the AEC and Maritime Administration by Orleans Film Productions. Tells the story of the development, construction, testing and operation of the world's first nuclear passenger-cargo ship.

ATOMIC POWER PRODUCTION: 14 minutes, color, produced by Handel Film Corp. Explains the need for atomic power and the basic principles of several different types of power reactors.

MAN AND THE ATOM: 58 minutes, color, produced by National Educational Television, Inc. (NET). The story of the AEC's role in developing and guiding the nation's atomic energy programs.

CHALLENGE: THE ALCHEMIST'S DREAM: 29 minutes, black and white, produced by NET. Explains how the chemistry division of Argonne National Laboratory produced a minute amount of berkelium by bombarding curium with deuterons from a cyclotron.

CHALLENGE: HARNESSING THE RAINBOW: 29 minutes, black and white, produced by NET. Describes the uses of spectroscopy in a nuclear laboratory.

CHALLENGE: A CHEMICAL SOMERSAULT: 29 minutes, black and white, produced by NET. A commonly-accepted scientific maxim, that the inert gases will not form chemical compounds, is shown false in this film depicting the making of xenon-fluorine compounds.

CHALLENGE: DOWN ON THE FARM: 29 minutes, black and white, produced by NET. Shows how algae are grown in heavy water in a unique "farm" at Argonne National Laboratory.

CHALLENGE: TESTING FOR TOMORROW: 29 minutes, black and white, produced by NET. Depicts aspects of nondestructive testing employed in a nuclear laboratory.

CHALLENGE: THE FUEL OF THE FUTURE: 29 minutes, black and white, produced by NET. Illustrates the manufacture of experimental reactor fuel, showing the special techniques employed in working with plutonium.

CHALLENGE: MACHINES THAT THINK: 29 minutes, black and white, produced by NET. Shows research at Argonne National Laboratory into the future scientific uses of electronic computers.

CHALLENGE: A BREEDER IN THE DESERT: 29 minutes, black and white, produced by NET. Describes Argonne's Experimental Breeder Reactor II and many of the features and operating characteristics of large scale fast breeder reactors.

CHALLENGE: MICROSCOPE FOR THE UNKNOWN: 29 minutes, black and white, produced by NET. Demonstrates the use of Argonne's Zero Gradient Proton Synchrotron, a spark chamber, and a bubble chamber in high energy physics research.

## Film Libraries

The Commission's domestic film libraries are located at the following AEC 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. |
| Berkeley, Calif | California, Hawaii, and Nevada. |
| Grand Junction, Colo | Colorado, Wyoming, Kansas, and Nebraska. |
| Argonne, Ill | North Dakota, South Dakota, Missouri, Iowa, Ohio, Indiana, Michigan, Minnesota, Wisconsin and Illinois. |
| Oak Ridge, Tenn | Kentucky, Mississippi, Arkansas, Louisiana, and Tennessee. |
| Albuquerque, N. Mex | Arizona, New Mexico, Texas, and Oklahoma. |
| Richland, Wash | Washington, Oregon, and Alaska. |

# APPENDIX 5

## LICENSE APPLICATIONS FILED AND ACTIONS TAKEN

## SUMMARY OF LICENSING ACTIONS [1]

| Type of action | Sept. 1, 1954 to Nov. 30, 1964 | Nov. 30, 1963 to Nov. 30, 1964 | Permits and licenses in effect as of Nov. 30, 1964 |
|---|---|---|---|
| FACILITIES | | | |
| Power reactors (Pt. 50): | | | |
| Construction permits | [2] 14 | [2] 2 | [2] 3 |
| Construction permit amendments and orders | 28 | 4 | ------------- |
| Licenses to operate | 11 | 1 | 11 |
| License amendments, authorizations and orders | 215 | 65 | ------------- |
| Power reactors (Pt. 115): | | | |
| Construction authorizations | 5 | 0 | 1 |
| Construction authorization amendments | 1 | 1 | ------------- |
| Construction authorizations terminated | 2 | 2 | ------------- |
| Operating authorizations | 6 | 3 | 4 |
| Operating authorization amendments | 36 | 22 | ------------- |
| Test reactors: | | | |
| Construction permits | 5 | 0 | 1 |
| Construction permit amendments and orders | 5 | 0 | ------------- |
| Licenses to operate | 4 | 1 | 4 |
| License amendments and authorizations | 47 | 20 | ------------- |
| Research reactors: | | | |
| Construction permits | 81 | 5 | [3] 5 |
| Construction permit amendments and orders | 76 | 6 | ------------- |
| Licenses to operate (including acquire and operate) | 90 | 3 | 68 |
| License amendments | 360 | 80 | ------------- |
| Reactor exports: | | | |
| Research reactor licenses | 44 | 4 | (4) |
| Test reactor licenses | 3 | 0 | (4) |
| Power reactor licenses | 8 | 3 | (4) |
| Critical experiment facilities | 2 | 1 | (4) |
| License amendments | 75 | 4 | ------------- |
| Critical experiment facilities: | | | |
| Construction permits | 23 | 1 | 0 |
| Construction permit amendments and orders | 14 | 0 | ------------- |
| Licenses to operate | 22 | 3 | 16 |
| License amendments | 96 | 23 | ------------- |
| Production facilities: | | | |
| Construction permits | 2 | 0 | 1 |
| Construction permit amendments and orders | 5 | 1 | 0 |
| Licenses to operate | 0 | 0 | 0 |
| Import licenses | 1 | 0 | 1 |
| REACTOR OPERATORS | | | |
| Operator licenses (including senior) | 2,235 | 496 | 1,549 |
| Operator license amendments and renewals | 1,101 | 147 | ------------- |
| Operator license denials | 245 | 63 | ------------- |
| MATERIALS | | | |
| Special nuclear material licenses | 830 | 93 | 568 |
| SNM license amendments and renewals | 1,894 | 359 | ------------- |
| SNM license denials | 7 | 0 | ------------- |
| Source material licenses issued or renewed | 9,244 | 233 | 475 |
| Source material export licenses | 5,020 | 136 | (4) |
| Source material license denials | 12 | 0 | ------------- |
| Byproduct material licenses (domestic use) | 15,988 | 1,560 | 8,018 |
| Byproduct material license amendments | 32,985 | 5,593 | ------------- |

[1] Applications to construct and operate are filed simultaneously; conversions from construction permits to licenses to operate are made upon satisfactory completion of construction.

[2] Does not include provisional construction permit issued December 15, 1964, to Jersey Central Power and Light Co. for power reactor in Orange County, N.J.

[3] Permits authorize construction of eight reactors and relocation of one reactor.

[4] Export licenses terminate upon completion of shipment.

# APPENDIX 6

## INDEMNITY AGREEMENTS

| Organization | Thermal power level | Private financial protection required |
|---|---|---|
| Commonwealth Edison Co | 700, 000 kw | $60, 000, 000 |
| Yankee Atomic Electric Co | 600, 000 kw | 60, 000, 000 |
| Consolidated Edison Co | 585, 000 kw | 60, 000, 000 |
| Consumers Power Co | 240, 000 kw | 36, 000, 000 |
| Pacific Gas & Electric Co | 165, 000 kw | 29, 700, 000 |
| General Electric Co | 50, 000 kw [1] | 12, 000, 000 |
| Carolinas Virginia Nuclear Power Associates, Inc | 44, 300 kw | 6, 645, 000 |
| Saxton Nuclear Experimental Corp | 23, 500 kw | 4, 300, 000 |
| The Babcock & Wilcox Co | 6, 000 kw [1] | 3, 500, 000 |
| Industrial Reactor Laboratories, Inc | 5, 000 kw | 2, 500, 000 |
| Union Carbide Corp | 5, 000 kw | 2, 500, 000 |
| Battelle Memorial Institute | 3, 000 kw [1] | 2, 500, 000 |
| Lockheed Aircraft Corp | 3, 000 kw | 2, 500, 000 |
| General Dynamics Corp | 1, 500 kw [1] | 2, 500, 000 |
| Northern States Power Co | 1, 000 kw | 1, 500, 000 |
| Power Reactor Development Corp | 1, 000 kw | 1, 500, 000 |
| Northrop Corp | 100 kw | 1, 500, 000 |
| IIT Research Institute | 75 kw | 1, 500, 000 |
| Westinghouse Electric Corp | 10 kw [1] | 1, 000, 000 |
| North American Aviation, Inc | 200 w | 1, 000, 000 |
| United Nuclear Corp | 100 w | 1, 000, 000 |
| Martin-Marietta Corp | 50 w [1] | 1, 000, 000 |
| Aerojet-General Nucleonics | 20 w | 1, 000, 000 |
| Allis-Chalmers Manufacturing Co | ------------ | 1, 000, 000 |
| American Radiator & Standard Sanitary Corp | ------------ | 1, 000, 000 |
| 52 educational institutions and Federal agencies | ------------ | None |

[1] More than one indemnified licensed activity; power level shown is highest power level for that license.

# APPENDIX 7

## RULES AND REGULATIONS

The Commission's regulations are contained in Title 10, Chapter I, of the Code of Federal Regulations (10 CFR 1). Effective and proposed regulations directly concerning licensed activities, and published in the Federal Register during 1964, are set forth below.

### REGULATIONS AND AMENDMENTS PUT INTO EFFECT

*Part 1—"Statement of Organization, Delegations and General Information"*

On April 30, 1964, Part 1 was amended to set out the delegations of authority of four recently created Divisions reporting to the Director of Regulation. The Divisions now reporting to the Director of Regulation are as follows: Divisions of State and Licensee Relations, Compliance, Safety Standards, Reactor Licensing, and Materials Licensing.

*Part 2—"Rules of Practice"*

On December 8, 1964, Part 2 was amended to extend the time within which the Commission may review on its own motion initial decisions in facility licensing cases from the present 30 day period to a period of 45 days. Such decisions include those which grant or amend construction permits or operating licenses under 10 CFR Part 50 and construction or operating authorizations for facilities owned by the Commission under 10 CFR Part 115.

*Part 3—"Rules of Procedure in Contract Appeals"*

On September 11, 1964, the Commission amended its regulations for the disposition of appeals from decisions of contracting officers in certain disputes arising out of contracts and certain subcontracts of the AEC. The amendments transferred this function from the Office of Hearing Examiners to a newly created Board of Contract Appeals, and, in a new Part 3, revised, simplified and made more flexible the procedures pertaining to the disposition of contract appeals.

*Part 4—"Nondiscrimination in Federally Assisted Commission Programs"*

On December 31, 1964, a new part 4 was published to effectuate the provisions of Title VI of the Civil Rights Act of 1964 to the end that no person in the United States shall, on the basis of race, color, or national origin, be excluded from participation in, be denied the benefit of, or be otherwise subjected to discrimination under any program or activity receiving Federal financial assistance from the AEC. Part 4 will become effective on January 30, 1965.

*Part 20—"Standards for Protection Against Radiation"*

On October 21, 1964, Part 20 was amended to (*a*) incorporate revised concentration limits, based on Federal Radiation Council recommendations, for radium 226, iodine 131, strontium 89, and strontium 90 that will govern the release by licensees of these radionuclides into unrestricted areas; (*b*) place limitations on the gross quantity of radioactive material released from a licensed activity in specified periods of time; (*c*) require more specific information in support of applications for authority to release concentrations of radioactive material in effluents which exceed Part 20 limits; and (*d*) revise the criteria for approval of proposed limits in excess of Part 20 limits to require an applicant for such approval to demonstrate that he has taken reasonable steps to minimize radioactivity discharged in the effluent streams.

*Part 30—"Licensing of Byproduct Material"*

*Part 40—"Licensing of Source Material"*

*Part 50—"Licensing of Production and Utilization Facilities"*

*Part 70—"Special Nuclear Material"*

On October 20, 1964, amendments were published to the Commission's regulations, 10 CFR Parts 30, 40, 50, and 70 which redefine and clarify the scope of exemptions from licensing of certain AEC contractors generally described as being "contractors with and for the account of the Commission", by specifying certain categories of AEC contractors which are exempted from the Commission's licensing requirements. They are:

(1) Prime contractors performing work for the Commission at U.S. Government-owned or controlled sites;
(2) Prime contractors performing research in, or development, manufacture, storage, testing or transportation of atomic weapons or weapons components;
(3) Prime contractors using or operating nuclear reactors or other nuclear devices in a U.S. Government-owned vehicle or vessel; and
(4) Any other prime contractor or subcontractor when the Commission determines:
    (a) that the exemption of such a contractor or subcontractor is authorized by law; and
    (b) that, under the terms of the contract or subcontract, there is adequate assurance that the work can be accomplished without undue risk to the public health and safety.

The amendments will become effective on January 18, 1965.

*Part 30—"Licensing of Byproduct Material"*

On May 5, 1964, Part 30 was amended to (1) issue general licenses for the receipt, possession, acquisition, ownership, use and transfer of americium 241 in calibration or reference sources, and for the export of americium 241, and (2) specify requirements for a specific license for persons who manufacture such sources for distribution to persons generally licensed.

On July 14, 1964, Part 30 was amended to conform the Commission's regulations for the export of byproduct material to the export regulations of the U.S. Department of Commerce with respect to exports to Cuba. The Commission revoked its general license for export to Cuba of medicinals and similar items containing radioisotopes and placed all exports of such materials under its specific license requirements.

On July 21, 1964, Part 30 was amended to provide for a general license for the ownership of byproduct material. The general license includes the right both to receive and transfer such ownership, but does not authorize possession, use, import or export of byproduct material.

On August 8, 1964, Part 30 was amended to (1) exempt from licensing the receipt, possession, use, transfer, export, ownership and acquisition of balances of precision or balance parts containing not more than 0.5 millicurie of tritium per balance part and not more than 1.0 millicurie of tritium per balance. and (2) set out specific licensing requirements for the application of tritium to precision balances or parts and for the import of balances or parts.

*Part 40—"Licensing of Source Material"*

On December 27, 1963, Part 40 was amended to exempt from licensing requirements the receipt, possession, use, transfer and import into the United States of uranium contained in detector heads for use in fire detection units, provided that not more than 0.005 microcurie of uranium is contained in each detector head. This amendment did not authorize the manufacture of any detector head containing uranium. Manufacture would have to be authorized by Commission specific or general license or similar license from an agreement State. The amendment to Part 40 became effective January 26, 1964.

On November 17, 1964, Part 40 was amended to exempt from licensing the distributon and use of glass enamel and glass enamel frit containing not more than 10 percent by weight source material, such as uranium. The amendment also specifies the percentages in the existing exemption for source material in glazed ceramic tableware and glassware in terms of weight.

*Part 70—"Special Nuclear Material"*

On May 5, 1964, Part 70 was amended to (*a*) issue a general license authorizing the receipt, possession, use and transfer of plutonium in calibration or reference sources, and (*b*) specify requirements for a specific license for persons who manufacture such sources for distribution to persons generally licensed.

*Part 140—"Financial Protection Requirements and Indemnity Agreements"*

On June 17, 1964, amendments were published consisting of an endorsement to the form of nuclear energy liability insurance policy set forth in Appendix "A" of Part 140 and a related change, for the purpose of clarification, in the form of indemnity agreement set forth in Appendix "B" of Part 140. The form of the endorsement is intended by the insurers for use in reinstatement of liability coverage following payment by the insurers of an incurred loss.

On July 14, 1964, an amendment was published consisting of an endorsement to the nuclear energy liability insurance policy set forth in Appendix "A" of part 140. The form of the endorsement is intended for use in eliminating from nuclear liability insurance policies coverage of public liability claims which are covered by the Commission's indemnity agreements.

## PROPOSED REGULATIONS AND AMENDMENTS

*Part 2—"Rules of Practice"*

On December 10, 1964, a proposed amendment was published which would delete the notice requirements of Part 2 with respect to facility licenses authorizing export only.

*Part 20—"Standards for Protection Against Radiation"*

On April 8, 1964, a proposed amendment to Part 20 was published which would establish additional requirements for transportation of radioactive materials by AEC licensees and the delivery of materials to carriers by AEC licensees. The proposed amendment would provide generally applicable standards for the transportation of radioactive materials where the shipments are not subject to regulations of the Interstate Commerce Commission, the Federal Aviation Agency, the Coast Guard, or the Post Office Department by reason of the fact that the transportation does not occur in interstate or foreign commerce. The proposed amendment would not apply to shipments subject to the regulations of these agencies.

On October 29, 1964, a proposed amendment to Part 20 was published which would require that containers in which licensed material greater than specified quantities is used or transported be labeled with information as to the kinds and approximate activities of the contained radioactive material, and, except for natural uranium or thorium, the dates for which the activities are specified. At the present time Part 20 requires this type of information only with respect to containers in which radioactive material is stored. The proposed amendment would delete the present requirement that the label on a storage container state quantities and dates of measurement of natural uranium or thorium.

*Part 30—"Licensing of Byproduct Material"*

On May 20, 1964, a proposed amendment to Part 30 was published which would extend the current exemptions from licensing requirements for possession and use of tritium activated timepieces or hands or dials and automobile lock illuminators to include units activated by promethium 147. The amendment would also extend the current general license for the possession and use of tritium activated luminous aircraft safety devices to include promethium 147 activated devices under specified conditions. Specific licensing requirements for manufacture of the promethium 147 activated items were included in the proposed amendment.

On June 6, 1964, a proposed amendment was published which would establish a general license for the use by physicians of the following well established and useful medical diagnostic applications of radioisotopes: iodine 131 as sodium iodide for measurement of thyroid uptake and as iodinated human serum albumin for determination of blood and blood plasma volume; cobalt 58 or cobalt 60 for measurement of intestinal absorption of cyanocobalamin; and chromium 51 as sodium radiochromate for determinations of red blood cell volumes and survival time. The Commission has deferred consideration of the general license proposed in January 1962 for therapeutic uses of radioisotopes in medicine. A specific license still will be required for these uses.

*Part 30—"Licensing of Byproduct Material"*

*Part 31—"Radiation Safety Requirements for Radiographic Operations"*

On December 17, 1964, a proposed recodification of Parts 30 and 31 was published, which would retain common requirements applicable to byproduct material licensing in Part 30, and relocate the remainder of the sections in new parts applicable to certain classes or categories of uses or users of byproduct material. The purpose of the recodification of Part 30 is to simplify and clarify the format of the present regulations; no substantive changes are proposed.

*Part 30—"Licensing of Byproduct Material"*

*Part 150—"Exemptions and Continued Regulatory Authority in Agreement States Under Section 274"*

On December 17, 1964, proposed amendments to Parts 30 and 150 were published which would make clear that persons holding an agreement State specific license are authorized to introduce byproducts material in exempt concentrations into products or materials for persons in non-agreement States who are not licensed by the Commission.

## PROPOSED FINANCIAL PROTECTION REQUIREMENTS FOR SPENT FUEL PROCESSING PLANTS

On May 26, 1964, the AEC published the amounts of public liability insurance or other financial protection and the indemntiy fee it proposes to establish, on an interim basis, for the Nuclear Fuel Services, Inc., chemical processing plant presently under construction in New York. The AEC also requested public comment and suggestions concerning the factors that should be taken into account and the weight that should be given them in the development of a generally applicable formula for determining the amounts of financial protection and indemnity fees for processing plants of varying sizes, types and locations.

# APPENDIX 8

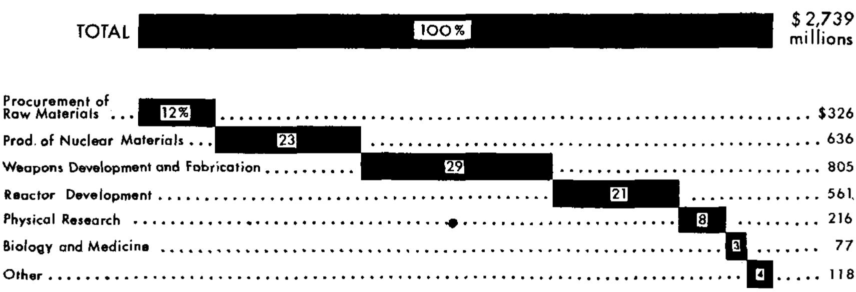
## AEC FINANCIAL SUMMARY[1] FOR FISCAL YEAR 1964

The Atomic Energy Commission is an independent agency, responsible to the President and Congress. It was established by the Atomic Energy Act of 1946, with its functions and responsibilities revised and expanded by the Atomic Energy Act of 1954 to encourage the peaceful uses of atomic energy.

Funds are provided to the AEC in two congressional appropriations—one for construction and one for operations. The AEC accounting system, therefore, must comply with the requirements of Federal Government accounting. However, since the AEC is engaged in large industrial and research activities, its management requires knowledge of the cost of each step in its operations. The AEC accounting system, approved by the U.S. General Accounting Office, provides this through the application of commercial accrual and cost accounting principles, including the recording of depreciation. For the AEC, both governmental and commercial accounting have been combined into a single system.

Most of the work involved in actually achieving the AEC goals is performed by commercial firms, or educational or other nonprofit organizations under contract to the AEC. Government-owned facilities are operated by contractors who maintain complete accounting records on their AEC activities. The summary contained in the following pages is a consolidation of unclassified information obtained from financial reports submitted to the AEC by the contractors as well as information obtained from the AEC records.

### 1964 OPERATING COSTS




[1] Material in this appendix is extracted from the "United States Atomic Energy Commission—1964 Financial Report" available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, price 40 cents.

# UNITED STATES ATOMIC ENERGY COMMISSION BALANCE SHEET

[In thousands]

| ASSETS* | June 30, 1964 | June 30, 1963 |
|---|---|---|
| Cash: | | |
| Funds in U.S. Treasury | $1, 559, 546 | $1, 581, 449 |
| Transfers from other agencies | 19, 868 | 29, 333 |
| Cash on hand and with contractors | 22, 492 | 33, 993 |
| Total | 1, 601, 906 | 1, 644, 775 |
| Accounts receivable: | | |
| Federal agencies | 25, 501 | 33, 178 |
| Other | 17, 589 | 18, 148 |
| Total | 43, 090 | 51, 326 |
| Inventories: | | |
| Source and nuclear materials leased and at research installations | 707, 503 | 715, 342 |
| Special reactor materials | 101, 486 | 102, 352 |
| Stores | 102, 844 | 86, 482 |
| Isotopes | 27, 795 | 22, 026 |
| Other special materials | 15, 374 | 15, 112 |
| Total | 955, 002 | 941, 314 |
| Plant: | | |
| Completed plant and equipment | 8, 169, 613 | 7, 651, 633 |
| Less—Accumulated depreciation | 2, 592, 221 | 2, 332, 628 |
| Subtotal | 5, 577, 392 | 5, 319, 005 |
| Construction work in progress | 408, 556 | 581, 818 |
| Total | 5, 985, 948 | 5, 900, 823 |
| Other | 56, 428 | 51, 427 |
| TOTAL ASSETS | $8, 642, 374 | $8, 589, 665 |

| LIABILITIES AND AEC EQUITY* | June 30, 1964 | June 30, 1963 |
|---|---|---|
| Liabilities: | | |
| Accounts payable and accrued expenses | $324, 910 | $327, 437 |
| Advances from other agencies | 33, 275 | 43, 518 |
| Funds held for others | 12, 501 | 13, 986 |
| Accrued annual leave of AEC employees | 8, 629 | 7, 921 |
| Deferred credits | 5, 468 | 3, 870 |
| Total liabilities | 384, 783 | 396, 732 |
| AEC equity, July 1 | 8, 192, 933 | 7, 447, 131 |
| Additions: | | |
| Funds appropriated—net | 2, 742, 661 | 3, 134, 776 |
| Nonreimbursable transfers from other agencies | 55, 147 | 6, 196 |
| Total | 2, 797, 808 | 3, 140, 972 |
| Deductions: | | |
| Net cost of operations—after special items | 2, 711, 472 | 2, 388, 538 |
| Nonreimbursable transfers to other agencies | 21, 633 | 6, 607 |
| Funds returned to U.S. Treasury | 45 | 25 |
| Total | 2, 733, 150 | 2, 395, 170 |
| AEC equity, June 30 | 8, 257, 591 | 8, 192, 933 |
| TOTAL LIABILITIES AND AEC EQUITY | $8, 642, 374 | $8, 589, 665 |

## *NOTES TO THE BALANCE SHEET

1. *The Balance Sheet Does Not Include in Assets:*
   a. Certain inventories for security reasons.
   b. 64,751,316 troy ounces of silver loaned to AEC by the Treasurer of the United States for use as electrical conductors in plants. Of this amount, 280,500 troy ounces have been lost in usage and are, therefore, not returnable. Based on market quotations at June 30, 1964, the value of the silver on loan was $83,723,000. The value of silver lost and the cost of recovering and processing that on hand and returning it to the Treasury is estimated at $678,000.
   c. Plant and equipment on loan from other Federal Agencies at June 30, 1964 amounting to $39,594,000.
   d. Contested claims against others of $1,963,000.
2. *The Balance Sheet Does Not Include in Liabilities:*
   a. Contingent liabilities related to contracts for the supply of electric power and natural gas for the Oak Ridge, Paducah and Portsmouth production facilities. If cancellation notice had been given at June 30, 1964, the estimated liabilities would have amounted to $258,089,000.
   b. Contingent liabilities as guarantor of loans to the extent of $8,288,000.
   c. Contingent liabilities for claims against AEC of approximately $46,553,000.
   d. Commitments for an estimated 68,400 tons of $U_3O_8$ at an estimated cost of $1,063,000,000.
   e. Commitments under Section 56 of the Atomic Energy Act of 1954, as amended, for the acquisition of plutonium. Estimated commitments of $1,302,000 for fiscal year 1965 are based upon projected quantities of plutonium to be produced and delivered by domestic licensees during this period. There will also be additional liability, impossible to estimate at this time, for purchase under Section 56 of the Atomic Energy Act of 1954, as amended by the "Private Ownership of Special Nuclear Materials Act", Public Law 88–489, August 26, 1964, of additional quantities of certain licensed reactor-produced plutonium delivered to the AEC prior to January 1, 1971 and uranium enriched in the isotope U-233 delivered to the Commission during future periods yet to be determined.
   f. Outstanding contracts, purchase orders and other commitments of $1,099,000,000.

## U.S. ATOMIC ENERGY COMMISSION STATEMENT OF OPERATIONS

| | *Fiscal Year* 1964 | *Fiscal Year* 1963 |
|---|---|---|
| | (in thousands) | |
| Production: | | |
| Procurement of raw materials | $326, 338 | $477, 873 |
| Production of nuclear materials | 636, 366 | 652, 426 |
| Weapons development and fabrication | 804, 598 | 696, 866 |
| Total | 1, 767, 302 | 1, 827, 165 |
| Research and development: | | |
| Development of nuclear reactors | 561, 191 | 507, 343 |
| Physical research | 215, 682 | 198, 526 |
| Biology and medicine research | 77, 352 | 70, 523 |
| Peaceful application of nuclear explosives | 13, 921 | 11, 002 |
| Isotope development | 8, 521 | 6, 815 |
| Total | 876, 667 | 794, 209 |
| Community operations: | | |
| Expenses | 10, 591 | 10, 931 |
| Revenues | (5, 706) | (5, 973) |
| Total | 4, 885 | 4, 958 |
| Sales of materials and services: | | |
| Cost | 14, 251 | 18, 060 |
| Revenue | (15, 400) | (18, 888) |
| Total | (1, 149) | (828) |
| Education and training | 9, 221 | 8, 630 |
| AEC administrative expenses | 72, 866 | 67, 068 |
| Security investigations | 6, 282 | 6, 930 |
| Other expenses | 9, 954 | 12, 849 |
| Other income | (6, 970) | (7, 774) |
| Net cost of operations [1] | 2, 739, 058 | 2, 713, 207 |
| Special items: | | |
| Adjustments to costs of prior years—net | (3, 575) | (178, 917) |
| Transfers to inventories—net | (24, 011) | (145, 752) |
| Net cost of operations—after special items | $2, 711, 472 | $2,388, 538 |

[1] Includes depreciation of $302 million in 1964 and $282 million in 1963.

## COSTS INCURRED BY AEC LABORATORIES

A major portion of AEC research and development is conducted in government-owned laboratories. The acquisition cost of AEC-owned research facilities at June 30, 1964, was $2,148 million. These facilities include research reactors, accelerators, 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; research in the physical and life sciences; and research to improve nuclear materials production processes and techniques.

The 10 laboratories listed are the principal AEC-owned research centers. The operating costs of these laboratories together with the costs incurred at other AEC-owned installations and the cost of the work performed in facilities owned by universities, industrial, and other privately owned organizations are included in the costs of the various research areas shown in this summary.

| *LABORATORIES* | *Acquisition Cost of Completed Plant June 30, 1964* | *Operating Costs Fiscal Year* | |
|---|---|---|---|
| | | *1964* | *1963* |
| | *(in thousands)* | | |
| Ames Research Laboratory | $12, 365 | $6, 777 | $6, 184 |
| Argonne National Laboratory [1] | 232, 746 | 70, 868 | 59, 708 |
| Bettis Atomic Power Laboratory [1] | 118, 256 | 72, 124 | 67, 332 |
| Brookhaven National Labatory | 162, 921 | 47, 689 | 41, 968 |
| Hanford Laboratory [2] | 92, 174 | 40, 703 | 40, 875 |
| Knolls Atomic Power Laboratory [1] | 120, 582 | 54, 224 | 52, 115 |
| Lawrence Radiation Laboratory [3] | 226, 627 | 154, 997 | 143, 606 |
| Los Alamos Scientific Laboratory [3] | 200, 162 | 96, 838 | 92, 872 |
| Oak Ridge National Laboratory | 211, 177 | 74, 819 | 72, 399 |
| Savannah River Laboratory | 60, 499 | 16, 893 | 16, 858 |

[1] Includes facilities at NRTS, Idaho.
[2] Renamed Pacific Northwest Laboratories effective January 1, 1965.
[3] Includes facilities at Mercury, Nevada.

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## COSTS INCURRED BY AEC BY LOCATION

The following table shows the costs incurred by AEC in fiscal year 1964. Allocations of costs are made in accordance with the physical location of contractors and AEC offices but do not necessarily represent funds spent in those locations.

| *LOCATION* | *Operations* [1] | *Plant and capital equipment* | *Total* |
|---|---|---|---|
| | | *(in thousands)* | |
| Alabama | $197 | ------- | $197 |
| Alaska | 63 | ------- | 63 |
| Arizona | 8, 077 | $2 | 8, 079 |
| Arkansas | 392 | ------- | 392 |
| California | 316, 213 | 61, 649 | 377, 862 |
| Colorado | 67, 983 | 10, 321 | 78, 304 |
| Connecticut | 31, 723 | 3, 144 | 34, 867 |
| Delaware | 76 | 54 | 130 |
| District of Columbia | 13, 226 | 13 | 13, 239 |
| Florida | 17, 719 | 3, 125 | 20, 844 |
| Georgia | 738 | ------- | 738 |
| Hawaii (Including Pacific Test Area) | 21, 930 | 30 | 21, 960 |
| Idaho | 39, 106 | 33, 669 | 72, 775 |
| Illinois | 77, 016 | 24, 981 | 101, 997 |
| Indiana | 6, 518 | 375 | 6, 893 |
| Iowa | 13, 465 | 2, 557 | 16, 022 |
| Kansas | 494 | ------- | 494 |
| Kentucky | 81, 318 | 1, 869 | 83, 187 |
| Louisiana | 242 | ------- | 242 |
| Maine | 274 | ------- | 274 |
| Maryland | 37, 494 | 356 | 37, 850 |
| Massachusetts | 22, 396 | 6, 637 | 29, 033 |
| Michigan | 3, 321 | 660 | 3, 981 |
| Minnesota | 2, 082 | 177 | 2, 259 |
| Mississippi | 70 | ------- | 70 |
| Missouri | 114, 061 | 9, 621 | 123, 682 |
| Montana | 23 | ------- | 23 |
| Nebraska | 124 | 1, 271 | 1, 395 |
| Nevada | 130, 265 | 24, 419 | 154, 684 |
| New Hampshire | 70 | ------- | 70 |
| New Jersey | 14, 327 | 5, 859 | 20, 186 |
| New Mexico | 397, 862 | 41, 779 | 439, 641 |
| New York | 116, 557 | 22, 858 | 139, 415 |
| North Carolina | 1, 408 | 10 | 1, 418 |
| North Dakota | 21 | ------- | 21 |
| Ohio | 150, 961 | 8, 299 | 159, 260 |
| Oklahoma | 128 | ------- | 128 |
| Oregon | 786 | 300 | 1, 086 |
| Pennsylvania | 70, 642 | 10, 478 | 81, 120 |
| Puerto Rico | 2, 282 | 2, 283 | 4, 565 |
| Rhode Island | 566 | ------- | 566 |
| South Carolina | 85, 234 | 14, 205 | 99, 439 |
| South Dakota | 5, 380 | ------- | 5, 380 |
| Tennessee | 197, 054 | 42, 415 | 239, 469 |

See footnote at end of table.

| *LOCATION* | *Operations* [1] | *Plant and capital equipment* | *Total* |
|---|---|---|---|
| | | *(in thousands)* | |
| Texas | 21, 727 | 2, 494 | 24, 221 |
| Utah | 39, 750 | 95 | 39, 845 |
| Vermont | 46 | ------- | 46 |
| Virginia | 3, 921 | 294 | 4, 215 |
| Washington | 133, 924 | 32, 000 | 165, 924 |
| West Virginia | 106 | ------- | 106 |
| Wisconsin | 4, 050 | 2, 163 | 6, 213 |
| Wyoming | 37, 898 | ------- | 37, 898 |
| Foreign Countries | 132, 615 | 162 | 132, 777 |
| Totals | $2, 423, 921 | $370, 624 | $2, 794, 545 |

[1] Excludes depreciation.

## AEC COST FOR ACTIVITIES PERFORMED BY COLLEGES AND UNIVERSITIES [1]

In addition to the activities of the AEC laboratories, some of which are operated for AEC by universities or associations of universities, AEC had other contracts with 310 colleges or universities for atomic energy work. The table below shows that the cost of this work totaled about $102 million in fiscal year 1964 and identifies the universities where costs in excess of $500,000 each were incurred.

| *COLLEGES AND UNIVERSITIES* | *Fiscal year 1964 (in thousands)* |
|---|---|
| California Institute of Technology | $2, 503 |
| California, University of | 5, 215 |
| California, University of, at Los Angeles | 2, 578 |
| Carnegie Institute of Technology | 1, 764 |
| Case Institute of Technology | 811 |
| Chicago, University of | 1, 292 |
| Colorado, University of | 688 |
| Columbia University | 4, 771 |
| Cornell University | 1, 047 |
| Duke University | 716 |
| Florida State University | 929 |
| Harvard University | 6, 134 |
| Illinois Institute of Technology | 649 |
| Illinois, University of | 2, 884 |
| Johns Hopkins University | 780 |
| Maryland, University of | 935 |
| Massachusetts Institute of Technology | 7, 138 |
| Michigan, University of | 2, 348 |
| Minnesota, University of | 1, 229 |
| New York University | 2, 073 |
| Notre Dame, University of | 1, 203 |
| Oregon, University of | 631 |
| Pennsylvania State University | 504 |
| Pennsylvania, University of | 1, 984 |
| Princeton University | 14, 456 |
| Puerto Rico, University of | 2, 124 |
| Purdue University | 1, 106 |
| Rensselaer Polytechnic Institute | 1, 108 |
| Rice University | 689 |
| Rochester, University of | 4, 587 |
| Stanford University | 959 |
| Tennessee, University of | 1, 266 |
| Utah, University of | 815 |
| Virginia, University of | 659 |
| Washington, University of | 2, 065 |
| Western Reserve University | 549 |
| Wisconsin, University of | 1, 801 |
| Yale University | 3, 352 |
| Other (272 colleges or universities) | 15, 635 |
| Total | $101, 977 |

[1] These costs exclude depreciation and include construction and capital equipment.

## AEC COSTS INCURRED BY PRINCIPAL PRIME INDUSTRIAL CONTRACTORS [1]

Private industrial organizations working under contract with the Commission perform most of the production and much of the research and development work accomplished by AEC. In fiscal year 1964, AEC's principal prime industrial contractors accomplished work amounting to some $1,862 million. The following table lists the industrial supply, production, and research and development contractors where costs incurred exceed five million dollars.

| *Industrial Organizations* | *Fiscal year 1964 (in thousands)* |
|---|---|
| ACF Industries, Inc | $33, 544 |
| Aerojet-General Corp | 50, 123 |
| Allied Chemical Corp | 8, 861 |
| Anaconda Co | 12, 095 |
| Atlas Corp | 37, 781 |
| Atomics International Division, North American Aviation, Inc | 68, 976 |
| Bendix Corp | 112, 745 |
| Catalytic Construction Co | 6, 558 |
| Dow Chemical Co | 39, 883 |
| Edgerton, Germeshausen & Grier, Inc | 20, 107 |
| E. I. duPont, de Nemours & Co | 96, 490 |
| Federal-Radorock-Gas Hills Partners | 5, 025 |
| Fluor Corporation, Ltd | 9, 553 |
| General Atomic Division, General Dynamics Corp | 8, 154 |
| General Electric Co | 231, 649 |
| Goodyear Atomic Corp | 78, 998 |
| H. K. Ferguson Co.—Morrison-Knudsen Co., Inc | 10, 930 |
| Holmes & Narver, Inc | 24, 790 |
| Homestake-Sapin Partners | 17, 578 |
| Kaiser Engineers Division of H. J. Kaiser Co | 9, 049 |
| Kermac Nuclear Fuels Corp.—Kerr-McGee Oil Industries, Inc | 26, 383 |
| Mallinckrodt Chemical Works | 10, 056 |
| Mason & Hanger—Silas Mason Co | 25, 534 |
| Mines Development, Inc.—Susquehanna Corp | 5, 241 |
| Monsanto Research Corp.—Monsanto Co | 19, 457 |
| National Lead Co | 27, 459 |
| Pan American World Airways, Inc | 8, 631 |
| Petrotomics Co | 5, 700 |
| Phillips Petroleum Co | 20, 504 |
| Pratt & Whitney Aircraft Division of United Aircraft Corp | 26, 138 |
| Reynolds Electrical and Engineering Co, Inc | 88, 575 |
| Sandia Corp.—Western Electric Co. Inc | 230, 454 |
| Union Carbide Corp | 230, 390 |
| United Nuclear Corp | 15, 859 |
| Utah Construction & Mining Co | 10, 012 |
| Western Nuclear, Inc | 9, 774 |
| Westinghouse Electric Corp | 83, 664 |
| Other | 135, 551 |
| Total | $1, 862, 271 |

[1] These costs exclude depreciation and include construction and capital equipment.

## AEC PLANT AND EQUIPMENT BY LOCATION

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects [1] [2] | Total |
| **CALIFORNIA** | | | | |
| Lawrence Radiation Laboratory University of California | | | | |
| Berkeley | $78.5 | $9.5 | $23.4 | $111.4 |
| Livermore | 134.2 | 5.7 | 44.8 | 184.7 |
| Total | 212.7 | 15.2 | 68.2 | 296.1 |
| Stanford University, Palo Alto: | | | | |
| Linear Electron Accelerator | 6.6 | 23.7 | 83.7 | 114.0 |
| Other research facilities | 3.0 | | 4.2 | 7.2 |
| Total | 9.6 | 23.7 | 87.9 | 121.2 |
| Research facilities, Sandia Corp., Livermore | 17.2 | 1.5 | 3.5 | 22.2 |
| Medical research facilities, University of California, Los Angeles | 1.5 | | .2 | 1.7 |
| Research facilities, California Institute of Technology, Pasadena | 2.2 | | 2.0 | 4.2 |
| Reactor and research facilities, Atomic International Division, North American Aviation, Inc., Canoga Park—Santa Susana | 35.9 | 6.9 | 17.3 | 60.1 |
| Computer facilities, University of California, La Jolla | 1.2 | | | 1.2 |
| Research facilities, Holmes & Narver, Inc., Los Angeles | .6 | | .1 | .7 |
| Bio-Med research facilities, University of California—Davis | 1.7 | .1 | .4 | 2.2 |
| Total California | 282.6 | 47.4 | 179.6 | 509.6 |
| **COLORADO** | | | | |
| Uranium handling, sampling and general facilities, Lucius Pitkin, Inc., Grand Junction | 4.1 | | | 4.1k |
| Rocky Flats Plant, Dow Chemical Co., Boulder | 94.7 | 9.5 | 25.5 | 129.7 |
| University of Colorado, Boulder | 1.3 | | .1 | 1.4 |
| Total Colorado | 100.1 | 9.5 | 25.6 | 135.2 |
| **CONNECTICUT** | | | | |
| Pratt & Whitney, Middletown | 67.3 | .6 | 7.3 | 75.2 |
| Linear accelerator, Yale University, New Haven | 4.2 | 1.5 | 1.9 | 7.6 |
| Submarine reactor facilities, Combustion Engineering, Inc., Windsor | 14.9 | .2 | .1 | 15.2 |
| Total Connecticut | 86.4 | 2.3 | 9.3 | 98.0 |
| **FLORIDA** | | | | |
| Pinellas Plant, General Electric Co., Clearwater | 13.3 | 2.2 | 2.7 | 18.2 |

See footnotes at end of table.

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects[1 2] | Total |
| **IDAHO** | | | | |
| National Reactor Testing Station, Phillips Petroleum Co.: | | | | |
| Chemical processing plant | $55.1 | $0.3 | $0.3 | $55.7 |
| Advanced test reactor | .1 | 30.9 | 20.9 | 51.9 |
| Materials test reactor | 15.1 | .4 | .7 | 16.2 |
| Engineering test reactor | 15.4 | | | 15.4 |
| MTR-ETR facilities | 19.0 | .1 | .3 | 19.4 |
| Nuclear safety engineering test facilities | 4.2 | .8 | 24.6 | 29.6 |
| Reactor facilities | 51.6 | 2.0 | 10.4 | 64.0 |
| General facilities | 46.2 | 2.7 | 3.3 | 52.2 |
| Total | 206.7 | 37.2 | 60.5 | 304.4 |
| Westinghouse Electric Corp.: | | | | |
| Large ship | 35.6 | .4 | | 36.0 |
| Submarine thermal reactor | 16.0 | .8 | | 16.8 |
| Other research facilities | 12.4 | 2.7 | 2.0 | 17.1 |
| Total | 64.0 | 3.9 | 2.0 | 69.9 |
| Reactor facilities, Argonne National Laboratory | 23.6 | 15.1 | 24.1 | 62.8 |
| Knolls Atomic Power Laboratory, General Electric Co | 3.7 | 14.0 | 2.4 | 20.1 |
| Experimental Beryllium Oxide Reactor, General Atomics | 1.7 | 6.7 | 2.4 | 10.8 |
| Total Idaho | 299.7 | 76.9 | 91.4 | 468.0 |
| **ILLINOIS** | | | | |
| Argonne National Laboratory, University of Chicago, Argonne | 209.2 | 41.9 | 47.6 | 298.7 |
| Argonne Cancer Research Hospital, University of Chicago, Chicago | 5.1 | .1 | .2 | 5.4 |
| University of Illinois, Urbana | 1.8 | | .7 | 2.5 |
| Total Illinois | 216.1 | 42.0 | 48.5 | 306.6 |
| **INDIANA** | | | | |
| Radiation Laboratory, University of Notre Dame, Notre Dame | 2.2 | .1 | .3 | 2.6 |
| **IOWA** | | | | |
| Research facilities, Ames Research Laboratory, Ames | 12.4 | 4.8 | 3.3 | 20.5 |
| Iowa Ordnance Plant, Mason & Hanger, Burlington | 35.7 | .2 | 4.4 | 40.3 |
| Total Iowa | 48.1 | 5.0 | 7.7 | 60.8 |

See footnotes at end of table.

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects [1, 2] | Total |
| **KENTUCKY** | | | | |
| Paducah: | | | | |
| Gaseous diffusion plant, Union Carbide Nuclear Co. | $755.8 | $1.5 | $2.6 | $759.9 |
| Feed materials plant, Union Carbide Nuclear Co. | 31.2 | | | 31.2 |
| Total Kentucky | 787.0 | 1.5 | 2.6 | 791.1 |
| **MARYLAND** | | | | |
| AEC Headquarters, Germantown | 21.0 | | .4 | 21.4 |
| **MASSACHUSETTS** | | | | |
| Cambridge electron accelerator, Harvard University, Cambridge | 16.5 | .6 | 4.1 | 21.2 |
| Research facilities, Edgerton, Germeshausen & Grier, Inc., Boston | 12.2 | .5 | 4.4 | 17.1 |
| Research facilities, Massachusetts Institute of Technology, Cambridge | 3.3 | .3 | .6 | 4.2 |
| Total Massachusetts | 32.0 | 1.4 | 9.1 | 42.5 |
| **MINNESOTA** | | | | |
| Linear accelerator, University of Minnesota, Minneapolis | 2.3 | 1.5 | 1.7 | 5.5 |
| Elk River Reactor, Rural Cooperative Power Association, Elk River | 9.7 | | 1.6 | 11.3 |
| Total Minnesota | 12.0 | 1.5 | 3.3 | 16.8 |
| **MICHIGAN** | | | | |
| Research facilities, University of Michigan, Ann Arbor | .6 | .8 | .3 | 1.7 |
| **MISSOURI** | | | | |
| Kansas City Plant, the Bendix Corp., Kansas City | 56.8 | 3.8 | 14.5 | 75.1 |
| Feed materials plant, Mallinckrodt Chemical Works, Weldon Spring | 61.3 | .6 | 1.7 | 63.6 |
| Total Missouri | 118.1 | 4.4 | 16.2 | 138.7 |
| **NEBRASKA** | | | | |
| Hallam Nuclear Power Facility, Consumers Public Power District, Hallam | 33.4 | | .6 | 34.0 |

See footnotes at end of table.

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQIUPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects[1 2] | Total |
| **NEVADA** | | | | |
| Mercury: | | | | |
| Nevada Test Site, Reynolds Electrical and Engineering Co., Inc | $89.9 | $2.6 | $21.5 | $114.0 |
| Research facilities, University of California (LASL) | 10.6 | .2 | .2 | 11.0 |
| Laboratory facilities, Lawrence Radiation Laboratory | 14.1 | 1.5 | 1.1 | 16.7 |
| Total | 114.6 | 4.3 | 22.8 | 141.7 |
| Las Vegas: Improvement of U.S. Highway 95 | | 1.8 | 2.7 | 4.5 |
| Tonopah: Research facilities, Sandia Corp | 8.6 | .4 | .8 | 9.8 |
| Nuclear Rocket Development Station, Project Rover | 33.5 | 13.8 | 20.7 | 68.0 |
| Total Nevada | 156.7 | 20.3 | 47.0 | 224.0 |
| **NEW JERSEY** | | | | |
| Princeton: | | | | |
| Princeton-Pennsylvania proton accelerator, Princeton University | 21.6 | 4.1 | 7.4 | 33.1 |
| Model C stellarator facilities, Princeton University | 23.8 | | 1.7 | 25.5 |
| Total | 45.4 | 4.1 | 9.1 | 58.6 |
| New Brunswick Laboratory, Atomic Energy Commission, New Brunswick | 3.0 | | | 3.0 |
| Total New Jersey | 48.4 | 4.1 | 9.1 | 61.6 |
| **NEW MEXICO** | | | | |
| Albuquerque: | | | | |
| Lovelace Foundation Laboratory | 2.6 | .1 | 1.2 | 3.9 |
| Sandia Laboratory, Sandia Corp | 127.3 | 5.1 | 38.9 | 171.3 |
| South Albuquerque Works, ACF Industries, Inc | 31.6 | .1 | 5.0 | 36.7 |
| Diagnostic aircraft support facilities, Kirkland, AFB | | .3 | .1 | .4 |
| Total | 161.5 | 5.6 | 45.2 | 212.3 |
| Los Alamos: | | | | |
| Los Alamos Scientific Laboratory, University of California | 189.6 | 12.7 | 39.0 | 241.3 |
| Community and general maintenance facilities, the Zia Co | 139.2 | 2.6 | 7.6 | 149.4 |
| Total | 328.8 | 15.3 | 46.6 | 390.7 |
| Total New Mexico | 490.3 | 20.9 | 91.8 | 603.0 |

**See footnotes at end of table.**

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects [1 2] | Total |
| **NEW YORK** | | | | |
| New York City: | | | | |
| Computing and other research facilities, New York University | $1.8 | | $0.1 | $1.9 |
| Accelerator and research facilities, Columbia University | 3.7 | | .2 | 3.9 |
| Health and Safety Laboratory | 1.7 | | .1 | 1.8 |
| Total | 7.2 | | .4 | 7.6 |
| Brookhaven National Laboratory, Associated Universities, Inc., Upton | 162.9 | $22.7 | 43.6 | 229.2 |
| Boron plant, Page Airways, Inc., Niagara Falls | 7.5 | | | 7.5 |
| Research Laboratory, University of Rochester, Rochester | 6.1 | | .3 | 6.4 |
| Knolls Atomic Power Laboratory, General Electric Co., Schenectady and West Milton | 116.8 | 1.1 | 11.4 | 129.3 |
| Fuel and canning preparation areas, Sylvania Electric Products, Inc., Hicksville | 2.7 | | | 2.7 |
| Accelerator facility, Rensselaer Polytechnic Institute, Troy | 2.4 | | .3 | 2.7 |
| Total New York | 305.6 | 23.8 | 56.0 | 385.4 |
| **OHIO** | | | | |
| Research facilities, General Electric Co., Cincinnati | 7.7 | | 1.2 | 8.9 |
| Gaseous diffusion plant, Goodyear Atomic Corp., Portsmouth | 762.3 | .4 | 2.7 | 765.4 |
| Feed materials plant, National Lead Co., Fernald | 120.3 | .4 | 2.6 | 123.3 |
| Mound Laboratory, Monsanto Chemical Co., Miamisburg | 42.3 | 3.0 | 8.8 | 54.1 |
| Piqua Nuclear Power Facility, City of Piqua, Piqua | 8.9 | | .9 | 9.8 |
| Feed materials facility, Reactive Metals, Inc., Ashtabula | 1.6 | .1 | .2 | 1.9 |
| Total Ohio | 943.1 | 3.9 | 16.4 | 963.4 |
| **PENNSYLVANIA** | | | | |
| Bettis Atomic Power Laboratory, Westinghouse Electric Corp., Pittsburgh | 54.3 | 1.3 | 16.3 | 71.9 |
| Accelerator and research facilities, Carnegie Institute of Technology, Pittsburgh | 1.4 | | | 1.4 |
| Shippingport Atomic Power Station, Duquesne Light Co., Shippingport | 50.3 | 14.2 | 4.4 | 68.9 |
| Astro Nuclear Laboratory, Westinghouse Electric Corp., Large | 2.1 | | 1.1 | 3.2 |
| Total Pennsylvania | 108.1 | 15.5 | 21.8 | 145.4 |

See footnotes at end of table.

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects [1 2] | Total |
| **SOUTH CAROLINA** | | | | |
| Savannah River Plant, E. I. duPont de Nemours and Co., Inc., Aiken: | | | | |
| Production reactor and separation facilities | $891.8 | $11.9 | $26.3 | $930.0 |
| Feed materials production facilities | 30.1 | .8 | .3 | 31.2 |
| Heavy water production facilities | 163.5 | .2 | .4 | 164.1 |
| Works laboratory | 60.5 | 1.0 | 2.2 | 63.7 |
| General facilities | 162.9 | 1.6 | 10.3 | 174.8 |
| Total South Carolina | 1,308.8 | 15.5 | 39.5 | 1,363.8 |
| **TENNESSEE** | | | | |
| Oak Ridge: | | | | |
| Research Laboratory, Oak Ridge Institute of Nuclear Studies | 4.5 | .1 | .2 | 4.8 |
| Agriculture Research Laboratory and Farm, University of Tennessee | 2.1 | .2 | .8 | 3.1 |
| Experimental Gas Cooled Reactor, TVA | 2.2 | 46.6 | 11.2 | 60.0 |
| Oak Ridge gaseous diffusion plant, Union Carbide Nuclear Co | 835.6 | 1.8 | 5.1 | 842.5 |
| Y-12 Plant, Union Carbide Nuclear Co | 391.7 | 6.2 | 23.9 | 421.8 |
| Oak Ridge National Laboratory, Union Carbide Nuclear Co | 211.2 | 27.1 | 36.8 | 275.1 |
| Service facilities | 21.5 | .2 | 4.8 | 26.5 |
| Total | 1,468.8 | 82.2 | 82.8 | 1,633.8 |
| Clarksville facility, Mason & Hanger, Clarksville | 2.3 | | | 2.3 |
| Total Tennessee | 1,471.1 | 82.2 | 82.8 | 1,636.1 |
| **TEXAS** | | | | |
| Pantex Plant, Mason & Hanger, Amarillo | 46.3 | .3 | 4.5 | 51.1 |
| Medina facility, Mason & Hanger, San Antonio | 16.1 | | .2 | 16.3 |
| Research facility, Rice University, Houston | 1.5 | | | 1.5 |
| Total Texas | 63.9 | .3 | 4.7 | 68.9 |
| **UTAH** | | | | |
| Monticello: Uranium ore processing plant, Lucius Pitkin, Inc | 1.1 | | | 1.1 |

See footnotes at end of table.

## AEC PLANT AND EQUIPMENT BY LOCATION—Continued

(At cost) June 30, 1964

[In millions]

| LOCATION AND CONTRACTOR | AUTHORIZED PLANT AND EQUIPMENT | | | |
|---|---|---|---|---|
| | Completed | Construction Work In Progress | Estimated Cost To Complete Construction Projects [1] [2] | Total |
| **WASHINGTON** | | | | |
| Hanford Works, General Electric Co., Richland: | | | | |
| Production reactor facilities | $714.1 | $2.3 | $13.8 | $730.2 |
| Separations facilities | 195.7 | 9.3 | 20.8 | 225.8 |
| Feed materials production facilities | 30.5 | .6 | 1.1 | 32.2 |
| Works laboratory | 92.2 | 5.9 | 15.6 | 113.7 |
| General facilities | 89.4 | .8 | 3.2 | 93.4 |
| Total Washington | 1,121.9 | 18.9 | 54.5 | 1,195.3 |
| **WEST VIRGINIA** | | | | |
| Huntington pilot plant, International Nickel Co., Huntington | 4.7 | | | 4.7 |
| **WISCONSIN** | | | | |
| Research facilities, University of Wisconsin, Madison | 1.3 | | .1 | 1.4 |
| LaCrosse Boiling Water Reactor, Genoa | | 3.3 | 8.2 | 11.5 |
| Total Wisconsin | 1.3 | 3.3 | 8.3 | 12.9 |
| **PUERTO RICO** | | | | |
| Puerto Rico Nuclear Center, University of Puerto Rico, Mayaguez | 5.1 | .1 | .5 | 5.7 |
| Boiling Nuclear Super Heat Reactor, Punta Higuera | 9.6 | 1.8 | 1.8 | 13.2 |
| Total Puerto Rico | 14.7 | 1.9 | 2.3 | 18.9 |
| **JAPAN** | | | | |
| Research facilities, National Academy of Science, Hiroshima | 2.2 | | .3 | 2.5 |
| **ALL OTHER** | | | | |
| NS *Savannah* | 27.3 | | 1.5 | 28.8 |
| Weapons storage facilities | 24.7 | | | 24.7 |
| Other | 23.1 | 3.0 | 44.7 | 70.8 |
| Total All Other | 75.1 | 3.0 | 46.2 | 124.3 |
| TOTAL | $8,169.6 | $408.6 | $878.3 | $9,456.5 |

[1] Includes Capital Equipment.
[2] Includes "Plant and capital equipment" authorized in Public Law 88-332 approved June 30, 1964.

# U.S. ATOMIC ENERGY COMMISSION TEN-YEAR SUMMARY OF FINANCIAL DATA

(Dollars in thousands)

| | 1964 | 1963 | 1962 | 1961 | 1960 | 1959 | 1958 | 1957 | 1956 | 1955 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cost of operations | $2, 739, 058 | $2, 713, 207 | $2, 695, 936 | $2, 612, 909 | $2, 619, 143 | $2, 496, 648 | $2, 298, 589 | $1, 918, 258 | $1, 607, 973 | $1, 289, 535 |
| Procurement of raw materials | 326, 338 | 477, 873 | 537, 363 | 636, 832 | 716, 507 | 699, 996 | 596, 391 | 397, 813 | 278, 946 | 193, 586 |
| Production of nuclear materials | 636, 366 | 652, 426 | 688, 533 | 732, 524 | 731, 348 | 713, 247 | 750, 178 | 762, 815 | 730, 972 | 588, 445 |
| Weapons development and fabrication | 804, 598 | 696, 866 | 705, 893 | 512, 317 | 505, 448 | 491, 981 | 443, 536 | 337, 183 | 280, 765 | 258, 706 |
| Development of nuclear reactors | 561, 191 | 507, 343 | 433, 150 | 437, 274 | 399, 252 | 355, 600 | 306, 225 | 255, 667 | 168, 853 | 114, 557 |
| Physical research | 215, 682 | 198, 526 | 171, 782 | 154, 105 | 132, 845 | 112, 318 | 87, 719 | 69, 657 | 56, 547 | 48, 221 |
| Biology and medicine research | 77, 352 | 70, 523 | 62, 782 | 53, 866 | 48, 878 | 42, 781 | 35, 958 | 33, 148 | 29, 849 | 28, 898 |
| Community operations—net | 4, 885 | 4, 958 | 4, 432 | 4, 463 | 7, 090 | 9, 892 | 11, 162 | 8, 897 | 8, 954 | 10, 321 |
| Administrative expenses | 72, 866 | 67, 068 | 60, 592 | 57, 709 | 51, 197 | 50, 135 | 46, 435 | 38, 499 | 38, 195 | 34, 027 |
| Miscellaneous expenses and income—net | 39, 780 | 37, 624 | 31, 409 | 23, 819 | 26, 578 | 20, 698 | 20, 985 | 14, 579 | 14, 892 | 12, 774 |
| Plant construction and equipment costs incurred during the year | $376, 898 | $409, 114 | $423, 765 | $432, 688 | $331, 516 | $298, 979 | $289, 744 | $317, 022 | $301, 682 | $842, 504 |
| Total AEC assets excluding inventories of certain products at June 30 | $8, 642, 374 | $8, 589, 665 | $7, 803, 222 | $7, 802, 395 | $7, 689, 385 | $7, 764, 770 | $7, 652, 784 | $7, 397, 911 | $7, 368, 272 | $8, 077, 836 |
| Plant investment at June 30 (gross) | $8, 578, 169 | $8, 233, 451 | $7, 869, 250 | $7, 664, 736 | $7, 344, 751 | $7, 292, 784 | $7, 110, 797 | $6, 907, 896 | $6, 713, 061 | $6, 487, 301 |
| Production plants | 5, 497, 362 | 5, 447, 496 | 5, 344, 523 | 5, 453, 568 | 5, 458, 201 | 5, 552, 646 | 5, 494, 440 | 5, 392, 464 | 5, 212, 776 | 4, 645, 750 |
| Research and development facilities | 2, 147, 574 | 1, 885, 929 | 1, 713, 986 | 1, 434, 967 | 1, 271, 253 | 1, 124, 543 | 937, 682 | 792, 633 | 753, 468 | 707, 107 |
| Other | 524, 677 | 318, 208 | 306, 162 | 313, 403 | 288, 608 | 365, 838 | 407, 529 | 411, 582 | 499, 793 | 505, 492 |
| Plant construction in progress at June 30 | 408, 556 | 581, 818 | 504, 579 | 462, 798 | 326, 689 | 249, 757 | 271, 146 | 311, 217 | 247, 024 | 628, 952 |
| Funds appropriated—net | $2, 742, 661 | $3, 134, 776 | $2, 547, 338 | $2, 666, 760 | $2, 649, 614 | $2, 635, 335 | $2, 333, 974 | $1, 898, 700 | $834, 227 | $1, 209, 860 |
| Operations | 2, 342, 661 | 2, 872, 031 | 2, 351, 978 | 2, 456, 210 | 2, 387, 114 | 2, 385, 406 | 2, 225, 470 | 1, 740, 400 | 1, 146, 400* | 1, 098, 978 |
| Plant and capital equipment | 400, 000 | 262, 745 | 195, 360 | 210, 550 | 262, 500 | 249, 929 | 108, 504 | 158, 300 | (312, 173)* | 110, 882 |
| Appropriation expenditures | $2, 764, 565 | $2, 757, 876 | $2, 805, 700 | $2, 713, 465 | $2, 622, 838 | $2, 541, 181 | $2, 267, 960 | $1, 931, 485 | $1, 633, 549 | $1, 861, 875 |
| Employment at June 30 | 136, 620 | 135, 278 | 126, 623 | 122, 989 | 122, 718 | 121, 928 | 121, 059 | 119, 455 | 110, 197 | 112, 618 |
| AEC employees | 7, 268 | 7, 120 | 6, 863 | 6, 846 | 6, 907 | 6, 855 | 7, 107 | 6, 910 | 5, 637 | 6, 076 |
| Operating contractor employees | 117, 257 | 115, 012 | 106, 394 | 103, 313 | 104, 612 | 105, 195 | 103, 290 | 98, 176 | 90, 238 | 82, 936 |
| Construction contractor employees | 12, 095 | 13, 146 | 13, 366 | 12, 830 | 11, 199 | 9, 878 | 10, 662 | 14, 369 | 13, 322 | 23, 606 |

*Includes transfer to operations of $571,400,000 appropriated in prior years as plant and equipment.

# INDEX

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