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UNITED STATES ATOMIC ENERGY COMMISSION

Sixteenth Semiannual Report to the Congress

OF THE

ATOMIC ENERGY COMMISSION

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LETTER OF SUBMITTAL

WASHINGTON, D. C.,
30 July 1954.

SIRS: We have the honor to submit herewith the Sixteenth Semiannual Report of the United States Atomic Energy Commission, as required by the Atomic Energy Act of 1946.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
JOSEPH CAMPBELL.
THOMAS E. MURRAY.
H. D. SMYTH.
EUGENE M. ZUCKERT.
LEWIS L. STRAUSS, *Chairman.*

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

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SUMMARY

The past half-year in the atomic energy program saw the domestic production of uranium ore and uranium concentrates attain record levels, while production from foreign sources continued to increase. Exploration activity by the Commission, other Government agencies and by private mining firms and individuals stood at an all-time high in the United States.

Increased availability of raw materials, along with startup of new plant capacity, and operational flexibility of the Nation's complex of production facilities resulted in a sharp rise in the production of fissionable materials, at lower unit cost.

During the 6 months, plant capacity continued to be enlarged, as a number of the components of the Savannah River, S. C., construction project were placed in operation, and construction of additional reactor capacity at Hanford, Wash., proceeded on schedule. Also, the first gaseous diffusion plant and portions of a second plant at Paducah, Ky., went into operation, while an addition to the Oak Ridge, Tenn., gaseous diffusion plant was partially completed. Construction of the new plant at Portsmouth, Ohio, proceeded satisfactorily.

Largely as a result of this progress in construction, capital investment in atomic energy plant facilities was estimated to have reached about $5.7 billion.

The weapons research and development program included a successful test series (Operation CASTLE) conducted at the Pacific Proving Ground during the period of this report. Data on radiation exposures resulting from the tests are included in this report.

A contribution to national civil defense was made through the declassification and public release of "Operation IVY"—official film of the test of a thermonuclear device at the Pacific Proving Ground in 1952.

Progress continued in the Commission's program of developing improved reactors for industrial nuclear power and for naval and aircraft propulsion and other military requirements during the first 6 months of 1954. In a report submitted to the Joint Congressional Committee on Atomic Energy the AEC presented a specific pattern of research and development to be followed during the next 5 years in a major effort to decrease the cost of power generation with nuclear fuels. It would allow increased participation by contractors presently in the reactor program and encourage additional groups outside the Commission to participate.

The longest practical step yet taken toward the goal of civilian power was the attainment of an agreement with the Duquesne Light Co. of Pittsburgh for partial financing of construction of a 60,000-kilowatt version of the pressurized water reactor for operation by the company. Development work and design of the reactor is being carried out by the Westinghouse Electric Corp. under contract with the Commission. Ground for the new plant, the Nation's first full-scale power reactor will be broken this year.

The AEC's work on the power plant for the USS *Nautilus*, the first nuclear powered submarine, whose hull was launched by the Navy on January 21, neared completion and the prototype for the second nuclear submarine, the USS *Sea Wolf*, also was nearly completed.

The mounting interest among industrial concerns in development of nuclear power was evident in the addition of 5 industrial teams surveying reactor technology and studying reactor designs in research and development during the past 6 months. This brought the total of such teams to 13.

Physical research in atomic energy resulted in growth of scientific knowledge, while possibilities for further progress through research remained large. Two new research reactors will be in operation in two of the national laboratories during the year; while 3 new accelerators went into operation and 2 others were in the design stage. Interest in research reactors was stimulated at the University Research Reactor Conference held in Oak Ridge in February by an announcement of AEC policy on lending fissionable material to non-profit institutions for use in research reactors.

In the field of biological and medical applications progress was reported on studies of the effects of all types of ionizing and non-ionizing radiations on man, animals, and living plants. Emphasis was given to the investigation of the relative biological effectiveness of high energy particles as compared with X- and gamma-rays. A series of very useful public hearings on present and potential peaceful uses of atomic energy was held by the Subcommittee on Research and Development of the Joint Committee on Atomic Energy during the spring of 1954. The hearings presented information on the contributions of atomic energy and its byproducts to agriculture and to the medical sciences.

In its community operations, the Commission's proposed legislation to facilitate the establishment of local self-government and to provide for disposal of federally owned properties at Oak Ridge, Tenn., and Richland, Wash., was introduced in Congress on April 1.

On June 30 the term of Commissioner Eugene M. Zuckert expired. Mr. Zuckert was appointed to the Commission on February 25, 1952.

In the staff, a number of positions in the Office of the General

Manager were filled to provide for closer coordination in the work of atomic energy during the period of rapid development ahead. R. W. Cook (employed in the project since 1944) was named Assistant General Manager for Manufacturing and Alfonso Tammaro (employed in the project since 1943), Assistant General Manager for Research and Industrial Development. Two new Assistants to the General Manager—Harry S. Traynor and Paul S. Foster—were appointed. E. J. Bloch succeeded Mr. Cook as Director of Production and John A. Derry succeeded Mr. Bloch as Director of Construction and Supply. John J. Flaherty left the San Francisco Operations Office to succeed Mr. Tammaro at the Chicago Operations Office and H. A. Fidler was appointed Manager of the San Francisco Office. Allan C. Johnson succeeded L. E. Johnston as Manager of the Idaho Operations Office. Following reassignment of the duties of the New York Operations Office to provide for closer integration of the production program, Henry B. Fry left that office to become the Assistant Manager for Administration and Services of the Santa Fe Office and was succeeded by Merril Eisenbud. Carroll L. Tyler was succeeded as Manager of the Santa Fe Office by Donald L. Leehey.

Raw Materials

The rate of production by all sources of uranium concentrates was as scheduled during the first half of 1954. Foreign sources continued to provide a substantial quantity of the raw material needed for the atomic energy program. New foreign sources increased their production. The domestic uranium mining industry was at its highest state of activity to date, and exploration for and production of uranium on the Colorado Plateau reached record proportions. Research and process development studies into new and improved methods of finding and extracting uranium from low grade as well as commercial grades of uranium-bearing materials, continued to yield useful results.

Domestic Production

Production of uranium ore and uranium concentrates in the United States attained record levels in the past 6 months. Interest in prospecting for uranium increased significantly, being stimulated by several recent discoveries of large uranium ore bodies. Many large and long-established mining companies showed greater interest in this strategic material and entered the uranium mining industry. With the advent of more large mines—uranium mining is becoming more stable and modern, large-tonnage mining methods are coming into wider use.

Ore Production

By May 1, 1954, some 430 mining operators were producing and delivering uranium ore from 530 mines in the United States, with the Colorado Plateau remaining the most important source of domestic uranium production. Nearly all of the large ore bodies discovered in the past 2 years are located in this area. At one time there were only 4 known uranium deposits containing ore reserves in excess of 100,000 tons of ore. Now there are known at least 15 such large ore bodies, and several of these greatly exceed 100,000 tons.

Uranium mineralization is now known in at least 18 different stratigraphic horizons on the Colorado Plateau. Important uranium production is being derived from 5 of these formations. The Salt Wash member of the Morrison formation, occurring throughout the Plateau and at one time the only producing horizon, continues to be an important producer. Intensive exploration in recent months expanded the producing areas of this formation. Other important producing formations include the Shinarump, Chinle, and Moenkopi in the Monument Valley, White Canyon, Green River Desert, Big Indian Wash, and San Rafael Swell areas of Arizona and Utah, and the Todilto limestone of the Zuni and Lucero Uplift between Albuquerque and Gallup, N. Mex. Vanadium producing ores of the Entrada formation near Rifle, Placerville, and Rico, Colo., have also produced byproduct uranium.

Off the Colorado Plateau, the following contain uranium mineralization: The Wasatch formation in the Powder River Basin and Red Desert areas; the Wind River formation on the western slopes of the Gas Hill anticline; the Brown's Park formation of Carbon County; and Pre-Cambrian rocks near Lusk, all in Wyoming. The Wasatch and Pre-Cambrian rocks on the Plateau have yielded some production. The Lakota and Fall River formations, in the area in South Dakota and Wyoming surrounding the Black Hills, have been a source of production for several years.

The Lehigh Coal and Navigation Co. in Eastern Pennsylvania recently announced plans for the production of uranium from a small ore body the company has developed near Mauch Chunk. This will be the first uranium production in the eastern part of the United States.

The Marysvale district of Utah is still the only important source of uranium production from primary vein-type deposits, although deposits of this type also occur throughout the Rocky Mountain area. Active exploration and development are proceeding in several regions, notably the Boulder Batholith of Montana, the Colorado Front Range of Colorado and several isolated points in Arizona, Nevada, and California.

Ore Processing

The discovery and development of several large ore bodies has created a need for additional ore processing facilites on the Colorado Plateau. Ore reserves are now at an alltime high and ore production is expected to exceed the present level of output during the next few years. Ground was broken in January by Kerr-McGee Oil Industries, Inc., for a new ore-processing mill at Shiprock, N. Mex., to treat ores produced in the nearby Lukachukai and Carrizo Mountain areas. The completion of this mill, expected late this year, will bring to 9 the number of mills currently in operation on the Colorado Plateau.

Construction by the Anaconda Copper Mining Co. of an additional milling unit to treat sandstone-type ores produced in the Grants, N. Mex., area commenced in May. The existing plant at Bluewater, N. Mex., for limestone-type ores was completed by Anaconda last September and now is in full operation.

Additional new mills are planned to treat the ores of the Big Indian Wash district in the vicinity of Moab, the ore from the Jo Dandy ore body near Bedrock, Colo., and to treat the White Canyon ores at Hite, Utah. Construction of these mills is expected to commence this year. Expansion of existing facilities is being considered by Vanadium Corp. of America, by Climax Uranium Co., and by Vitro Uranium Co. The Commission also plans to expand its Monticello, Utah, mill to treat the various types of ore mined in that region.

The AEC, in May, established a provisional uranium ore-buying station at Moab, Utah, to provide a market for ores produced in the Big Indian Wash area, while a new crushing and automatic sampling plant, to be completed later this year, is under construction. This will also build up a stockpile of ore for the projected mill at Moab. Construction was also commenced, in June, on an ore-buying station, to be completed in August, in White Canyon, 15 miles east of Hite, Utah, to encourage ore production in that area. The stations will be operated for the Commission by the American Smelting and Refining Co., which operates the Commission's ore-buying depots at Monticello and Marysvale, Utah, Shiprock, N. Mex., and Edgemont, S. Dak. Improved equipment was installed at the Edgemont station to accommodate the handling of railroad shipments from distant points in Wyoming and from other areas.

Uranium From Phosphate

In April and May the third and fourth plants for byproduct recovery of uranium from Florida phosphate rock were completed by the International Minerals and Chemical Corp. at Bartow, Fla., and by the Virginia-Carolina Chemical Corp. at Nichols, Fla. These plants will begin continuous production shortly. The Commission is negotiating with several other phosphate chemical firms for the construction of additional facilities for this purpose.

Uranium Leases

On January 29, the Commission issued Domestic Uranium Program Circular 7, providing for the issuance of uranium mining leases on certain public lands covered by oil and gas leases issued under mineral leasing laws. Such lands are not open to mineral entry under the mining laws. The circular is designed to encourage private companies and individuals to develop and produce uranium bearing ores from these public lands. A large amount of land in the Western United States, where active uranium prospecting is taking place, is covered by such leases. Public Law 250, 83d Congress, signed by the President on August 12, 1953, provided means for validating mining locations staked subsequent to July 31, 1939, and prior to January 1, 1953, for uranium on lands covered by oil and gas leases. This statute did not, however, provide for validation of mining locations for uranium on such lands after January 1, 1953. Circular 7 establishes a means for the uranium prospector to produce uranium found on these lands. The leasing program is administered by the Commission's Grand Junction Operations Office.

Land Withdrawals

The Department of the Interior announced early this year that over 105,000 acres of public land in Colorado and Utah, previously withdrawn from public entry for AEC use, had been restored to the public domain. The lands were returned by the Commission because no significant uranium deposits were found there. From time to time the Commission has requested the withdrawal from public entry of lands that are not being actively explored by private interests, which it believes are favorable to uranium exploration and which it wishes to explore. Lands found to contain uranium are leased by AEC for mining as Government-controlled land.

Leases on Government-Controlled Lands

A program for granting leases on uranium-bearing Government-controlled lands has been sponsored by the Commission for several years. The Grand Junction Operations Office of AEC maintains an active file of applicants for leases. As lands become available for leasing, the qualifications of each applicant are considered by a committee of AEC mining engineers and the best qualified applicant is selected as the lessee. To date 41 such leases have been issued. The production from these leases constitutes an important source of ore.

Bonus Program

Under the terms of the Commission's Domestic Uranium Program Circular 6, providing for the payment of a bonus for the production of the initial 10,000 pounds of U_3O_8 (uranium oxide) contained in ores produced from certain eligible uranium mines on the Colorado Plateau, over \$3,600,000 has been paid out in bonus awards. These awards ranged from \$15,000 to \$35,000. Payments have been made to 379 certified mining properties, and some 64 properties have received full benefits under the circular.

Foreign Production

Production of uranium by various foreign sources continued to increase during early 1954 with newer suppliers becoming more important.

Belgian Congo

The Shinkolobwe mine in the Belgian Congo remained an important source of uranium for the atomic energy program.

Canada

Canada continued to be the center of intensive widespread prospecting activity. Production and deliveries of uranium from the Eldorado mine on Great Bear Lake in the Northwest Territory were according to schedule. This mine—operated by the Eldorado Mining and Refining Co., a Crown company—has been a steady source of uranium for the atomic energy program. Eldorado's Ace mill in the Lake Athabaska region of Saskatchewan was in continuous production. A substantial expansion program is planned for completion late this year. Arrangements have been made for treating ore from neighboring mines as well as from Eldorado's properties. Exploration and development activity at a number of other properties in the area may produce additional important discoveries. Gunnar Mines, Ltd., continued developing its deposit in the Lake Athabaska area and planned the construction of a large mill on its property.

Favorable results were obtained from extensive exploration underway in the Blind River area of Ontario. Ore occurs in a conglomerate bed at the base of the Mississagi quartizite, and more than 70 miles of outcrop are being explored by a number of companies. Pronto Uranium Mines, Ltd., is developing a large ore body in this formation near Blind River, and is considering plans for a treatment plant. Algom Uranium Co. is proceeding with development of two promising properties, the Quirke Lake and the Nordic, on other sections of the uranium bearing conglomerate to the north of the Pronto properties.

South Africa

Uranium receipts from South Africa reached important proportions since the start of production in October 1952. The sixth plant to recover uranium on the Witwatersrand, was placed in operation by Randfontein Estates Gold Mining Co. in February. Several additional new plants are scheduled for completion and initial production later this year.

Australia

In South Australia construction of the Port Pirie ore concentrator to treat ore from Radium Hill is expected to be completed late in 1954. Another uranium deposit in this region at Myponga in the Adelaide Hills, 35 miles south of Adelaide, is being explored. At Rum Jungle in the Northern Territory, the White's and Dyson deposits were being developed, and the processing mill under construction is scheduled for completion late this fall. In preparation for the opening of the mill, ore is being produced from both properties and stockpiled by Territory Enterprises Proprietary, Ltd.

Domestic Exploration

During early 1954 exploration activity by the Commission, other Government agencies, and by private mining firms and individuals stood at an alltime high on the Colorado Plateau and elsewhere in the United States.

Drilling

AEC, and the U. S. Geological Survey and Bureau of Mines on behalf of the Commission, drilled approximately 500,000 feet. Drilling by private interests was estimated at an additional 500,000 feet. Government drilling is largely exploratory and investigative, establishing the presence of uranium ore bodies.

Airborne Radioactivity Surveying

Airborne radioactivity surveying was expanded by Government and private exploration groups. This method is used in prospecting broad areas for radioactive deposits. Necessary steps in perfecting this means of prospecting were: the development of highly sensitive scintillation detection equipment; adoption of radar altimeters to correct radioactivity measurements for variations in altitude due to topographic change; and establishment of systematic surveying techniques.

The AEC has already conducted surveys in parts of Arizona, California, Colorado, Montana, Nevada, New Jersey, New Mexico, New York, Pennsylvania, South Dakota, Texas, Utah, and Wyoming.

Results of these surveys are released through the posting of base maps showing the location of areas of high radioactivity (anomalies). In most instances, these are monthly index maps posted at all AEC exploration offices, and at certain offices of the U. S. Geological Survey and Bureau of Mines. In some cases, they are made available at temporary posting points in the areas in which a particular survey is conducted. Maps showing the results of surveys carried out by the USGS are released at the conclusion of each project and posted at numerous offices of AEC and USGS. Survey projects completed by the USGS so far in 1954 include the Black Hills and White River Badlands area of South Dakota, Carbon, and Sweetwater counties of Wyoming, the Gulf of Mexico beaches and the peripheral area to the phosphate fields in Florida, and the Atlantic beaches from Virginia to Florida.

Posting information on monthly index maps is believed to be the quickest way for disseminating this information. The Commission does not make copies of its maps directly available to the public. However, arrangements have been made to make the maps available to a number of commerical printing houses for their reproduction and sale.[1]

The Commission also prepared a manual "Prospecting With a Counter" for the use of uranium prospectors. This handbook—a companion volume to "Prospecting for Uranium" of which over 150,000 copies have been sold—covers the operation, use, and abuse of field counters, and their application to prospecting, mining and geologic problems. (See Appendix 6, "Publications of the U. S. Atomic Energy Commission.")

Numerous private planes are engaged in surveying for private firms in addition to the Government surveys. Mileage flown so far in 1954 by the Survey, by the Commission, and by private firms totaled approximately 200,000 miles.

Process Development

The Commission continued its search for new and better means of recovering uranium from various materials and of developing new exploration techniques. Process development work in connection with the new mills and expanded facilities planned for the Colorado Plateau was an important phase of this program. Research was also done in new geologic techniques and instrumentation, particularly geophysical work in connection with airborne radioactivity surveying.

[1] A list of the posting points where the monthly index maps may be examined, and a list of the commercial firms which reproduce and sell the maps, may be obtained by writing to the Grand Junction Operations Office, U. S. Atomic Energy Commission, P. O. Box 270, Grand Junction, Colo., or to the Division of Raw Materials, U. S. Atomic Energy Commission, Washington 25, D. C.

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Western Ore Process Development

The Commission's Raw Materials Development Laboratory at Winchester, Mass., and the pilot plant at Grand Junction, Colo., both operated by the American Cyanamid Co.,[2] concentrated on the development of processes for new mills on the Colorado Plateau. Additional pilot test work was carried out by the Bureau of Mines and the Dow Chemical Co., at the Bureau's station in Salt Lake City, Utah; the Galigher Co. at Monticello, Utah; the Anaconda Copper Mining Co. at Grants, N. Mex.; the Climax Uranium Co. at Grand Junction, Colo.; the Vitro Uranium Co. at Salt Lake City, and other private companies. The Bureau of Mines cooperated with Kerr-McGee Oil Industries, Inc., in the development of the process for the Shiprock, N. Mex., mill. The engineering firm of Knowles Associates assisted in preliminary engineering design and equipment layouts for the proposed plants. Battelle Memorial Institute, University of Nevada, University of Utah, and the Colorado School of Mines also conducted important studies contributing to this program.

Uranium From Low-Grade Sources

The Commission continued its studies into the feasibility of extracting uranium, and such possible coproducts as phosphate and alumina, from the leached zone material overlying the commercial phosphate rock in Florida. Pilot plant studies of processes at International Minerals and Chemical Corp. and the Tennessee Valley Authority show promise. An independent evaluation of the TVA process is nearing completion. Battelle Memorial Institute, the Bureau of Mines and Columbia University continued work on the Chattanooga uraniferous shale project.

Production

A sharp rise in the production of fissionable materials occurred during the first 6 months of 1954, because of startup of new plant capacity, increased availability of raw materials, and operational flexibility of the Nation's complex of production facilities. Unit cost of production of fissionable materials was lower than in the preceding 6-months period.

[2] Effective July 1, the National Lead Co. assumed responsibility for the operation of the Raw Materials Development Laboratory at Winchester and the pilot plant at Grand Junction. (See listing in Appendix 3.)

Enlarged Plant Capacity

The Savannah River construction project in South Carolina neared completion and a number of its components were placed in operation. First returns from this $1.5 billion investment are now being realized. At Hanford, Wash., construction of additional reactor capacity proceeded on schedule.

The first gaseous diffusion plant at Paducah, Ky., authorized in 1950, went into full operation, as did portions of the second Paducah plant, authorized 2 years later. The addition to the Oak Ridge gaseous diffusion plant, authorized 2 years ago, is partially completed. Construction of the new plant at Portsmouth, Ohio, proceeded satisfactorily. The construction peak there is expected late this summer.

Operational Flexibility

A characteristic of the atomic energy industrial complex is the degree of flexibility that has been built into the system. Operational flexibility is available through the reuse of the same source material. Given the proper processing facilities, natural uranium can be placed in a reactor to produce plutonium and then the depleted uranium can be enriched in gaseous diffusion plants by an amount sufficient to permit reuse in the reactor. (A possible method for recycling uranium is illustrated in the diagram on page 10.)

This flexibility of operation makes it possible to operate the Nation's various production facilities to achieve maximum economic use of uranium feed. Sudden changes in needs for specific items of output from the system can be met by adjusting the level of operation of various plants and diverting material among processes and plants.

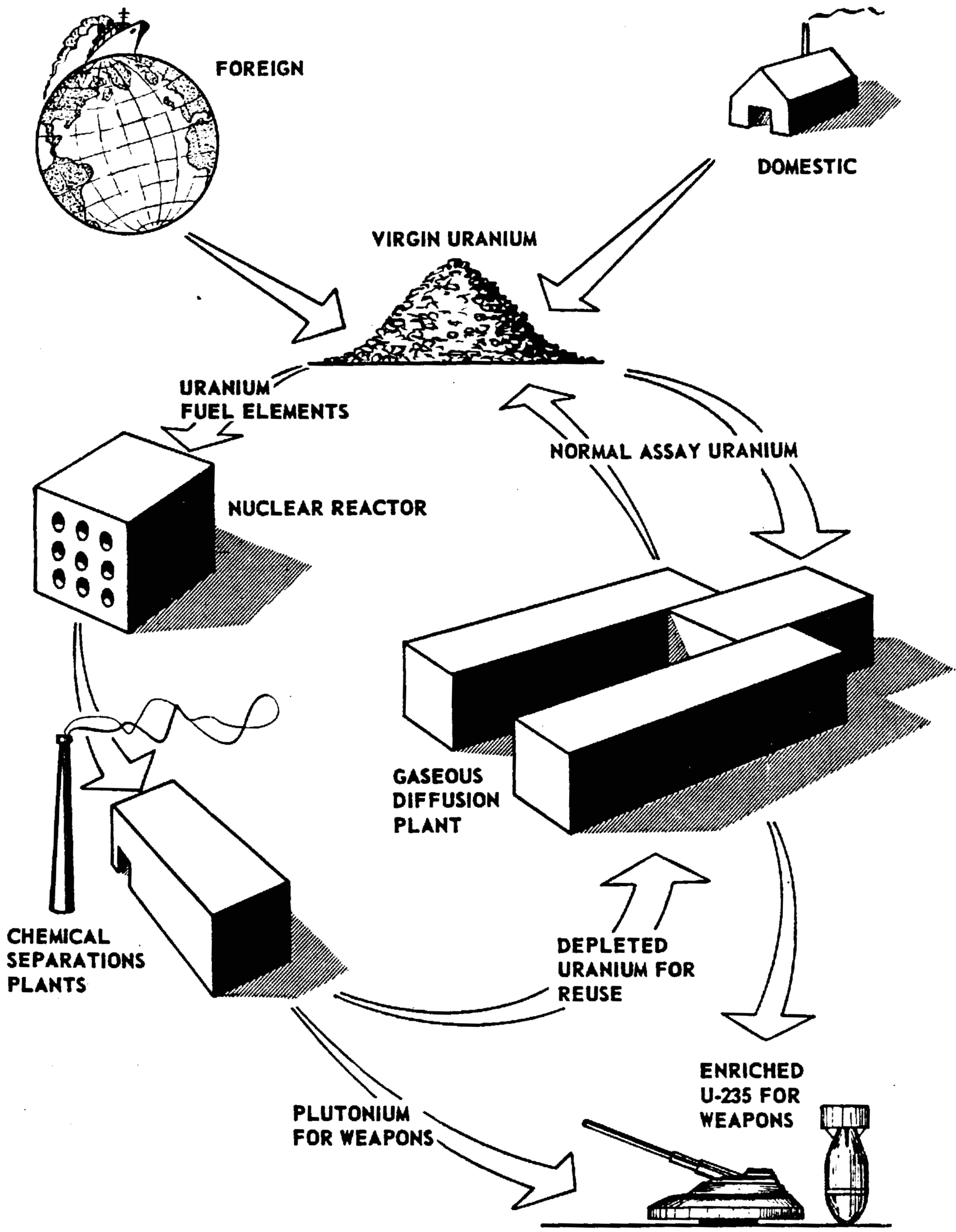
The ability of nuclear reactors to produce materials other than plutonium provides further flexibility in the production of atomic materials. The units at both Hanford and Savannah River have this potential.

Electric Power for Gaseous Diffusion Plants

Five additional steam electric generating units to provide power for the Commission's gaseous diffusion plants were placed in operation during the first 6 months of 1954.

The fourth generator of TVA's Shawnee steam plant began operation on January 8, and the third unit of the Electric Energy, Inc., Joppa plant on April 18. The Shawnee and Joppa generating stations provide power to the Paducah gaseous diffusion plants. TVA's

CONCEIVABLE PRODUCTION CYCLE



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Kingston plant delivering power to Oak Ridge placed three generating units in operation, the first on February 8, the second April 29, and the third June 11.

Process Development

At this time it seems useful to note in most general terms the unclassified facts about progress made in recent years in this field and the technology of production of source and fissionable materials. The following gives such a summary.

The process development program supporting fissionable materials production is one of the most rewarding activities carried on by the Commission. Major reductions in cost of fissionable materials have resulted from these efforts. The program is conducted by contractors operating the major fissionable materials production facilities, and is analogous to the development and improvement programs pursued by progressive private industries.

Each separate activity in the process development program is required to be economically justified by an existing or foreseeable production problem or goal. This feature of the program is in marked contrast to research, either basic or applied. Process development is in a sense a continuing investment program which, if properly executed, should repay the sum invested in a reasonable time with an acceptable investment return.

The fissionable materials process development program has yielded returns exceeding by many times the cost of the program. Returns have been realized principally by increasing the capacity of existing facilities, with proportionately smaller increases in operating expense, and by reducing the capital and operating costs of new facilities.

Gaseous Diffusion Improvements

All components of the gaseous diffusion process, such as barriers, gas compressors, gas coolers, and coolant, have been under study since the K–25 plant at Oak Ridge was put into operation in 1945. As a result of these studies, intensified when the expansion program started, improvements have been made in every part of this process. The net results of these improvements, which have been made over the years, are that the capital costs for diffusion plants built since 1946 have been several billion dollars less than they would have been if the plants had been built using the same types of equipment used in the original K–25 plant. In addition to the savings in capital investment, these improvements also have resulted in annual operating costs which are several hundred million dollars less than they would have been if plants of the K–25 type had been built.

The total gaseous diffusion plant capacity, including that under construction, has now reached the point where even small improvements in process efficiency have a substantial value in terms of increased production.

The field for further improvements has by no means been exhausted. A number of new developments, which were made too late to be included in plants built during the expansion program, can be incorporated in existing plants when the most efficient way to make these changes has been established. These changes will result in further large savings.

Graphite Piles

Similar progress has been made in the field of plutonium production. For example, the capacity of the original production facilities at Hanford has been increased substantially. New facilities, which have been built or are under construction, are capable of even more economical production. Continuing success of process improvements to increase power levels is an optimistic indication that the ultimate capacity of these units has yet to be reached.

Chemical Separations

In the intricate chemical process of extracting plutonium from the highly radioactive uranium discharged from the piles, important advances were made also. The new chemical plants separate both plutonium and uranium from fission products. The uranium thus reclaimed can be used as feed for the gaseous diffusion plant. This new chemical process, originally designed in the Commission's national laboratories, is far more economical than the process originally used.

Heavy Water Production

An active program of process development is being conducted to develop and test new processes and equipment incorporated in the design of the Savannah River plant. In the postwar years a significant advance has been made in the large scale production of heavy water. This has resulted in a volume production at a cost much below that of the wartime program.

Another important phase of the Savannah River process development program is to ensure a constant improvement in the productive capacity of the Savannah River units above their basic design ratings. It is significant that this improvement program began even before initial operation of the plant.

Uranium Feed Materials

The feed materials phase of the production program deals with the conversion of uranium ore and concentrates to uranium metal suitable for reactor fuel, or to uranium hexafluoride to be fed to the gaseous diffusion plants. While these operations present some special problems, they are much more similar to conventional processes of the chemical and metals industries than are reactor and diffusion plant operations.

Feed materials process development has undergone substantial expansion to serve the increased reactor and diffusion plant capacity. Many improvements and new processes of great potential importance are now being studied. Some of these developments have already been incorporated into production practice.

In the field of metals production, for example, reuse of certain materials in metallurgical operations has reduced waste losses. In addition, several totally new processes for metal production are being explored. One or more of these processes may eventually afford opportunities for substantial reductions in the unit costs of metal. New metal fabrication techniques are also being investigated. These techniques are important, not only because of the cost of the operation itself, but because of the profound effect which the process may exert on the behavior of uranium metal under prolonged irradiation.

A new process has been devised in the refining of uranium ore concentrates. It possesses the great flexibility required for handling concentrates of the many different types now being received or contemplated.

Construction and Supply

As of May 31, 1954, largely as a result of continued progress in the construction of the Savannah River plant, and major new facilities at Paducah, Oak Ridge, Portsmouth, and Hanford, capital investment in atomic energy production plant facilities was estimated to have grown to about $5.7 billion before depreciation reserves. Expansion of process facilities at Oak Ridge was the only major construction started during the past 6 months.

Costs incurred for new plant and equipment averaged about $106 million per month during the first half of 1954, compared with an concerted development effort on thermonuclear weapons. In view of important progress made in fission and thermonuclear weapon development programs, a national policy decision was made to take every advantage of such progress to assure that the United States maintains its superiority. The President directed the Commission to continue to produce atomic weapons during 1954 consistent with this decision.

The weapons research and development program was highlighted by the tests conducted at the Pacific Proving Ground during the period of this report. This test series, known as Operation CASTLE, was conducted by Joint Task Force 7 composed of personnel of the Commission, Army, Navy and Air Force. Following the pattern established for earlier tests at the Pacific Proving Ground, the Commission, through the Los Alamos Scientific Laboratory and the weapons research laboratory of the University of California Radiation Laboratory at Livermore, Calif., was responsible for the test devices. Both the AEC and the Department of Defense participated in the scientific measurements. The Department of Defense was responsible for certain supporting operations and services. These tests were successful in development of thermonuclear weapons. Special mention for their part in this enterprise should go to the management and staff members of the Los Alamos Scientific Laboratory as the agency primarily responsible for these thermonuclear developments.

A number of significant contract actions took place during this period. A 5-year renewal contract was signed with Western Electric Co., Inc., for operation of Sandia Laboratory at Albuquerque, N. Mex., by a wholly-owned subsidiary, Sandia Corp. Also, a 3-year renewal of contract with Bendix Aviation Corp. for operation of the Commission's facility at Kansas City, Mo., was executed. Contracts were signed also with ACF Industries, Inc., providing for continuing engineering and fabricating services.

One of the oldest buildings occupied by the Los Alamos Scientific Laboratory was demolished during the spring of 1954. The temporary-type, wood-frame structure, known as "D" building, was erected in 1943 when the first scientists on the Laboratory's staff were moving into Los Alamos. The early extensive chemical and metallurgical work on the characteristics of plutonium and the development of safe methods of processing this dangerous material were conducted in the structure. The first pieces of plutonium readily visible to the naked eye were fabricated in the building, and later, the nuclear parts of the bombs set off at Trinity Site, near Alamogordo, N. Mex., and at Hiroshima and Nagasaki, Japan, were produced there. No harmful radiation was received by any person working in the building during its long occupancy. However, some room surfaces were contaminated with small quantities of radioactive materials. Experience gained through the use of "D" building has been of high value in the design of a permanent structure, safe from radioactive contamination, recently built as its replacement.

Community Operations

The Commission's proposed legislation to facilitate the establishment of local self-government and to provide for disposal of Federally-owned properties at Oak Ridge, Tenn., and Richland, Wash., was introduced in Congress on April 15, 1954, by members of the Joint Committee on Atomic Energy. A bill[5] (H. R. 8861) was introduced in the House of Representatives by Chairman Rep. W. Sterling Cole and an identical bill (S. 3324) was introduced in the Senate by Sen. Bourke B. Hickenlooper.

The proposed bills are based on the plan recommended by the Panel on Community Operations[6] with some modifications resulting from further studies. Salient features of the bill are: (1) The AEC would assist the residents in establishing local self-government. As soon as local governments were established, the AEC would transfer governmental responsibilities and donate municipal facilities to them. Upon this transfer the Commission would have divested itself of control and responsibility over local municipal affairs. (2) To lessen the shock of such a drastic change in the operation of these single-industry-type communities in which there is at present an inadequate tax base, a Federal contribution to maintain essential municipal services and to operate the schools and hospitals would be made for a period of 5 years, and might be extended another 5 years. (3) Single-family and duplex houses would be offered for sale at 90 percent of their appraised values. Present tenants would be given first chance to purchase the property, and other project-connected persons would have purchasing rights before the general public. Appraisal for all property to be sold would be made by the Housing and Home Finance Agency or its designee. (4) The present lessees of properties used for commercial, industrial, church, and nonprofit purposes would have a priority right to purchase such properties at the appraised values. (5) Mortgage insurance on residential properties would be made available through the FHA. If necessary, direct AEC mortgaging would be provided. Some further protection against the special risks of buying houses in these communities would be provided by an AEC commitment to relieve the purchasers of liability for deficiency under mortgage

[5] The bill, a section-by-section analysis, a financial analysis, and the Commission's letter of transmittal to the Joint Committee on Atomic Energy are set forth in a Joint Committee print dated April 1954.

[6] See the 11th, 12th, and 13th Semiannual Reports, pages 14, 9, and 19, respectively.

indebtedness should the employment level at either of the projects fall drastically. (6) The AEC would administer the program.

Housing and Community Facilities

Oak Ridge

Of the 900 units programed by the Housing and Home Finance Agency, under Title VIII and Title IX of the National Housing Act, all were completed and, as of May 31, 775 were occupied. As this privately-financed housing has become available vacancies have increased in Government-owned housing. This trend has made possible the removal of the requirement that project employees must live beyond a 45-mile radius of Oak Ridge to be eligible to rent Government-owned houses.

On April 1, 117 acres of land were leased to Oak Ridge Properties, Inc., for the development of a new privately-financed commercial center. The lease requires that the first stage of development, consisting of 150,000 square feet of building space, be completed in 2 years. Total required development will involve 500,000 square feet of space.

Savannah River

Occupancy in the rental-guarantee trailers dropped to 273 by June 30, reflecting the rapid decrease in construction employment. Of the original 4,000 trailers, 3,345 have been sold and the balance are expected to be disposed of during the fall of 1954.

The Housing and Home Finance Agency withdrew controls from all permanent Title IX housing in Augusta, Ga., and Allendale, Barnwell, Blackville, and Williston, S. C., during January 1954. HHFA completed decontrol of the Title IX program, in May 1954, by taking the same action in Aiken and North Augusta, S. C.

Portsmouth

The peak construction employment for the Portsmouth area project is now estimated to be 22,500, a reduction of 3,500. As of June 30, 750 of the 1,500 programed temporary housing accommodations for construction workers were completed and all were occupied. Almost 770 of the 1,000 permanent Title IX dwellings for operating personnel have been completed and most of them are occupied.

Federal grants totalling $1,063,300 have been approved under Public Law 139 by HHFA to assist in the necessary expansion of sewer and water facilities. School assistance in excess of $3,000,000 for construction of permanent classroom facilities has already been allocated to local school districts by the Office of Education. Additional amounts will be allocated to assist in the maintenance and operation of the school facilities. These grants are authorized under Public Laws 815 and 874, 81st Congress, as amended.

Los Alamos

The Los Alamos Scientific Laboratory was opened during wartime as a remote temporary facility. The Manhattan Engineer District in 1946 authorized an increment of housing for the laboratory's key scientific personnel. In 1947 the AEC continued the program initiated by MED, authorizing facilities which established the laboratory as a major Government installation, thereby necessitating certain community adjustments. The replacement of temporary-type housing with permanent-type was included in plans made in 1948 for modernizing and expanding the Los Alamos wartime project. Scheduled to begin in 1950, it was postponed after outbreak of the Korean War and is just now getting underway. Construction of 118 new housing units has commenced.

Other Areas

All of the 1,000 Title VIII housing units at Richland, Wash., were completed, and 929 were occupied on May 31. Occupancy of Government-owned houses in Richland has not been affected significantly by the availability of these 1,000 units. In the Paducah, Ky., area vacancies in the 948 Title VIII and IX programed housing units were increasing as the project neared completion and construction workers were being laid off.

Reactor Development

Progress in the Commission's program of developing improved reactors for industrial nuclear power and for naval and aircraft propulsion and other military requirements continued during the first 6 months of 1954. For these purposes expenditures of about $126 million were incurred during the fiscal year ending June 30. In addition, the AEC continued its research and development aimed specifically at improving production reactors at Hanford and Savannah River.

A report [7] describing the Commission's program of industrial nuclear

[7] Report of the Subcommittee on Research and Development, Joint Committee on Atomic Energy, on the Five-year Power Reactor Development Program Proposed by the Atomic Energy Commission, March 1954 (Joint Committee print).

power development over the next 5 years was sent by AEC to the Joint Congressional Committee on Atomic Energy on February 5. The report presented a specific pattern of research and development to be followed in a major effort to decrease the cost of nuclear power. It allows increased participation by contractors presently in the reactor development program and encourages additional groups outside the Commission to participate.

The program provides for development of 5 distinct technological approaches with experimental reactor powerplants costing nearly $200 million and outlines general research and development activities costing about $8.5 million annually over a 5-year period. These approaches are the outgrowth of the Commission's efforts over the past several years. These projects, their total estimated cost over the entire 5 years, and the dates estimated for completion of experimental plants are shown in the following table. None of these plants is expected to produce economically competitive electrical power because of their small size, experimental nature, or limitations of the new technology. However, there is reasonable expectation that electricity will be generated from nuclear fuel at a cost competitive with electricity from fossil fuels in the foreseeable future.

Project (Research, Development, and Construction)	Estimated cost [8]	Estimated completion	Experimental scale
	Million		
1. Pressurized water reactor	$85	1957	Full.
2. Boiling water reactor	17	1956	Medium.
3. Sodium graphite reactor	10	1955	Medium.
4. Homogeneous reactor	47	1956–58	Medium.
5. Fast breeder reactor	40	1958	Medium.
TOTAL	199	5 years	

[8] All costs estimates are conditional on annual congressional appropriations.

Industrial teams at work surveying reactor technology, studying reactor designs, or engaging in research and development now number 13, five having been added in the past 6 months. AEC-sponsored work on the powerplant for the USS *Nautilus*, the first nuclear-powered submarine, launched by the Navy on January 21, neared completion. The prototype of the powerplant for the second nuclear submarine, the USS *Sea Wolf*, was nearly completed.

POWER REACTORS

Since the attainment of economic nuclear power at the earliest possible date is of vital importance to the Nation, the Commission proposed to proceed in the 5-year program to develop the 5 major reactor types which seem most likely to achieve this goal. These are set forth in the table on page 20. From the standpoint of time required to perfect each type, they can be grouped as follows: First, "short term," ready for large scale experimental testing in 2 or 3 years with a reasonable chance of mechanical success; second, "middle term," ready for testing on a large scale in about 5 years; and finally, "long term," ready for testing in not less than 5 years, unless an unexpected technical breakthrough occurs. Most authorities agree that the Pressurized Water and Sodium Graphite Reactors would be short term; the Experimental Boiling Water Reactor middle term; and the Homogeneous and Fast Breeder Reactors long term.

The program is to be reviewed annually so that work can be redirected, enlarged, or eliminated in line with unanticipated technological or managerial developments. It should also be remembered that results sought in research and development cannot be guaranteed within estimated expenditures.

Pressurized Water Reactor

Westinghouse Electric Corp. continued development work on the Pressurized Water Reactor, to be the Nation's first civilian nuclear powerplant, in a project authorized by the Commission in July 1953. This type is moderated and cooled by water and uses slightly enriched uranium fuel.

The design was selected for the full-scale PWR since more is known about this than about other types. A number of the earlier reactors were water-cooled, and the technology was advanced considerably by Westinghouse's recent work on the Submarine Thermal Reactor and on the canceled large ship reactor (the CVR).

The PWR plant is to have a power level of approximately 300,000 kilowatts of heat, and an output of at least 60,000 kilowatts of useful electricity. Reserve capacity in the generating plant is to be included, in the event that the 300,000 figure is exceeded. The project is not expected to produce electricity at costs competitive with those of plants using conventional fuels. However, it will make possible firm cost estimates for the future and provide design and technological experience obtainable only from a full-scale plant operation.

This project will contribute to pressurized water technology by developing and testing fuel elements for long irradiation cycles, by advancing the physics of slightly enriched uranium fuel in ordinary water, and by testing whether the relatively large pressure vessel can be built satisfactorily according to specifications for reactor operations. Methods will be evolved for charging and discharging fuel elements through the pressure shell.

The Westinghouse Electric Corp. is responsible for the development, design, and construction of the nuclear portion of the PWR project. Stone and Webster Engineering Corp., Boston, Mass., was selected to perform architect-engineering services for the same portion of the project as a subcontractor under Westinghouse.

The plant will be built in the vicinity of Shippingport, Pa., on the Ohio River, 25 miles northwest of Pittsburgh. It will be operated by the Duquesne Light Co. of Pittsburgh, whose proposal to participate in the project was accepted by the Commission as the most favorable to the Government of 9 major offers submitted. The terms of Duquesne's proposal are to: Furnish a site for the entire project and build and operate a new electric generating plant at no cost to the Government; operate the reactor part of the plant and bear the labor costs thus entailed; assume $5 million of the cost of research, development, and construction of the reactor portion of the plant; buy steam from the Commission, and waive any reimbursement by the Government of costs incident to termination of the contract.

It is estimated that—along with revenues from the sale of steam generated by the reactor—the company's proposal would reduce by an estimated $30 million the expenditures the Government would have had to make during the period of construction and 5 years of operation if it had undertaken the full cost of the project.

Experimental Boiling Water Reactor

It was formerly believed that boiling within the core of a water-cooled reactor would cause unstable operation. However, experiments conducted last year by the Argonne National Laboratory at the National Reactor Testing Station in Idaho, have indicated this to be untrue. In addition, these experiments may have an important bearing on the safety of industrial power reactors, for it is possible that boiling reactors may be designed to operate in a stable self-regulating manner, shutting themselves down without serious damage in case of trouble.

The tests at NRTS during the summer of 1953 consisted of setting up and operating a water-cooled and moderated reactor and imposing conditions normally expected to cause a "run away." It was previously assumed that under these circumstances the core would melt and allow the escape of fission products.

However, these things did not happen in last summer's tests. Experimental results with a small, temporary water-cooled and moderated reactor showed that power excursions could take place quite rapidly and neither produce melting of the fuel nor radioactive contamination of the surroundings. In experiments which allowed the power to rise to several thousand kilowatts in a fraction of a second, the steam cut off the nuclear reaction completely before a dangerous temperature was induced. More boiling experiments are to be conducted by Argonne at NRTS in the summer of 1954.

Perhaps this mechanism applied to power reactors could be a safety device making it impossible for the nuclear reaction to create dangerously high temperatures. Further, a reactor used as a direct source of steam in a power plant might reduce capital costs by eliminating the heat exchanger (steam boiler) outside the reactor, by reducing the pressure of the primary coolant system, and the pumping power required for the system.

Plans called for starting construction during the year ahead of an Experimental Boiling Water Reactor designed to produce 20,000 kilowatts of heat and 5,000 kilowatts of electricity, to be completed in the winter of 1956. The reactor will make use of normal uranium fuel plus enriched uranium 235 and will be moderated and cooled by ordinary (light) water. As with the PWR, the slight enrichment of fuel is necessary to bring a light water moderated reactor to criticality.

An important aspect of tests with the Experimental Boiling Water Reactor will be to determine whether it can be operated without troublesome or hazardous deposit of radioactivity in the turbine, condenser, feedwater pumps, or other equipment outside the reactor. The deposited radioactivity might cause major maintenance problems in the event of failure of the equipment.

Sodium Graphite Reactor

Although a proposed sodium-cooled, graphite-moderated reactor has been determined to be feasible in principle, there are still numerous features of such a plant significant to the economies of the system that have not been tested in actual practice. For example, these include the upper limits for fuel and coolant temperatures, burn-up, and other operating variables.

North American Aviation, Inc., the major contractor exploring the sodium-graphite approach, continued its investigation in this field. The firm has agreed to contribute $2.5 million of the $10 million required for development, construction, and operation of a graphite-moderated Sodium Reactor Experiment (SRE) during the period 1954–58. The SRE is planned to produce 20,000 kilowatts of heat and would not be equipped with a turbogenerator.

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A full-scale reactor, using slightly enriched uranium fuel, would be expected to have a regeneration ratio of 0.9. If charged with uranium 233 and thorium, it is believed it would have a ratio slightly greater than one and operate as a power breeder producing more uranium 233 than it burns.

Tests with the Sodium Reactor Experiment are planned to include fuel element performance, maximum permissible fuel element and structure temperatures, and corrosion and radioactive transfer. The reactor's temperature and specific power will be increased gradually to determine performance limitations.

Completion of construction and the beginning of experimental operation are scheduled for 1956.

Homogeneous Reactors

The potential advantages of homogeneous reactors include: Low cost due to simplified design, economical chemical processing, and elimination of fuel element fabrication.

Oak Ridge National Laboratory continued the operation of Homogeneous Reactor Experiment No. 1 during the early months of 1953–54. This first power reactor of its type circulated uranyl sulfate fuel solution at nearly 500° F. under a pressure of 1,000 pounds per square inch and at a power density of 30 kilowatts per liter. It had a heat output of 1,000 kilowatts and a small turbogenerator.

In testing the self-regulation of HRE No. 1, the reactor's power was purposely increased as rapidly as possible, but the reactor did not "run away." Its power rose quickly to an abnormally high but very short peak and then leveled off at a moderately high value as the expanding fuel solution caused the core to lose reactivity. This reactor also demonstrated safe operation after its fuel solution became highly radioactive from fission products, and while a mixture of hydrogen and oxygen was formed by irradiation-produced decomposition of the solution water.

The HRE No. 1 was dismantled in the spring of 1954 to make way for the construction—in the same building at Oak Ridge—of Homogeneous Reactor Experiment No. 2, which should be completed and put in operation early in 1956.

The HRE No. 2 will have a heat output of 5,000 kilowatts. Its primary purpose is to produce a simplified, mechanically reliable plant demonstrating operability and reliability over a long period under conditions more closely simulating those of a full-scale reactor. It will furnish steam for a small turbogenerator, as did HRE No. 1, and will dissipate excess steam. The plant will include chemical processing equipment for purification of the fuel solution by removing fission products. It will also seek additional information on the effect of irradiation on the corrosion of materials and on chemical stability of the fuel solution.

In the development of the homogeneous type, corrosion tests without irradiation demonstrated the compatibility of a dilute uranyl sulfate solution with a number of materials at high temperatures. Data on the effects of varying temperatures, salt concentration, acidity, and solution velocity were also obtained. The Oak Ridge National Laboratory completed a full-scale model of an "in-pile loop," which consists of an assembly of piping, pumps, and instruments for the purpose of circulating a fuel solution past samples of different materials while they are under intense neutron bombardment in the Low Intensity Test Reactor at ORNL and the Materials Testing Reactor.

New information obtained from these and other investigations will be applied to the design of a Homogeneous Thorium Reactor now in the planning stage. The HTR is to produce about 65,000 kilowatts of heat, of which some 16,000 kilowatts will be converted into electricity. It will have a blanket of thorium from which uranium 233 will be produced.

Although the core diameter of the Homogeneous Thorium Reactor will not be as large as that of a full-scale plant, the thickness of the thorium blanket and the concentration of fertile material will be the same as for a central power station of this type. In addition, two chemical plants—one for removing fission products from the fuel solution and another for separating the uranium 233 from the thorium blanket—are to be an integral part of the plant.

Following development and design of the HTR by ORNL, construction is expected to begin during fiscal year 1957 and be completed in fiscal year 1959. The reactor will probably start operating with uranium 235 and change later to uranium 233, as this synthetic fissionable material is produced in the blanket.

Experimental Breeder Reactor No. 2

After 2 years of operating experience with the Experimental Breeder Reactor No. 1 at the National Reactor Testing Station in Idaho, the AEC plans to build a much larger unit, the Experimental Breeder Reactor No. 2. The EBR No. 1, developed and operated by Argonne National Laboratory, was the first reactor to produce electricity and to demonstrate breeding.

The EBR No. 2 is planned as a scale-up to 62,500 kilowatts in heat power and 15,000 kilowatts in electrical generating energy. The

EBR No. 1 supplied 1,400 kilowatts of heat and 170 kilowatts of electricity.

The EBR No. 2 will closely resemble a large central station power-breeder reactor in power, control, fuel handling, and other features. Much of the equipment for a full-scale powerplant will also be used—such as pumps, heat exchangers, valves, and flow meters. In addition to providing information on engineering features, the EBR No. 2 will be operated to develop fuel-handling techniques, power-cycle conditions, core and blanket concentration, and component designs.

Heat transfer and mechanical components under simulated operating conditions will be tested in mechanical mockups of the EBR No. 2, scheduled to be built at the ANL during 1955. The startup of the reactor itself is planned for 1958.

Plutonium will be used as fuel in EBR No. 2 although it may be necessary to supplement it with uranium 235 for metallurgical reasons. However, the fuel charge will be changed to plutonium later. The blanket will be composed of natural or depleted uranium 238 which will be transmuted into plutonium. A greater production of plutonium will be achieved by using this element as a fuel than by using uranium 235. The objective will not be to produce a large quantity of fissionable material, but rather to test engineering features of the reactor and its auxiliaries.

The Experimental Breeder Reactor No. 1 will continue in operation. Its contributions in fast neutron reactor physics and radiation damage are expected to continue.

Industrial Participation

Consistent with its policy of encouraging industrial participation in the development of economic nuclear power, the Commission approved 5 new study group agreements with commercial firms during the first 6 months of 1954. This brings to 13 the total number of participating study teams, each of which represents one or more contractors.

Since the initiation of this program in 1951, industrial contractors, through their teams or groups, invested (by the end of 1953) an estimated $3 million surveying reactor technology, making preliminary designs and economic studies, and carrying on research and development. It is believed that this figure will reach $8 million by the end of 1954.

The five new industrial study groups[9] approved by the Commission since January are:

BABCOCK AND WILCOX CO., of New York, whose independent study will concentrate on the design, development, and manufacture of equipment needed in operating nuclear powerplants.

AMERICAN MACHINE AND FOUNDRY CO., of New York, who will study machines and equipment associated with nuclear powerplants and explore the feasibility of developing low-power reactors for industrial research.

BENDIX AVIATION CORP., of Detroit, who will study the future of atomic power and its byproducts, anticipating the development of new reactor designs and discovery of new uses for radioactive fission products.

WESTINGHOUSE ELECTRIC CORP., of Pittsburgh, who will survey the Commission's reactor development activities, determining engineering, technical, and economic aspects of practical applications of atomic power.

PACIFIC NORTHWEST POWER CO., of Spokane, who will study the engineering, economic and technical feasibility of constructing a nuclear reactor for the production of electrical power. The Pacific Northwest Power Co. includes: the Montana Power Co., Washington Water Power Co., Pacific Power and Light Co., Portland General Electric Co., and Mountain States Power Co.

New Power Reactor Studies

The Commission approved an agreement for new power reactor studies by the Dow Chemical-Detroit Edison group. This group, which includes 24 associated firms in addition to the two principals, has been studying nuclear power technology since the industrial participation program began in 1951.

Under the agreement running until January 31, 1955, the Dow-Detroit Edison group will spend an estimated $2,300,000 on a detailed program of research and development on a special type of breeder

[9] In addition to the new industrial participation teams, there are the following: (1) Nuclear Power Group including American Gas and Electric Co., Bechtel Corp., Commonwealth Edison, Pacific Gas & Electric Co., and Union Electric Co.; (2) Duquesne Light Co.-Walter Kidde Nuclear Laboratories; (3) General Electric Co.; (4) Newport News Shipbuilding and Dry Dock Co.; (5) Tennessee Valley Authority; (6) Monsanto Chemical Co.; (7) Dow Chemical Co.-Detroit Edison Co., including: Allis-Chalmers Manufacturing Co., Atlantic City Electric Co., Babcock & Wilcox Co., Bendix Aviation Corp., Cincinnati Gas & Electric Co., Cleveland Electric Illuminating Co., Consolidated Edison Co. of N. Y., Consolidated Gas Electric Light & Power Co., Consumers Power Co., The Detroit Edison Co., the Dow Chemical Co., the Ford Motor Co., General Public Utilities Corp., Gibbs & Cox, Inc., Hartford Electric Light Co., New England Electric System, Niagara Mohawk Power Corp., Philadelphia Electric Co., Potomac Electric Power Co., Public Service Electric & Gas Co., and Rochester Gas & Electric Corp., Southern Services, Inc., Toledo Edison Co., United Engineers & Constructors, Inc., Vitro Corporation of America, and Wisconsin Electric Power Co.; and (8) Foster Wheeler-Pioneer Service & Engineering Co.-Diamond Alkali Co., including: California-Oregon Power Co., Louisville Gas & Electric Co., Northern States Power Co., Oklahoma Gas & Electric Co., San Diego Gas & Electric, and Wisconsin Public Service Corp.

reactor for generation of electric power and production of other products, and on related equipment and processes.

When specified research projects can best be carried out in the AEC's specialized facilities this may be done at the group's expense if the AEC finds that it is feasible and no AEC project has higher priority. The group may spend about $300,000 on such work. Where the investigations of the group require work which is of direct interest to the AEC and forms part of its approved program, the expense of the project will be borne by the AEC. The cost of the work within this category is estimated at about $300,000.

The group will submit a report to the Commission at the conclusion of its studies, which will contain recommendations concerning the desirability of further work on a nuclear reactor for commercial use. It will also detail the group's proposed contribution to and plans for the development, design, construction, and operation of such a reactor.

Army Power Reactors Program

Early in January, the Department of Defense requested that the AEC cooperate with the Army's Corps of Engineers in a program to meet military requirements for nuclear powerplants. Studies by the Army and the Commission had previously established that nuclear powerplants for installation at remote military bases appear to be technically feasible and would have strong military advantages.

The Commission and the Army have agreed to initiate the program by building a prototype of a small nuclear powerplant. The prototype will be based on a conceptual engineering design of a pressurized light water reactor by the Oak Ridge National Laboratory. This nuclear plant in order to approach a competitive status with conventional military plants in certain situations, will be designed to make use of proven components requiring minimum development.

The Commission, in cooperation with the Army's Corps of Engineers, sent an exploratory letter to a number of industrial firms to find out if they were willing and able to design, construct, and test a prototype of such a nuclear powerplant at a fixed price. After a careful evaluation of the replies, invitations to submit proposals on the plant will be extended to those firms that have demonstrated their interest in and qualifications for the prime contract. The award of a lump-sum contract will be made to the one whose proposal is most favorable to the Government from the viewpoint of price, design, and other factors.

New Army Reactors Branch

An Army Reactors Branch was established in the Division of Reactor Development. The new branch will carry on and expand the work of the former Army Liaison Office. It will plan and give staff direction to the technical phases of the development of reactors designed to furnish electric power and heat for military purposes other than propulsion. Since March of 1954 the branch has represented the interests of all military services in small stationary nuclear powerplants.

Naval Reactors Program

Progress was made on projects being carried on jointly by the AEC and the U. S. Navy.

Submarine Thermal Reactor (STR)

Experimental operation of the prototype Submarine Thermal Reactor, Mark I, at the National Reactor Testing Station in Idaho was continued by the Westinghouse Electric Corp. as a part of the program for testing this reactor.

Power for the USS *Nautilus*, launched at Groton, Conn., on January 21, will be furnished by the STR, Mark II.

Submarine Intermediate Reactor (SIR)

Construction of the second nuclear-powered submarine, the USS *Sea Wolf*, continued at the Electric Boat Division of General Dynamics Corp., Groton, Conn. The ship will be powered by Submarine Intermediate Reactor, Mark B.

The prototype powerplant, SIR Mark A, neared completion at West Milton, N. Y., as the Electric Boat Division progressed with installation of machinery in the hull section. The hull section was moved into the spherical powerplant building on March 20.

Research and development on the Mark A and Mark B plants continued at the Knolls Atomic Power Laboratory, near Schenectady. KAPL is operated for AEC by the General Electric Co.

Submarine Advanced Reactor (SAR)

The Knolls Atomic Power Laboratory and Argonne National Laboratory continued work on the development of another nuclear powerplant suitable for a high performance submarine.

Aircraft Reactors Program

The AEC-Air Force program of research and development for aircraft nuclear propulsion continued. Principal AEC contractors in the program are: General Electric Co. (through its Aircraft Nuclear Propulsion Department, Evendale, Ohio); Carbide and Carbon Chemical Co. (through the Oak Ridge National Laboratory); and United Aircraft Corp. (through Pratt and Whitney Aircraft Division, East Hartford, Conn.).

Construction at Testing Station

A $2 million contract was awarded in April to the Arrington Construction Co., of Idaho Falls, for work at the National Reactor Testing Station there. The agreement calls for completion in 1955 of certain ground testing facilities. The Utah Construction Co., of Salt Lake City, which began the first phase of construction of the test facilities in 1953, is expected to complete its work this summer.

Tower Shielding Facility Completed

Construction of a tower shielding facility was completed in April at the Oak Ridge National Laboratory at a cost of $2 million.

The facility includes four 324-foot steel towers. Protective shielding for the crew and a test reactor with its own shielding can be suspended from these towers well above the ground, simulating shielding conditions of an airplane in flight. Experiments began early in May.

Expansion of Pratt & Whitney Facilities

Facilities of the Pratt & Whitney Aircraft Division will be expanded by the leasing of a new 97,000 square-foot building. The building will be constructed according to Pratt & Whitney specifications and completed by October 1954.

General Engineering and Development

Materials Testing Reactor To Serve Public

The Commission made available to the public the specialized irradiation facilities of the high intensity 30,000-kilowatt Materials Testing Reactor at the NRTS in Idaho.

Designed and built as a major step in the development of high neutron intensity reactors, MTR's primary function is to test materials for possible use in future reactor construction. The MTR may also supplement other AEC reactors in isotope production. Because of its high flux, it can produce isotopes of higher specific radioactivity than the Argonne, Brookhaven, and Oak Ridge reactors currently offering irradiation services to the public.

Charges for public irradiations in the MTR are based on the recovery of all costs involved, yet are sufficiently low to make the service available to qualified research organizations.[10]

New Reactor Development Tools

Thermocouple for measuring fuel element temperatures.—A uniquely

Food Sterilization Program Transferred to Army

At the close of fiscal year 1954, the Commission completed transfer to the Army of all five of its contracts for studies of the effects of irradiation on food. These contracts were with Massachusetts Institute of Technology, Columbia University, University of Michigan, Food Research Institute of the University of Chicago, and American Meat Institute Foundation, Chicago, Ill.

The Army Quartermaster Corps, under the direction of the Quartermaster Food and Container Institute for the Armed Forces, is beginning a broad study of the sterilization of food by irradiation. The long-range objective is to determine if foods can be preserved by irradiation as a substitute for present treatment by heat, chemicals, and other processing, without detracting from their natural odor, color, flavor, and texture.

The AEC will continue to furnish radiation sources for this program, preparing them chiefly by the irradiation of special materials.

Utilization of Radioactivity

Meanwhile, the Commission is continuing its efforts to develop practical radiation sources from the large supply of fission products. For example, Argonne National Laboratory fabricated a special experimental radiation source for food studies at Massachusetts Institute of Technology. It consists of a small cylindrical block of concrete which was prepared by use of the liquid fission product waste instead of water. The radioactive concrete is surrounded by several inches of ordinary concrete and lead for shielding. Materials lowered into a hole in the center of the block are subject to radiation.

Investigations are also being made to determine workable ways of utilizing the intense gamma radiation of cooling fuel elements. In a University of Michigan study of trichinosis control, pork was exposed to the radiation from spent Hanford slugs and MTR fuel elements. Plastics, insulating materials, and organic liquids were given similar exposure at the MTR by California Research Corp., General Electric Co., and Phillips Petroleum Co. To determine the possible usefulness of glass for measuring radiation from high-level sources, different kinds of glass were subjected to spent-fuel irradiation by the Naval Research Laboratory. Army contractors exposed various foods at the MTR.

Portable X-ray Unit

A small, inexpensive and portable X-ray unit, which has potential uses in medicine and industry, was also developed at Argonne. The active component of the instrument is a tiny particle of radioactive thulium, a rare earth metal, procured from the AEC's rare earth separation facilities at Iowa State College and irradiated in the MTR in Idaho. The entire unit weighs less than 10 pounds. Tests are in progress to determine specific practical applications.

Sanitary Engineering

Data from completed development work by A. D. Little, Inc., Cambridge, Mass., on high-temperature, high-efficiency filters were made available to filter manufacturers. The company started production to meet the requirements of AEC contractors and to fulfill commercial demands.

Fall-out studies were continued at Harvard University and Rensselaer Polytechnic Institute. Major emphasis was on investigating the passage of fall-out material through the water treatment and supply systems of Lawrence, Cambridge, and Boston, Mass., and Troy and Albany, N. Y. Data obtained indicated removal efficiencies of 30 to 50 percent, as compared with 90 percent removal of radioactivity in laboratory studies using manufactured isotopes. Work continued on determining the characteristics of fall-out material and on accounting for this difference. Activity levels obtained were considerably below allowable concentrations from a health standpoint.

Work progressed at Brookhaven on the project of ultimate waste disposal by fixation on clay. A pilot plant was completed.

Design and specifications for a 25 to 30 pound-per-hour and a 100 pound-per-hour incinerator for burning radioactive combustible wastes were completed by the U. S. Bureau of Mines. The small unit was designed for isotope users such as hospitals and research laboratories. Information [11] will be made available to manufacturers so that the incinerators can be made and sold commercially.

Two radioactive tracer runs were made by the U. S. Geological Survey on the Mohawk River. Information obtained was used to assess quantitatively the dilution of Knolls Atomic Power Laboratory wastes released in the river. KAPL, Harvard University, and the New York State Health Department cooperated on this project.

A preliminary report, "Disposal of Radioactive Waste in the Northeastern United States," by the Johns Hopkins University, indicates the feasibility of using a common centrally located burial ground for certain contaminated wastes. It shows that with present practices the unit cost of disposing of wastes at sea is higher than that for land burial.

[11] Inquiries should be addressed to R. C. Corey, Chief, Fuels Technology Division, U. S. Bureau of Mines, Central Experimental Station, Pittsburgh, Pa.

Oak Ridge School of Reactor Technology

In August, 79 students will be graduated from the 1953–54 session of the Oak Ridge School of Reactor Technology which is operated by the Oak Ridge National Laboratory. Of this number, 47 return to their sponsoring organizations—12 to industrial groups, 17 to AEC and military contractors and 18 to the military services and other Government agencies. Eighty new students are enrolled in the 1954–55 class and will be graduated in August 1955. Fifty-three are experienced men from industry and Government and the remainder are college graduates. The school has graduated 212 men who are now engaged in reactor design and development in industrial and Government organizations.

Physical Research

Physical research in the atomic energy program continued to result in growth of scientific knowledge. However, in spite of accomplishments achieved through the application of this knowledge, possibilites for further progress through research remain large. Basic research leading to new principles and broadening the understanding of physical phenomena is as essential to continuing progress as is applied research directed toward specific goals of practical accomplishment. The latter serves the immediate needs of the Commission's program, while the former underlies future capabilities. Research of both types contributes to the training of scientific manpower.

AEC's laboratories perform a vital role in the research program because of their unique facilities. Nevertheless, universities, colleges, and other independent research institutions make significant contributions also.

This section briefly describes some phases of unclassified approaches to the solution of problems in physics, chemistry and metallurgy as they relate to atomic energy. Certain aspects in the development or improvement, and construction and operation of research tools are also outlined.

Physics

High Energy Nuclear Interactions

Research with high energy beams from the cosmotron at the Brookhaven National Laboratory continued during the first 6 months of 1954. It was directed chiefly toward gaining a better understanding of the structure and behavior of protons and neutrons—chief constituents of atomic nuclei. One of the characteristics of protons and neutrons is that they emit short-lived particles called mesons upon colliding with other nucleons of high energy. Quantitative information about meson creation was obtained under known and controllable conditions through the use of high-energy accelerators.

Indicative of the strength of the nuclear forces with which one nucleon acts upon another is the answer to the question of whether "pi-mesons" (whose mass is equal to 280 times the mass of the electron) are always created singly or whether they can also be created in pairs. Experiments showed that not only can pi-mesons be created in pairs, but that at 2 Bev (billion electron volts) pair meson production actually predominates. Experiments with both cloud chambers and electron counters showed that neutron-proton collisions usually resulted in one positive and one negative meson, and proton-proton collision in two positive mesons. Although there was ample energy available, no cases of three or more mesons being created simultaneously were observed.

The creation of mesons heavier than protons or neutrons—"hyperons"—was also studied. The hyperon is unstable and may be thought of as a combination of a nucleon and a pi-meson. The system lives only 0.3 of a billionth of a second on the average and then decays into a proton or a neutron and a pi-meson. Whether these hyperons can be created singly is of considerable significance. Cloud chamber photographs showed many examples of a hyperon being produced together with another heavy particle, but no example of one being produced singly. Evidence also indicated that protons of at least 1.5 Bev energy are necessary to produce hyperons. This high energy again suggested that another heavy particle must accompany their creation.

Reactions of High Energy Photons

At the California Institute of Technology, investigators continued to use the 500 Mev electron synchrotron to perform fundamental experiments on the interaction of nuclei and elementary nuclear particles. Particular emphasis was placed on the photo-disintegration of the deuteron and the photo-production of charged mesons from deuterium. The photo-disintegration of the deuteron by high energy photons has been studied by measuring the emitted protons with a counter telescope. Results have been obtained for protons emitted at different angles and different energies.

As the photon energy is increased from 80 Mev, the cross section decreases and then shows a plateau or even a slight increase near 300 Mev followed by a rapid decrease in the differential cross section for higher energy. In the production of mesons from deuterium by energetic photons, it was found that the values obtained for the ratio of negative to positive mesons produced at forward angles lie between 1.0 and 1.2 and is almost independent of energy. In the backward direction, however, at 140° the ratio is 1.4 between 200 Mev and 300 Mev and increases somewhat at greater photon energies.

Detecting the Free Neutrino

Los Alamos Scientific Laboratory made further progress in determining whether the free neutrino [12] exists in nature. If it exists, the neutrino should be capable of causing the transmutation of free protons into free neutrons, accompanied by the creation of a positive electron (positron). The probability of this occurring when one neutrino passes a given proton is exceedingly small. However, if enough protons are placed in an intense beam of neutrinos, such as is supposedly emitted by a large nuclear chain reactor, the transmutation should occur often enough to be detected with appropriate apparatus.

First attempts to detect this event were made in 1953 near a large pile at Hanford, when apparatus designed at Los Alamos was used to record the frequency of observation of two almost simultaneous occurrences—one of which was the capture of a neutron and the other may have been the presence of a positron. The predicted pair of events was observed substantiating the theory. The next step in proving that these events are caused by neutrinos will consist in demonstrating that one of the pair is in fact a neutron "born" in the apparatus, and that the other is actually a positron produced at the same instant. An improved detector was designed at LASL using liquid scintillation techniques, and is now in the process of assembly. Consideration is being given to setting up this detector near a large reactor at the Savannah River plant in a further attempt to identify definitely the transmutation of protons to neutrons by neutrinos.

Interactions of Neutrons With Heavy Nuclei

Additional data on the interaction of neutrons with nuclei were obtained using the neutron beams from the Brookhaven reactor. Total neutron cross sections [13] of many heavy nuclei, with atomic weights of from 100 to 238 and in the energy range of a few to several hundred electron volts, were measured with the high resolution "fast chopper,"[13] a device for separating neutrons of different energy ranges. The

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[12] See p. 92, Seventh Semiannual Report to Congress.

[13] See pp. 28–30, 15th Semiannual Report for explanation of neutron cross sections and "fast chopper;" also, pp. 80–81, Seventh Semiannual Report for "neutron chopper."

strengths of the interaction of resonance energy neutrons [14] and nuclei were determined from these total cross section measurements—particularly for the rare earth elements around atomic weight 160—in testing theoretical models of the nucleus. Data agreed with recent concepts of nuclear models, predicting a stronger interaction in this atomic weight region than older theories which predicted a value independent of atomic weight.

Total cross section measurements in the resonance energy region with the "fast chopper" and crystal spectrometer were also analyzed to determine the capture of resonance neutrons for many of these heavy nuclei. The constancy of capture width for various resonances for a single isotope, its decrease with increasing atomic weight, and its unusually high values for isotopes having close to 126 neutrons were established. Results were significant in developing theories of nuclear structure. Measurements with the crystal spectrometer of the scattering of neutrons and activation cross section also yielded additional information on the interaction of neutrons with nuclei.

Cross Section Measurement Program at LASL

The Los Alamos Scientific Laboratory facilities for measuring cross sections of concern to AEC's nuclear weapons and reactor programs approached the planned goal of having available sources of fast neutrons covering a wide range of energy. The large Van de Graaf electrostatic accelerator, now able to accelerate particles to 6.5 Mev (million electron volts), was in routine use. Its most important function was producing neutrons of energies greater than 5 Mev for fission, scattering, activation, and gamma ray measurements in a relatively unknown energy region of great value in reactor, shielding, and weapons calculations.

One of the laboratory's 2.5 Mev accelerators provided intense neutron sources from a few thousand electron volts (kev) to several Mev energy, permitting measurements of fission cross sections and neutron scattering experiments in the range in which a large fraction of the neutrons are emitted in fission. An intense source of 14 Mev neutrons produced by the deuterium-tritium reaction was obtained from a 250-kev accelerator. Measurements similar to those at lower energies were made, but the large number of neutrons generated per second was of particular advantage in shortening exposure times and for obtaining radiochemical samples. This 250-kev Cockcroft-Walton accelerator will soon be replaced with a larger, 600-kev accelerator.

[14] Resonance energy neutrons are those which have energies within certain narrow bands for which the neutrons are very strongly scattered or absorbed by a given nucleus.

Since charged nuclei are also involved in neutron reactions, a second 250-kev accelerator was used primarily for studies of charged particle reactions at very low energies and for investigating the passage of protons or deuterons through matter. Similar emphasis was placed on measuring cross sections for interactions of tritium nuclei, accelerated with other charged particles by a 2.5 Mev accelerator.

Basic Studies on Neutron Physics of Multiplying Lattices

North American Aviation, Inc., conducted a comprehensive series of exponential experiments for heterogeneous uranium lattices. The exponential assembly is a subcritical, partial reactor core, driven by an external source of neutrons, which serves as a flexible facility with which to perform nuclear measurements for proposed full scale reactor designs. The results obtained in this program will be used to substantiate design calculations for reactor systems proposed for both production and electrical power application.

Chemistry

Radiation Chemistry

High energy particles and gamma rays emitted in fission, or by radioactive elements, promote chemical reactions in water. An understanding of such reactions is useful in view of their application to fundamental chemical and biological research and to the development of reactors using water as a coolant or moderator. Upon striking the water these high energy particles lose energy along their tracks. This energy is transferred to the water, decomposing it into stable molecular products (hydrogen and hydrogen peroxide) and into extremely reactive, short-lived hydrogen and hydroxyl free radicals.

At the Argonne National Laboratory methods were devised for measuring the yields of these stable products and free radicals produced along the tracks of the particles. Results showed that stable products predominate for heavy particle radiations, such as alpha rays and fission fragments, whereas free radical production predominated for gamma rays and beta particles. However, the average energy required for water decomposition into these products does not depend on the nature of the particle. In liquid water the free radicals hydrogen and hydroxyl are able to exist for only a split second and have never been detected, although their presence as transient species has long been assumed to explain the kinetics of the radiation effects. However, in ice irradiated at low temperatures these intermediates would be expected to be more stable. Substantial evidence for the existence of hydrogen and hydroxyl radicals in irradiated ice was obtained at ANL for the first time using the very sensitive method of observing their absorption of radio-frequency power when the irradiated ice is placed in a magnetic field.

At Oak Ridge National Laboratory, atomic hydrogen, i. e., free radical hydrogen, was discovered to exist in the solid state. It was produced by irradiating with gamma rays from cobalt 60 frozen samples of perchloric, sulfuric, and phosphoric acids cooled down to liquid nitrogen temperatures. Identification was made by the use of microwave spectroscopy techniques and confirmed by independent observation.

Chemical Effects of Nuclear Transformations

The energy released in nuclear reactions is large compared to that needed to break even the strongest chemical bonds. Thus, atoms experience many unusual chemical reactions after undergoing nuclear transformations. The study of these effects is sometimes called "hot atom chemistry."

For example, if ordinary nitrogen (one of the principal gases of the atmosphere) is subjected to neutron bombardment, some of the nitrogen atoms are converted to atoms of carbon 14. Carbon 14 is radioactive, decaying by emission of a beta particle to the original nitrogen 14. If a compound containing nitrogen is bombarded with neutrons. a much higher yield of carbon 14 atoms is achieved, because there are more nitrogen atoms per unit volume of the solid (or liquid) compound than in gaseous nitrogen. However, the energy released when a nitrogen atom is thus converted is sufficiently great to disrupt the compound into its original atoms and molecular fragments. These rearrange and react chemically to form stable compounds which are usually simpler than the original. Such "hot atom" systems were studied at Brookhaven National Laboratory.

Neutron Diffraction Study

Theoretically the magnetic behavior of the ferrites [15] is explained by assuming the existence of several interactions or coupling arrangements between individual atomic magnets. The dominant interaction has the effect of alining the atomic magnets into two opposing and noncompensating groups. Many interesting consequences of this picture were

[15] The ferrites constitute a class of nonmetallic materials possessing magnetism. When neutrons interact with the atomic magnets which compose magnetic substances such as the ferrites, the neutrons are scattered into an observable spatial pattern whose form is determined by the way in which the atomic magnets are packed together. Such neutron diffraction experiments have been used to establish models of the arrangement of these elementary carriers of magnetism.

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verified by earlier neutron diffraction experiments at Oak Ridge National Laboratory, Brookhaven National Laboratory, and elsewhere.

Recent experiments at BNL demonstrated the existence of one of the postulated subsidiary interactions in zinc ferrite where the dominant interaction is absent. Since this interaction is weak, it is necessary to perform the experiments at temperatures sufficiently low to overcome the masking effect of the thermal vibrations normally present at high temperatures. In these experiments neutron diffraction patterns of zinc ferrite were obtained by using special equipment at temperatures a few degrees above absolute zero (−459.72° F.). Abrupt changes in diffraction pattern attributed to this subsidiary interaction were found below 10° absolute zero. As a result of these neutron diffraction studies an understanding of the origin and nature of the magnetic properties of ferrites was extended.

Helium Studies

Although helium 3 occurs rarely in nature, experimental quantities of this stable isotope were produced in nuclear reactors through the reaction of neutrons with lithium. Radioactive tritium, which eventually decayed into helium 3, was first obtained. This source of helium 3 made possible a wide variety of studies of the properties of liquid helium at temperatures near absolute zero. These supplied important data concerning the binding forces existing between atoms and nuclei.

Scientists at Argonne National Laboratory recently measured the specific heat of liquid helium 3 at temperatures down to within 0.42° of absolute zero. Results indicated that above this temperature nuclear interactions are not sufficiently dominant to cause nuclear spins (p. 49) in liquid helium 3 to line up in an ordered fashion. The effect of nuclear interactions is an important consideration in attempts to explain the unusual properties encountered in certain materials near the absolute zero of temperature, such as the disappearance of fluid friction (superfluidity) and of electrical resistivity (superconductivity). Related work at other laboratories on the magnetic susceptibility of liquid helium 3 indicates, however, that the nuclear effects do begin to show up at temperatures only slightly lower than 0.42° absolute.

Measurements confirming the specific heat of liquid helium 3 were also made by different methods at Los Alamos Scientific Laboratory. In one instance it was added to liquid helium 4 and a large drop in temperature of the solution resulted, indicating a significant heat of mixing. Ideally the heat of mixing is zero, which holds true in the mixing of most isotopes. This experiment, which indicated that it did not hold true for helium 3 and helium 4, is an important step in understanding the forces between these two isotopes. In other experiments at Los Alamos, low-temperature properties of these two stable isotopes of helium were investigated. Data were obtained on the total cross section of liquid helium 4 for thermal neutrons. A combination of this information, with the atomic distribution function deduced from X-ray scattering experiments, permitted an approximate calculation of the mean atomic kinetic energy and the root mean square force per atom in the liquid. Before this these quantities had not been obtained so directly.

Ohio State University made similar studies on the specific heat of liquid helium 3 whose results agreed with those of Argonne and Los Alamos. The University designed and used a unique machine in making measurements at very low temperatures. It was a magnetic refrigerator producing continuous refrigeration at temperatures below 1° absolute zero.

New Elements Discovered

Discovery of two new transuranic elements was announced recently. These elements—numbers 99 and 100—extend the series of known elements by two. The series now comprises eight beyond uranium, number 92, which was the heaviest element known before the United States atomic energy project began.

Element 99 was produced by bombarding uranium 238 with 100 Mev ions of nitrogen 14 in the 60-inch cyclotron at the University of California Radiation Laboratory. The nucleus of element 99 thus produced rapidly evaporates five neutrons to give the isotope 247 of this element. The 247 isotope is very unstable, and decays with a half-life of 7.3 minutes, emitting alpha particles and transforming itself into berkelium. Prior to the production of element 99 by cyclotron bombardment, this element had been discovered as a result of research work, not yet declassified, at Argonne National Laboratory, Los Alamos Scientific Laboratory and the University of California Radiation Laboratory.

Production and identification of both elements 99 and 100 was made in another fashion by groups working independently at the Argonne National Laboratory and UCRL. The laboratories reported that the elements were produced by subjecting plutonium to neutron bombardment in the Materials Testing Reactor. Several new isotopes of plutonium, americium, curium, berkelium, and californium were produced also, making it possible to study nuclear and chemical properties of the newly produced nuclides.

Geochronologic Studies

Age determinations of the carnotite and related ores of the Colorado Plateau by the lead-uranium and Pb^{206}/Pb^{207} methods have had an important bearing on theories of origin of the ore and are affecting exploration studies. Early in the study of these ores they were interpreted as having been syngenetic (formed during or soon after the deposition of the enclosing sediments). These are of late Jurassic and late Triassic age—some 125 and 150 million years old, respectively. If a given deposit is syngenetic, then it should be limited to a given formation. If it was formed by later ascending hydrothermal solutions, ore minerals may have been deposited at any favorable location between the currently known deposits and the source of solutions. It is of utmost importance, therefore, to learn as much as possible about the age and manner of origin of these deposits.

In studies of the U. S. Geological Survey, the best age determinations thus far made on the uranium deposits of the Plateau give a value of about 70 million years, indicating a late Cretaceous or early Tertiary age. Intrusive rocks of about this age are numerous in the region; mineralogy of the deeper (unaltered) parts of some of the deposits strongly suggests hydrothermal origin. If this interpretation is correct, exploration should be carried to much greater depths than would have been considered under the original hypothesis of origin.

METALLURGY

Stainless Steel Fuel Elements

Techniques were developed at Oak Ridge National Laboratory for manufacturing stainless steel fuel elements to be used in a research reactor. Fuel assemblies similar in design to those used in the ORNL Bulk Shield Test Reactor [16]—a gridlike assembly of fuel-bearing plates joined to inert side plates—can be made. However, these may prove to have an even higher safety factor than the aluminum elements presently used in the Bulk Shield Test Reactor. Calculations indicated that the amount of stainless steel in the fuel element for low-powered research reactors may be reduced to such an extent that only a small penalty in critical mass will be sacrificed in replacing the aluminum with steel.

[16] See pp. 14-15, 12th Semiannual Report.

Radiation Damage

During the past year Knolls Atomic Power Laboratory investigated the effects of neutron bombardment on several of the ordinary structural metals, such as iron, molybdenum, copper, and the stainless steels. This neutron bombardment is unique to reactors. During the life of a reactor the number of neutrons which pass through a given volume of metal will far exceed the total number of atoms in that volume of metal.

A number of changes were observed in the basic properties of metals as a result of the intense neutron bombardment. First of all the basic properties of the metals were changed. For example, changes are produced in hardness, ductility, electrical conductivity, and other properties. In addition to observing the overall changes in metals, scientists at KAPL were able to propose many basic mechanisms to explain these changes. For example, they found that metals expand, giving experimental evidence that neutrons displace metal atoms from their normal positions. In addition, they found that upon heating to high temperatures, these atoms returned to what might be called their normal residences. Therefore, the program is to observe first how metals are changed in reactor use and then to understand what the basic changes are in the atomic structure of the metals.

The energy required to displace atoms from their normal positions in a metal crystal, and the subsequent migration of the interstitial atoms and lattice vacancies so produced were investigated by the Atomic Energy Research Department of North American Aviation, Inc. Irradiation at liquid nitrogen temperatures and measurement of electrical resistivity at liquid helium temperatures show that in pure copper, copper-iron alloys, and nickel, 25–30 electron volts are required to displace an atom.

By measurements at successively higher temperature it was shown that motion due to thermal activation of the defects takes place in two distinct temperature ranges, one beginning near $-50°$ C., depending on the metal, and another near 100° C., also depending on the metal. In the case of Cu-Au alloys it is concluded that crystal lattice vacancies cannot migrate below a temperature range around 100° C. Other measurements and calculations are establishing the relation between distortions and defects in metal crystals and their electrical and magnetic properties. These studies are combining to give a description of radiation damage in simple metals which is being extended to reactor fuels also.

Analogous studies on graphite, coupled with a theoretical description of the electronic and crystalline properties of graphite, have provided many of the parts of a complete description of the effects of radiation on this substance.

Structural Integrity of Reactor Components

Sudden temperature changes of structural parts of reactors produce severe stresses on the materials involved. Repetition of these changes can result in structural failure by a process known as "fatigue." This problem continued under study at KAPL from a fundamental viewpoint. These results would be applicable not only to reactor components design, but also to a variety of engineering structures subject to high temperature service.

Research Tools

Reactors, accelerators, and related facilities are the unique tools required in research in the atomic energy program. Interest was stimulated in research reactors by an announcement of AEC policy in this field. Another university received preliminary approval from the AEC for the loan of fuel material for its reactor. Also, two new research reactors will be in operation in two of the national laboratories during the year. Three new accelerators went into operation and two others were in the design stage. Improvements were made on spectrometers, neutron detectors, and spectrographs.

Research Reactors

The AEC policy on lending of fissionable material to universities for use in research reactors was announced at the University Research Reactor Conference held in Oak Ridge in February. The conference—sponsored by the Oak Ridge Institute of Nuclear Studies and Oak Ridge National Laboratory in cooperation with the National Research Council—was attended by 51 universities and 28 manufacturing concerns interested in, or already building, such reactors for universities.

Briefly, AEC will lend fissionable material for independent reactors, without charge for rental or processing, when this material is not in immediate demand for military use or for other use by the AEC, provided the Commission has determined that: (*a*) The institution can provide adequate financing for construction of the reactor and for its continued operation for a reasonable period of time, (*b*) the design and operation of the reactor will be in the hands of responsible and technically competent people, (*c*) the reactor will be used in a well-conceived research program expected to contribute significantly to the training of students in nuclear research, engineering, or other scientific fields, and (*d*) the loan meets the requirements of the Atomic Energy Act and is in accordance with the regulations of AEC regarding quantity of material, security, classification, accountability, and health and safety.

AEC will not commit itself to support the operation of such reactors nor to paying the costs of the buildings which house them. It will consider partial support of the construction of reactors at nonprofit institutions, subject to availability of funds.

The University Research Reactor Conference appeared to stimulate considerable interest in research reactors for use on university campuses.

Omega West Reactor

A new reactor, under construction for use at Los Alamos Scientific Laboratory, was scheduled for completion during the winter of 1954. The facility will replace the Fast Reactor popularly known as "Clementine," built at Los Alamos in 1946 and disassembled in 1953. The new machine known as the Omega West Reactor, was designed to operate at from 1 to 4 megawatts of power and is similar to the Low Intensity Training Reactor at Oak Ridge National Laboratory. The reactor and its associated facilities will greatly increase the research capabilities of LASL, and aid in solving the particular problems faced at Los Alamos.

CP–5

The CP–5 research reactor (Chicago Pile No. 5) at Argonne National Laboratory went critical at 7 p. m. on February 10. It is a heavy-water reactor designed to operate at one megawatt of power. Since December, two shifts of personnel were transferred from the operation of the CP–3 to the CP–5 for training and testing. This research reactor was built to replace the CP–3 to be dismantled as soon as present experiments have been completed.

University of Michigan Reactor

The University of Michigan submitted a formal proposal to the Commission to build and operate a one-megawatt research reactor. Funds for the project were provided by the Ford Motor Co. The University's request for the loan of fuel material was given preliminary approval by AEC. The reactor will be a "swimming pool" type, cooled and moderated with ordinary water and using enriched uranium fuel. Fuel elements will be suspended in a pool of water deep enough to serve as a shield against the radiation produced by the operating reactor. It will be part of the Michigan Memorial-Phoenix project, established with private endowments for studies of the peacetime implications and applications of atomic energy. The facility will be used for training engineers in research sponsored by the university and by industry.

North American Aviation-UCLA Medical Reactor

For the past 2 years the Atomic Energy Research Department of North American Aviation, Inc., and the School of Medicine at the University of California in Los Angeles have engaged in studies of a nuclear reactor designed specifically for cancer research and therapy utilizing neutron and gamma ray irradiations. A reactor design was developed which will provide highly purified beams of thermal neutrons, fast neutrons, and gamma rays for research with animals, as well as a specialized facility for patient therapy.

Heavy Particle Accelerators

The University of California Radiation Laboratory and Yale University began joint design studies leading to the construction of heavy particle (carbon and nitrogen) linear accelerators producing heavy ions of approximately 10 Mev energy per nucleon. Each accelerator will cost approximately $1.2 million.

The interactions of heavy nuclei with matter have not been extensively studied. These accelerators allow the production, identification and study of trans-plutonium and trans-californium elements and the highly neutron-deficient nuclides of heavy and medium-heavy elements. They would also provide new methods of studying the forces and structure of the nucleus, radiation damage to materials, and the biological and biophysical effects of heavy ionizing particles.

Two heavy particle cyclotrons have been in operation for some time. At Oak Ridge National Laboratory the 63-inch cyclotron was modified to produce 28 Mev triply charged nitrogen ions, permitting many new types of reactions to be observed and cross sections to be measured. At the Crocker Laboratory of the University of California, the 60-inch cyclotron, produced carbon and nitrogen ions, and was used for the production of element 99, previously mentioned. Modification of this cyclotron began in February to increase the energy level and make it more suitable for accelerating these heavy ions.

Minnesota Accelerator

The first section of the University of Minnesota linear accelerator with a proton beam energy of 10 Mev came into operation on February 17. This beam will be used in nuclear scattering experiments, even while work proceeds on getting the accelerator into full scale operation.

Stanford Linac

Stanford University completed construction of a new microwave laboratory and began assembly of a 20-foot model section of a high energy linear electron accelerator. This accelerator will be used to explore the ultimate limitations of electron linear accelerators in the energy range of billions of electron volts, as well as to improve the performance of components such as the klystron power tubes, injector, and structural members. The 220-foot, 1 Bev electron linear accelerator at Stanford will now be devoted primarily to fundamental nuclear research under joint AEC-Office of Naval Research sponsorship.

Caltech Synchrotron

The synchrotron at California Institute of Technology was operated on a regular experimental schedule during its first year of operation. The intensity of its electron beam was increased more than ten times and it accelerated electrons to an energy of 500 Mev. Modifications will be made to increase the maximum energy of the accelerated particles to over 1 Bev during 1954.

Bevatron

The initial attempt to inject particles into the UCRL bevatron was made on February 2. During its first week of operation protons were produced with an energy of about 5 Bev, the highest energy to which protons have been accelerated. No experiments have been performed with the protons produced as yet. However, it is expected that the bevatron will be in almost constant use in research work in the near future. Construction of the bevatron began early in 1949 and its total cost was $9.5 million.

Neutron Cross Section Spectrometer

The Knolls Atomic Power Laboratory neutron cross section spectrometer, using a 100 million-volt betatron as the neutron source, was improved by extending the neutron flight path from 7 to 20 meters. Since the energy resolution depends directly on the distance a neutron travels from the source, the increased flight path resulted in a threefold improvement. With the present resolution—about 20 times better than the best attainable at the close of World War II—it was possible to obtain extensive new information for the reactor and weapons programs.

Fast Neutron Detector

Until recently the only satisfactory neutron detector was the Geiger-Mueller counter tube filled with boron trifluoride. The efficiency of such counters of manageable size, thin density of gas, etc., for detection of neutrons was as low as a few tenths of one percent for moderate energies of neutrons, and was totally inadequate over a large range of higher energies.

However, a new detector was developed at the Argonne National Laboratory that raised this efficiency detection to between 50 to 100 percent, over a wide region of energy. It consisted of the usual type of liquid scintillator containing an addition of methyl borate. Neutrons that enter the liquid are slowed down and captured by boron nuclei to produce nuclear explosions, giving characteristic flashes of light that are detected by photomultiplier tubes. This sequence of events is very rapid, so that the response time of this detector tends to be less than the uncertainty in the time of response of an alternative boron fluoride counter. The uncertainty results from the time taken for the neutron to traverse the counter and the uncertainty as to just where it will interact in the counter tube. Unfortunately these counters are very sensitive to gamma rays and cannot be used in experiments where much gamma radiation is present. However, they permitted great improvement in those time-of-flight experiments in which no strong gamma rays are present.

Optical Spectroscopy

An extremely versatile 30-foot concave grating spectrograph was set up at the Argonne National Laboratory and is being used in investigations of nuclear spins, isotope shifts, isotope assay, and the investigation and determination of electronic energy levels in heavy element spectra. Attention was focused on rare samples of special interest to the atomic energy program. Considerable effort was devoted to the development of light sources which provide sufficient intensity to obtain the data desired using only very small samples.

The components of the nucleus (neutrons and protons) manifest the property of angular momentum usually called "spin." Since the rotation of a charged particle produces a magnetic moment, nuclei with spin also have magnetic moments associated with them. Nuclear spins can sometimes be determined from hyperfine structure in atomic spectra. Hyperfine structure arises from the fact that the energy of an atom is slightly different for different orientations between nuclear spin of the nucleus and angular momentum of the electrons because of the interaction between the nuclear magnetic moment and the magnetic field of the electrons. From the number of lines of the hyperfine structure in the spectrum of a given sample, the nuclear spin can be determined. Using the spectrograph at high resolution and with an improved light source, it was possible to investigate the nuclear spin of bismuth 210 with less than 0.1 microgram of material (one ten-millionth of a gram).

With another type of light source and photoelectric recording of the spectrum of a mixture of isotopes, it was possible to determine the isotope abundance ratio, using samples of the order of one microgram, with an accuracy which compared favorably with that obtainable with the mass spectrometer. The spectrograph was also used for precision wavelength measurements of heavy element spectra.

Gamma Ray and Beta Ray Spectroscopy

A program of precision measurements in spectroscopy of nuclear and atomic-energy levels continued at the California Institute of Technology utilizing novel instrumental techniques. A curved crystal gamma ray spectrometer, using the same basic principles of crystal diffraction as have long been applied in the field of X-rays, was perfected to work over the range of much shorter gamma ray wavelengths, from about 500 X-units down to 9 X-units corresponding to quantum energies from about 25 kilovolts to about 1.3 million volts, with extremely high absolute precision. A companion instrument of comparable precision, an axial focusing magnetic beta ray spectrometer with homogeneous field, was also developed in this same group for work coordinated and interdependent with the same program of nuclear spectroscopy. The latter instrument relies upon the former for its calibration, but performs many functions to which the former is not adapted.

One of the latest problems to which this equipment was applied is the energy level scheme of tungsten 183, a daughter product of tantalum 183 after beta decay produced by irradiation of natural tantalum in the MTR. Results of this decay scheme are currently of considerable theoretical interest because of their bearing on the new Bohr-Mottleson theory of rotational energy levels in nuclei.

The program of this group also involves precision determinations of the physical constants and precision X-ray spectroscopic measurements some of which have a bearing on nuclear physics and some on pure research in the lower energy field.

Neutron and Alpha Sources Available

Neutron and alpha sources made from polonium 210 are offered for sale by the radioisotope sales department of Oak Ridge National Laboratory.[17]

Neutron sources are made by mixing polonium with any of the neutron-yielding elements, principally beryllium, boron, fluorine, and lithium. Certain neutron spectra are now produced by mixing target elements in neutron sources. When spectra determinations now in progress are completed, it will be possible to produce neutron spectra which will conform more closely to desired specifications. The use of neutron sources for starting reactors, calibrating instruments, logging of wells, and in research has increased materially.

Alpha sources are made with or without covers absorbing 10 to 60 percent of the alpha energy. The sources are made to specifications for individual needs in research and industry.

Biology and Medicine

The biology and medicine program of the Commission includes research activities relating to the establishment of control measures against harmful exposure to radiation, and to the utilization of radiation sources. Application of close and careful safeguards to control radiation hazards involves the integration of protective procedures and techniques to safeguard the health of workers and the Nation in case of an emergency. Utilization of atomic energy is directed toward exploration and development of the beneficial effects of radiation in medical, biological, and agricultural studies.

During the current period, progress was reported on studies of the effects of all types of ionizing and nonionizing radiations on man, animals, and living plants. In particular, emphasis was given to the investigation of the relative biological effectiveness of high energy particles as compared with X- and gamma rays. Data are also included on the development and present status of instrumentation re-

[17] Inquiries should be addressed to the U. S. Atomic Energy Commission, Isotopes Division, Post Office Box E, Oak Ridge, Tenn.

search for improved dosimetry and methods of radiation detection and measurement.

Radiation Exposures in Recent Weapons Tests

Prior to the recent weapons tests a danger zone was established surrounding the proving grounds; within this area a hazard from radiation might exist to shipping or aviation. Appropriate notices on the boundaries and the establishment of the danger zone were carried in marine and aviation navigational manuals. Before each shot of the series, a careful survey was made of the winds at all elevations up to many thousands of feet, and survey aircraft searched the area for shipping. The purpose was to take every precaution against radiation exposure of inhabitants of the area, the task-force personnel, and crew or passengers of vessels or aircraft.

During the tests, radiological monitoring teams were set up and the monitoring network of stations as usual was in operation to collect and measure fall-out—radioactive particles from the explosion descending to the lower atmosphere, the sea, or the earth. Measurements were made of airborne, ground, and water activity. The only fall-out of consequence was that which followed the first detonation of March 1, when a shift of the winds occurring after the detonation carried radioactive particles toward the islands of Rongelap, Rongerik, and Utirik. Thirty-one American test personnel, and 236 Marshallese were exposed to radiation. A Japanese fishing trawler, the *Fukuryu Maru* (Fortunate Dragon) was also in the path of fall-out.

Evacuation of Test Personnel

The 31 Air Force, Army, and Navy test personnel were evacuated to Kwajalein for physical examinations and observations. None of the men experienced any symptoms of radiation illness, and medical observations to date do not indicate that any permanent harm has resulted. All of the men included in this group were returned to military duty following complete physical examinations at Tripler General Hospital, Honolulu, T. H.

Inhabitants of Marshall Islands

The Marshallese from the islands of Rongelap and Utirik within the area of fall-out following the first detonation were evacuated promptly by the Task Force to Kwajalein. It was found that of the 236 evacuated, 74, all from Rongelap, experienced radiation burns, principally on the scalp or the neck. These burns are now almost completely healed. Hair from the heads of about 39 of these had fallen out in patches. However, normal hair regrowth is taking place. Urinalysis tests for radioactivity indicated that the exposed persons had inhaled or ingested small amounts of fission products. Preliminary data show that in no case did the body burden for the various radioactive isotopes exceed the permissible limits.

Every possible effort was made to provide for the immediate comfort and well-being of the Marshallese at Kwajalein. Routine sick call and medication, physical examinations, and serial blood counts were continued throughout their stay. The medical observations to date indicate that there is no reason to expect any permanent after effects on the general health of these people. The residents of Utirik have returned to their homes. The Rongelap residents were moved to Majuro Atoll for temporary occupation of dwellings built for them. These are of a new and improved type, better adapted to the comfort and the needs of the people than the usual type of island houses. It is expected that occupation of Majuro will be for approximately 6 months to a year, after which the natives can be reestablished on their original homesites in their new-type homes which will be moved from Majuro. During their temporary occupation, they are being furnished with livestock, provisions, and other supplies in order to maintain living standards at least equivalent to those prior to their initial evacuation from Rongelap.

Japanese Vessel Exposed to Fall-out

The Japanese fishing vessel, *Fukuryu Maru*, was reported by its captain as being located at approximately 50 miles northwest of Rongelap Island (11° 53¼′ North latitude and 166° 35¼′ East longitude) at the time of fall-out in that area. Following return of the ship to Japan on March 14, a report by the Japanese authorities stated the crew members were ill and showed skin burns from radiation. Japanese physicians gave the crew members medical treatment. Medical assistance was offered the Japanese by the United States through the American Embassy at Tokyo. The Japanese have not yet called for such assistance. However, they did request United States aid in making chemical analyses of some urine samples. These were performed at Commission laboratories. The injured men are reported by the Japanese physicians to be improving satisfactorily.

It is regretted that the crewmen of the *Fukuryu Maru* were injured as the result of being exposed to radiation from the first detonation of the recently concluded series. The welfare of the patients will continue to be of interest to the United States, and the negotiations for settlement of this incident are being handled through the Department of State and the American Embassy in Tokyo. In this connection Ambassador Allison informed the Japanese Government that the United States would pay just compensation and also would reimburse the injured fishermen for reasonable expenses for current medical care and family relief, including wages.

Reports on Contaminated Tuna Fish

Fish aboard the *Fukuryu Maru* were reported by the Japanese press to be grossly contaminated with radioactive materials. Quantitative data on the degree of contamination are few. It appears probable that observed contamination consisted largely of radioactive materials on the exterior surfaces of the fish from contact with fall-out material on the ship. United States representatives in Japan were not afforded an opportunity to verify the fact or the degree of radioactivity reported for this or later for other cargoes.

Subsequent to the return of the *Fukuryu Maru,* a number of other Japanese fishing vessels and their cargo were reported to involve sufficient radioactivity to require destruction of the fish. In one instance a single specimen fish was made available for study. Analysis of this specimen at an AEC laboratory showed the radioactivity of the edible portions to be well within acceptable limits for food and water for continuous use by humans.

The amount of activity in Bikini and Eniwetok lagoons would make it unwise to eat fish from these areas, at least for the present, without having them monitored prior to human consumption. Information presently available indicates that the fish in the lagoons of Rongelap, Rongerik, and Utirik are suitable for consumption. The activity in the lagoons other than Bikini and Eniwetok and in the open sea is so small that no deleterious effects may be expected to the fish themselves nor will the edibility of the fish be impaired.

Informed scientific opinion, borne out by recent continuous monitoring by the Federal Food and Drug Administration of tuna fish coming to the west coast from the Pacific fishing grounds, and further supported by several years' results of AEC marine biological studies, provides no basis for alarm as to the consumption of tuna caught in the Pacific.

Fall-out in the United States

Following nuclear detonations, radioactive debris is distributed by normal air currents over large areas and with sufficiently sensitive instruments may be found to encircle the globe. Small amounts were deposited widely over the United States during the Pacific tests and in some areas resulted in transitory rises of the normal background radiation levels.

Transportation of the radioactive materials to the United States took only several days. Thus some of the shorter half-life radioisotopes, such as iodine 131 (8-day half-life), were still present in the fall-out. Although the amounts of radioactivity deposited were biologically insignificant, it was possible, by special techniques, to demonstrate radioiodine in the thyroid glands and in the urine of grazing animals. Extremely minute quantities of iodine 131 were also detectable in the urine of some humans for a short time.

The radioactive isotopes to be found normally in the body are potassium 40, carbon 14 and radium 226. The radiopotassium and radiocarbon are distributed throughout the tissues while the radium is almost entirely located in the skeleton. In addition to this internal irradiation, man is subjected to cosmic rays from without and to the gamma rays from radium in the soil. To this natural exposure, the radiation from bomb products is added. The point of interest in terms of health lies not in the mere presence of radioisotopes, but in the amounts and more specifically in the quantity of radiation doses delivered by these radioisotopes. The levels of activity from fall-out, outside the area surrounding the Pacific Proving Ground, have been far less than any required to produce detectable injury either from the radioisotopes within the body or from external radiation, or from a combination of the two.

CIVIL DEFENSE

In its cooperative program to furnish technical advice and information relating to national civil defense preparedness, the Commission participated in a number of special meetings and discussions. A White House Conference for State Governors, arranged by the Federal Civil Defense Administration included an address by Chairman Strauss outlining AEC civil defense activities common to the national security program. Sessions were held with staff members of FCDA and the Department of Defense to determine current needs of FCDA and the feasibility of future civil defense experiments during test operations.

The AEC expressed a willingness to cooperate in all ways possible in a civil effects test program comprising: Structures and associated services and equipment; industrial participation; civil defense training exercise; and observers and public media participation. Proposals have been submitted on certain parts of the total program by FCDA. These are being reviewed for feasibility pending official action on

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future AEC developmental tests. Staff members also reviewed design criteria for protection construction standards to be released by FCDA to guide Federal agencies and the public in erecting structures in or near designated target areas. Assistance was also given to the Bureau of Ships, Department of the Navy, on design criteria and materials necessary for construction of adequate shelters. A classified briefing was held for the Civil Defense Committee of the Life Insurance Association of America to acquaint them with the responsibilities of civil defense.

Emergency Radiation Monitoring Teams

Pending establishment of civil defense organizations with definite assigned functions for radiological defense, the Commission acted in 1949 to establish emergency radiation monitoring teams in about 20 locations throughout the United States, to operate under the jurisdiction of 5 AEC operations offices. These teams were composed of AEC and contractor personnel experienced in radiation detection work at atomic energy installations, and stood ready to monitor any radioactivity resulting from enemy attack or disaster, using radiation detection instruments stockpiled by the Commission.

In the period since establishing this emergency monitoring network, civil defense organization and training have made appreciable strides forward, with the result that on January 4, 1954, after consultation with the Federal Civil Defense Administration, the AEC teams were relieved of responsibility for civil defense radiological monitoring operations. AEC continues to serve as scientific and technical adviser to FCDA and to State and local civil defense bodies in this area and wherever AEC experience and competence apply.

Also, AEC continues to make available, on a loan basis, radiation detection instruments and certain radioisotopes for civil defense radiological training use by States and cities, upon endorsement of their applications by the FCDA. Loans to the following were made in the current 6 months period: Texas and Arkansas—instruments; Florida and Texas—radioisotopes.

Dissemination of Information from Civil Effects Tests

Information compiled from weapons test reports of the spring 1953 series at the Nevada Proving Ground was issued as public information by FCDA. It includes data on air-zero locators, identification tags, typical frame residences, and home shelters.

The genetics experiments in the spring 1953 test series were of particular scientific interest. Unclassified extracts from the weapons test reports were given at several scientific meetings, and 14 articles on the results of the exposures of genetic materials to nuclear radiation were reviewed for publication in scientific journals.

Declassification of Operation IVY Film

The declassification and public release of "Operation IVY"—the official film of the test of a thermonuclear device at the Pacific Proving Ground in 1952—was a major contribution to national civil defense.

Research Investigations

Increased emphasis continued to be given to integrated research studies on various types of radiation, providing data on the effects of radiation on biological systems. Particular attention was centered on the biological effects of neutrons. These effects are more difficult to study, and consequently, less well-known than those of X- and gamma rays. This is true because it is difficult to produce neutron irradiation without significant exposure to other types of radiation, and because of difficulties of measurement of neutron dose in the presence of other types of radiation. Neutron effects are important not only in research applications, as discussed here, but to the weapons development program and in civil defense activities.

Somatic Mutation Program

Studies at Brookhaven National Laboratory of the effects of radiation on plant growth and reproduction utilize both gamma and neutron sources developed in the reactor. Under the somatic mutation program, a cobalt source is used for experiments in a "gamma field" where plants of several varieties are planted in concentric circles at various distances from the center in order to receive varying radiation exposures throughout the growing season. This program, started in 1952 on a small scale, was expanded recently with the major agricultural experiment stations in the East cooperating in the project. The objective is to test the feasibility of producing useful mutations by means of ionizing radiations in plants, shrubs, and trees normally propagated asexually.

The experiment stations select the material to be treated, and after irradiation at Brookhaven Laboratory, any mutations produced are screened at the originating station for usefulness. Most of the material sent in is grown in the "gamma field" and careful observations are made of the effects produced. Continuous radiation upsets the normal growth of the plants, and it appears that each variety responds in a different way. At certain dosage rates, some plants grow more rapidly. The leaves of others grow in peculiar ways, and the coloring of some flowers changes. Many mutations are produced and careful analyses are made both for fundamental causes and in searches for useful new varieties. It is hoped that this research may supply positive answers concerning the usefulness of radiation as a tool in plant breeding in the near future.

In addition to the cobalt source, the Brookhaven National Laboratory is making use of thermal neutron facility for mutation production in plants. It was shown that thermal neutrons are more effective in producing mutations than other forms of radiation. Also, it is becoming clear from other studies that radiation damage to biological material from neutrons is produced by quite a different mechanism from that which occurs following X-ray or gamma irradiation.

Recent work with neutrons led to findings on inducing disease resistance in plants. Rust diseases bring annual losses of millions of dollars to the oat crop—the Nation's third largest cereal crop (after corn and wheat). Investigators at Brookhaven exposed several hundred oat seeds of the Mohawk variety to thermal neutrons. After the first crops were harvested, seeds were planted in the summer of 1953 and a second-generation group grown. Artificial inoculations of oat stem rust fungus (Race 7A), to which the Mohawk strain is particularly susceptible, were given to these plants. Seeds from the few uninfected plants were taken and planted in the fall. Resultant plants were inoculated with the rust disease but continued to show resistance against it. As far as is known, the new strains have all the desirable characteristics of the original Mohawk variety, including high yield. Further experiments to determine applicability to other varieties and crops will continue.

Radiation Effects on Tobacco and Potato Plants

Experiments in the Brookhaven "gamma field" [18] also included radiation of a species of tobacco plants. Results showed that irradiation produced a moderately high rate of induced tumors. The tumor-induction rate at fairly high dosages (300 roentgens, *r*, per day) in the gamma field was greatly increased over the control lot, not only in numbers of tumors per plant but in size of individual tumors. The significance of this response is not yet understood. However, it is the first report of a tumor in plants induced by gamma radiation, although radiation-induced tumors have been recognized in animals for many years.

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[18] See pp. 75-80, 11th Semiannual Report.

Investigations on the effect of radiation on the "keeping" qualities of potatoes also showed some interesting results. A quantity of potatoes was divided into five lots—four were given various radiation doses and the fifth lot kept as a control. The potatoes were all stored later under conditions comparable to standard potato storage conditions, and samples taken periodically from each lot were tested for taste and graded according to standard potato-grading procedures.

At the last test period, it was found that most of control lot had spoiled, but those that had been exposed to 20,000 *r* were still Grade A potatoes in all respects. Potatoes exposed to about 5,000 *r* might be classed as Grade B, as well as those exposed to 80,000 *r*. Apparently in late spring, when potatoes begin to sprout, an enzyme is released which is responsible for the breakdown of the starch. Sprouts are inhibited by relatively small doses of radiation, and consequently the starch is not broken down. At the higher doses, apparently, there is enough cellular destruction to cause a general breakdown over a long period of time. These explanations have not been verified. However, there seems to be little doubt of the existence of the phenomenon, since it was previously observed quite accidentally in other experiments, and this research project was designed specifically to investigate this point.

Radioisotope Tracer Studies in Lakes

Radioisotope tracer techniques, utilizing radiophosphorus, radiocalcium, and radiostrontium, have been of much value in contributing to studies of the uptake of radioactive elements in plants, and also to studies on the metabolism of plant nutrients. Phosphorus—an essential element to the growth of plants in both land and aquatic species—is often found to be deficient in soils, or in lake bottoms, for normal plant or animal growth. Investigators under an AEC-University of Wisconsin research project have been examining the problem of phosphorus uptake in the many lake regions of the State's northern water areas, classed as "bog" or "dead" lake areas. These lake regions have proved suitable for use in field experiments utilizing radioisotope tracer studies. The mineral nutrients in the water and mud bottoms of these lakes are so bound chemically that they have not been available to growing plants, fish, and aquatic insects and other forms of animal life.

A study of mud-water nutrient exchange was made by placing radioisotopes in mud core samples at different depths from the bottom lake mud, and measuring the uptake of these radioisotopes by the water under various conditions. The method for releasing the nutritional materials in these lakes consisted of neutralizing the acid conditions with appropriate amounts of lime. This cleared the water of the brown colloids present, and by undetermined reactions the nutrients—principally phosphorus—were released from the bottom muds. By this chemical application, phosphorus was made available for algae production, supplying food for small fish. This is similar to phosphate fertilization of pastures which increases food supplies for cattle, resulting in greater beef production.

Making use of the methods to release plant nutrients, many of the lakes were planted with rainbow trout and bass on an experimental production basis. The trout-carrying capacity of the "bog" lakes was increased to double that of its previous capacity. A return of at least 25 pounds annually can be expected for each acre of lake. Aside from food production value, the Wisconsin "bog" lakes can become important as recreational areas—a major source of income for the State. However, the usefulness of the knowledge obtained by the research group is not restricted to management of "bog" lakes. For example, its application to a clear-water lake such as Lake Mendota may prove valuable in increasing the fish-carrying capacity, since the amount of phosphorus in the bottom mud below the 10-meter contour is estimated as more than a million tons.

Effects of Alpha-Emitting Isotopes

Investigations were carried on at Mound Laboratory of the effects of alpha-emitting isotopes on laboratory animals and microorganisms. Polonium 210, a pure alpha emitter, when injected into rats was found widely distributed in all of the soft tissues. One-half of the amount injected is eliminated by natural processes and decay in about 35 days, and one-half of that remaining is eliminated in each succeeding 35-day period. The kidney appears to be the organ which is most affected following injection of a single small dose, although evidence of damage was observed long after polonium disappeared from the tissues. Experiments are being made to determine the precise method by which alpha radiation attacks tissues. The critical effective dose of polonium which will definitely shorten the life span of the rat was established, and an approximate critical value for humans calculated.

In the case of the element actinium, the effects are complicated by the decay of actinium through a series of eight major radioactive decay products (daughters). During this decay alpha, beta, and gamma radiations are emitted. A relatively simple procedure, not requiring chemical separations, was developed for the quantitative determination of actinium 227 and its relatively long-lived daughters, thorium 227 and radium 223. The method is ideally suited to biological studies. Preliminary data indicated that after intravenous injection of a mixture of actinium and its daughter products into rats, about 50 percent of the dose becomes localized in the bones and remains there almost indefinitely. The remainder of the dose is distributed to the soft tissues and is eliminated eventually. The daughter elements are eliminated from the tissues much more rapidly than the parent material. These experiments were extended to include the effects of the route entry, the effect on reproduction, and the transfer of active material to the young through the placenta and milk. A series of studies on the effects of small doses of actinium on mice is in progress, and a substantial number of bone tumors were noted at an earlier date than normally observed.

Studies with microorganisms showed that a number of organic compounds inhibit cell division in a manner similar to that of alpha or X-radiation. Studies being made to determine the mechanism of this inhibition have revealed significant differences in the relative amounts of various nitrogen-containing compounds found in normal and in treated cells.

Radiation Dose-Measuring Device

The damage of radiation in the human body generally takes place within the individual cells. Measurement of this radiation dose is an essential step in estimating the extent of injury to tissue or body fluids. Such information is also important in determining levels of permissible exposures for the various types of radiation.

An AEC-Columbia University research group developed a type of "wall-less" chamber which promises to be an effective dose-measuring device. The term "wall-less" chamber was applied to this device because the region (or ion-collecting volume) in which the ionization process takes place is defined by magnetic lines of force rather than material walls. By enclosing the system in an aluminum sphere or a cylindrical steel tank, pressures other than atmospheric or any tissue equivalent gas may be used. By varying the gas pressure it is possible to simulate cells of almost any size. The radiation dose in a single cell can then be determined no matter how small the cell or how the radioactive material may be distributed in the cell. Phosphorus 32 was used for these studies and continued investigations will include radioactive iodine, gold, sodium and potassium.

Neutron Toxicity Studies

With continued increase in activities involving the emission of neutrons, the need for firmer estimates of maximum permissible levels of exposure, both to neutrons alone and to neutrons in combination with gamma radiation, has intensified. One approach to this problem is the determination of the biological effectiveness of neutrons in terms of X- or gamma radiation for which exposure levels are well established. Neutron toxicity studies in this field were made at the Commission's national laboratories and data reported on current findings.

Argonne National Laboratory.—The first step in the ANL studies was the construction of complete survival curves of experimental animals after exposure to each of these ionizing radiations. The Carworth Farm female mouse was used in this acute lethality study.

Results showed that whether mice were irradiated during 1½ or 24 hours with a given dose of fast neutrons there was no significant change in their lethality. The dose that would kill 50 percent of the animals within a 30-day period after exposure (LD–50) remained the same—approximately 210 *r* equivalent physical of fast neutrons. Although the time of exposure, and consequently the dose rate, were changed by a factor of 16, there was no significant difference in the two survival curves after fast neutron irradiation.

However, it was found that with exposure to gamma rays from cobalt 60 the dose rate had a marked effect on mortality. When the total dose was given in 1½ hours, the LD–50 (lethal dose for 50 percent) was about 920 *r*. Increasing the time in which the total dose was delivered to 24 hours, increased the LD–50 by 44 percent to about 1,320 *r*.

The ratio of various doses required to produce the same biological effect of fast neutrons and cobalt 60 gamma rays can be calculated for lethality of the female mouse—4.4 for 1½-hour irradiation and 6.25 for 24-hour exposures.

After survival curves for pure radiations were established, experiments were undertaken in which the additivity of the effects of varying mixtures of the two radiations were studied. If mixtures of fast neutrons and gamma rays were completely additive in their biological effectiveness, then the mortality curves of the mixed and pure radiations should be identical. Results showed that this was not the case. The "departure from additivity" was greatest when the gamma component of the mixture was lowest. A maximum departure of 11 percent was obtained when the mixtures were made up of one-third gamma and two-thirds neutrons. It was concluded that the 1½ hour mixtures of the two radiations were not strictly additive in producing lethality, since the gamma component in a mixture, especially if small, did not contribute the same proportional lethal effect. Further experiments are being carried out to test this hypothesis.

Experiments are being made to determine the relative recovery of mice after both chronic and acute exposure to fast neutrons and to gamma rays. Animals were exposed for varying lengths of time, at different dose rates, and to fractionated doses with various time intervals. From such comparative studies that portion of the dose that caused irreparable damage could be estimated, as well as a "recovery factor" after such exposures.

The patterns of mortality following these two kinds of ionizing radiation are strikingly different. A single large peak of mortality occurred 4–9 days after acute exposure to fast neutrons, whereas the peak of death after gamma radiation occurred considerably later—about 12–15 days after irradiation.

In determining what protective effects might be taken against ionizing radiations, studies were made with streptomycin, an antibiotic, and cysteine, an amino acid. In previous experiments, some satisfactory results were obtained using these materials. Mice irradiated with fast neutrons were given daily subcutaneous injections of 5 or 6 milligrams of streptomycin. Irradiation controls received daily injections of sterile salt solution. Streptomycin therapy prolonged survival time at all dose levels, although it did not reduce the 30-day mortality as dramatically as in mice exposed to comparable doses of X-irradiation. The antibiotic, however, gave definite and marked protection to the mice for 10 or 11 days following the neutron exposure.

These results suggested that bacterial invasion was one factor in the deaths of mice exposed to fast neutrons. Work is continuing using injections of spleen homogenates, in order to identify clearly the different mechanisms that may come into play following exposure to fast neutrons and to gamma rays from cobalt 60.

Cysteine pretreatment was shown to confer significant protection in mice against the acute lethal effects of these two ionizing radiations. The protection observed against fast neutrons was, however, only about one-half as much as against gamma radiation. Data supported the concept of a true dose reduction in the sense that primary mechanisms were involved.

Studies are being continued on the production of tumors, leukemia, cataracts, as well as effects on fertility, development of young, and length of life, in animals surviving these pure radiations and mixtures. In addition, the gamma-neutron radiation chamber is used in collaboration with other investigators at Argonne National Laboratory and elsewhere, for the exposure of a variety of plants and animals to determine the biological effectiveness of the two ionizing radiations.

Los Alamos Scientific Laboratory.—The Los Alamos Scientific Laboratory continued neutron toxicity studies using a number of mammalian biological test systems. The radiations studied included: thermal neutrons and 4.9 Mev gamma radiation from the Los Alamos

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homogeneous reactor, fission neutrons from a Los Alamos critical assembly, 14 Mev neutrons from the Cockcroft-Walton accelerator, and gamma rays. In most of the test systems the relative biological effectiveness of neutrons was one to two times that of gamma or X-rays.

Additional studies included intensive and extensive experiments of the effects of massive, rapidly delivered doses of gamma rays and neutrons on mice, rats, and monkeys. The syndrome of acute radiation disease has been characterized in considerable detail over the dosage range of 400 to 150,000 *r*. Recent studies using a Los Alamos critical assembly gave additional information concerning the effects of dose rate.

Typing of Blood Platelets

Data were reported by AEC-New England Medical Center investigators at Boston on findings in blood platelet research. Platelets are colorless, disk-shaped bodies found in human blood and in the blood of all other mammals. It is now possible to type and group platelets much the same as is being done with red blood cells before normal blood transfusions. Platelets play an important part in blood clotting, and it was shown that some irradiated animals were protected from bleeding through transfusion of platelets from the blood. When the entire body was exposed to ionizing radiations in other experiments, a reduction in the number of blood platelets was produced among other effects. In some instances, platelet formation ceased entirely.

Further studies are needed, and continued efforts may prove of significant value in combating such maladies as thrombocytopenic purpura—a blood disease in which bleeding occurs under the skin and internally.

Nucleic Acid Metabolism and Neoplasia

The use of tracer isotopes in following the turnover of biochemical compounds in living cells brought out a number of differences between the metabolism of cancerous tissues and that of normal body tissues. One such study, recently reported from the Sloan-Kettering Institute for Cancer Research in New York City, concerned the incorporation of certain labelled purines (a certain type of organic base) into the nucleic acids of the nucleus and cytoplasm of cells incubated in tissue culture. The process is followed by radioautography of the tissue sections before and after digestion with enzymes attacking the nucleic acids.

Considering overall averages only, no difference was found in the concentration of the purines in the cells of embryonic mouse skin and in tumor cells after a given exposure. However, when a graph was made showing the number of cells in each range of isotope concentration, a considerable difference was apparent. The skin controls showed the usual statistical distribution around a single high peak. However, the tumor cells fell into a bimodal distribution, indicating that there were at least two cell types in respect to the purine uptake. The cells of the less active group appeared to be benign, while most of the more active cells were obviously malignant.

A further indication of the quantitative metabolic difference was brought out in experiments involving addition of ordinary adenine (one of the most important purines) to compete with the related radioactive purine in the medium. This depressed the uptake of the tracer in all cases, as would be expected, but the effect was more pronounced in the tumor cells than in the skin cells.

Studies of Protein Synthesis

An approach to the measurement of protein synthesis is being made by using carbon 14 labeled amino acid as tracers. Work was directed to provide a basic approach to the study of cell proliferation in tissue directly applicable to studies of irradiation damage and protection. Recent experiments at the California Institute of Technology, supported in part through AEC funds, present some significant developments.

Since reticulocytes (immature red blood cells) can be followed both in the test tube or in the body, these techniques were applied in studies using rabbit reticulocytes. A new class of biochemical cofactors was found which caused carbon 14 labeled amino acids to become incorporated into the cells. The stimulating factors, or system of factors, were certain amino acids, certain metals, and a carbohydrate factor or factors which may be isolated from the nonprotein fraction of the liver. Four additional factors were isolated from liver tissue and appeared to have a sugar, and certain amino acids in common. Each appears to be slightly different. Also, a stimulating factor was isolated from the nonprotein filtrate of plasma from anemic rabbits. The incorporation of labeled amino acids into protein is stimulated by all of these factors. The findings furnish a method of studying the concurrent synthesis of heme, globin, nucleo proteins and nucleic acids.

Analysis of Drug Actions

An AEC-research group at Rice Institute, Houston, Tex., used radioiodine (I–131) as a testing agent to determine the effectiveness of certain drugs. In the group's recent experiments with rats, it was found that the commercial anthelminthic drug "phenothiazine" had an immediate and marked blocking effect on the uptake of radioactive iodine in the rat thyroid. This drug is administered by veterinarians treating hogs, sheep, and cattle. In some cases, it is also employed in human treatment. Since the drug is a regular constituent of the diet of livestock, further investigations are being made to determine if the blocking action of the drug is typical of an antithyroid drug, or is due to possible impurities in the commercial preparations.

Radioactive Dust Retention in the Body

Studies on radioactive dust retention in the body progressed at the AEC-University of California (Los Angeles) project. Inhalation of radioactive dust particles in high concentrations constitutes one of the chief potential radiological hazards to animal life. Although some radioactive materials are eliminated from the body rapidly, others are retained and may concentrate in certain parts or organs of the body.

In recent experiments, rabbits were exposed to high levels of radioactive dust collected from the Nevada Proving Ground. Examination of sections of the lungs (in polarizing microscope) showed heavy deposition of particles in the alveolar membranes and in the smaller airways. Most of these particles measured 1–2 microns (the original dust ranging from 0 to 5 microns). Radioactivity retention as a result of such exposures was measured on ashed specimens of lung and stomach. The amount of retention indicated an increase with longer exposures and higher dust concentrations. However, this increase was less than would be predicted by a simple direct proportionality.

The results revealed a definite effect of particle size on the distribution and retention of radioactive material. With smaller particles (up to 5 microns) immediately after a 4-hour exposure, only 6 times as much activity was found in the stomach as in the lung. However, with similar exposure to larger dust particles (average diameter of 10 microns), the pulmonary retention became greatly reduced while the gastric retention increased. This gave a stomach/lung ratio of about 150 to 1, instead of 6 to 1 as with smaller particles. It appeared that the larger particles were trapped in the upper air passages, then swept out and swallowed, while the smaller particles were deposited in the terminal parts of the lung. Auxiliary studies showed that the bulk of these particles was subsequently carried to the gastrointestinal tract by phagocytic cells moving up the pulmonary tree, and that only a small amount was carried by the phagocytes into the lymphatic system.

Eniwetok Biological Station

The Commission recently completed construction and equipment of a small marine biological laboratory on Parry Island at Eniwetok Atoll. In addition to facilitating fundamental biological marine studies of the Marshall Islands area, the laboratory will provide a permanent base of operations for studies on radioactive contamination which have been routinely conducted by the AEC-University of Washington research group following test detonations in the Pacific. Previous surveys, operating from Seattle for a short period following the tests, were often handicapped by the inadequacy of temporary quarters and difficulty in transporting and handling material and equipment.

The new biological station will be operated by the AEC, with the University of Hawaii providing essential laboratory services. During periods of inactivity between tests it will be available for continued investigations by research scientists or biologists. These investigations will include those of universities or colleges without adequate facilities to carry on a marine research program and will help AEC-research contractors extend their programs by including data from the Marshall area. Studies will be made of the uptake of fission products by marine animal and plant life, and ecological changes in land areas and shore waters. Since the marine life and general environment are considerably different from those in other areas, many investigations on the effects of radioactive contamination on growth and physiology of individual tropical marine species may be undertaken.

Public Hearings on Peacetime Uses of Atomic Energy

On March 31 and April 1 the first session in a series of public hearings on present and potential peacetime uses of atomic energy was held by the Subcommittee on Research and Development of the Joint Committee on Atomic Energy. The first of the series presented information on atomic energy in the field of agriculture.[19]

Participants included personnel from AEC's Division of Biology and Medicine and Brookhaven National Laboratory, the U. S. Department of Agriculture, Michigan State College, University of Minnesota, and the University of Maryland. Information was presented on the use of radioisotopes in plant and animal studies, genetics and food preservation.

[19] Hearings before the Subcommittee on Research and Development, Joint Committee on Atomic Energy, on *The Contribution of Atomic Energy to Agriculture*, March 31 and April 1, 1954 (Joint Committee print).

In the session held June 2 and 3, the Commission provided information on contributions of atomic energy and its byproducts to the medical sciences.[20] Particular emphasis was placed on how atomic energy has aided studies in cancer, heart disease, and other chronic diseases, the general field of epidemiology, and on new developments in therapy units. Participating in the presentation of material were the National Institutes of Health of the U. S. Department of Health, Education, and Welfare; in addition to scientists from the AEC Division of Biology and Medicine and those working on AEC medical projects at Brookhaven National Laboratory, Argonne Cancer Research Hospital, Oak Ridge Institute of Nuclear Studies, the University of Chicago, and the University of California at Berkeley.

Radiation Instrumentation

Instruments for radiation measurement are indispensable tools to scientists and engineers in the atomic energy industry. In all AEC programs instruments and other electronic devices provide one of the common denominators of the research and production phases, and instrumentation has been developed progressively to keep pace with the expanded activities in the atomic energy enterprise.

The large-scale handling of nuclear energy by the Manhattan Engineer District created an immediate demand for types and quantities of instruments to detect and measure radiation intensities. There were numerous, varied and intricate problems in which instruments were needed for health-protection purposes, biological, chemical, and physical research, and production control. Many of the radiation instruments then available were scarcely more than laboratory curiosities, except the specialized instruments employed in the medical field for clinical X-ray treatment or therapy. Rigid security regulations of the Manhattan project limited outside participation in the development of radiation instruments to five industrial concerns. Since most of the work had to be done at project laboratories, the instrumentation groups became essentially self-sufficient in solving problems of design, development, and production. Basic instruments, allied electronic equipment and special components and parts for radiation measurement in current use are fundamentally products of the Manhattan Engineer Project.

After the war security restrictions on the instrument programs were eased, and immediate steps were taken to remove the burden of instrument production from AEC laboratories and production facilities. The Instrument Production Section was established at Oak

[20] Hearings before the Subcommittee on Research and Development, Joint Committee on Atomic Energy, 83d Cong., 2d sess., on *The Contributions of Atomic Energy to Medicine*, June 2, 3, and 4, 1954 (Joint Committee print).

Ridge to maintain continuity of the program and this section later became the Radiation Instrument Branch of the Commission's Division of Biology and Medicine. The primary function of this group was to examine the instrument activities of the various sites, and to initiate industrial contracts for commercial manufacture when feasible. It also helped other Government agencies meet their need for radiation instruments.

The program established at Oak Ridge was designed to: Encourage the growth of a competitive radiation instrument industry; reduce the manufacture of instruments within AEC laboratories; and reduce overlapping in AEC research and development programs by providing for the interchange of instrumentation techniques and data among the various AEC installations.

These objectives are essentially the objectives of the current AEC instrument program. Through consultation with the Washington instrument staff, assistance is provided industrial groups interested in the manufacture of radiation instruments. Greater interest in the widespread use of radioactive materials has increased the need for exchange of information among technical personnel. Conferences are held in selected fields of radiation instrumentation for AEC personnel, in which representatives of other Government agencies and private industry are invited to participate. Liaison is maintained with various industrial associations and professional societies in an attempt to standardize instruments and critical components. In addition, interchange of information is provided under the Technical Cooperation Program between the United States, Canada, and the United Kingdom. These activities furnish data on supply requirements, manufacture, production, current developments and improvements, new discoveries, and standardization of radiation instruments.

In 1951, a cooperative agreement was initiated with the National Bureau of Standards for the testing and evaluation of radiation instruments of interest to AEC. This includes calibration, spectral dependency, temperature, humidity, shock and vibration effects, and other characteristics as required. The instruments already tested include types fabricated within the AEC and samples of new radiation instruments purchased from private industry. The results of these tests are given in detail in reports prepared by the National Bureau of Standards for the AEC. This information and other pertinent data are distributed to AEC installations and contractors.

The growth of a substantial industry in radiation instruments has resulted from expansion of the atomic energy program, widespread use of radioactive materials, and needs for such measuring equipment by military and civil defense groups. In 1952 a study was undertaken to evaluate the relationship of the radiation instrument industry to the atomic energy program. The information obtained was of value in reviewing the effectiveness of AEC's policy of reliance on commercial sources for instruments, and in ascertaining that the AEC was making maximum use of the increased potential of this new industry. Since the radiation instrument industry represented one of the first areas of the atomic energy program in which private industry had made a substantial investment, the results presented significant data of use in the industrial participation program.

The study consisted of a survey of the radiation instrument industry, and an internal survey of the AEC program. Results of this study in 1952 showed that there were some 75 radiation instrument companies employing about 2,500 people and grossing an estimated $20 million annually. During the last half of 1946 employment in this industry amounted to only between 175 and 200 employees.

The status of the present market indicates that the radiation instrument industry provides still greater opportunities for expansion. The current trend in reducing Government expenditures in this field continued to be offset by growing demands by those utilizing radioisotopes outside AEC. Accordingly, many industrial companies are expanding their efforts and diversifying their products to meet the requirements for instruments and component parts in this field.

Recently an accounting study was completed of AEC costs and investment in radiation instrumentation. This study revealed that during fiscal year 1953, AEC incurred costs for radiation instruments totaled nearly $10 million. Inventory of radiation instruments represented an investment of approximately $13 million. Expenditures on costs and investment were incurred as follows:

Fabrication of instruments by AEC and/or contractors.	6 percent.
Purchases from commercial sources	28 percent.
Repairs and maintenance of instruments	22 percent.
Research and development	44 percent.

It is of interest to note that purchases from commercial sources were nearly five times the amount spent on the fabrication of instruments within AEC. The kinds and types of instruments that are being used in the atomic energy program were fully described in the Eighth Semiannual Report (pp. 138–139).

Current Research

Past experience with centralized research and procurement of completed radiation instruments proved unsatisfactory because of the varied and unique instrument requirements of industrial AEC sites. However, the development of certain critical components common to many different types of instruments can and is being accomplished satisfactorily on a centralized basis. The best example of this is the research program for improving and developing special electron tubes and scintillation crystals, both items being essential to the improvement of scintillation counters.

There is considerable interest in using the scintillation method for measuring nuclear radiations—one of the oldest methods of measuring radioactivity used as early as 1900. In this method a radiation quantum or particle causes certain types of crystals to emit light, which is converted to an electrical pulse by a sensitive photoelectric tube known as a photomultiplier. The pulse delivered by the photomultiplier tube is under certain conditions related to the radiant energy. With the growing interest in high energy particles, larger crystals are required to capture the energy of the particles. In recent experiments use was made of plastic scintillating materials or larger volumes of scintillating liquids. In order to capture the maximum amount of the light produced in these large scintillators, photomultiplier tubes that have larger detecting surfaces and more sensitive electrical characteristics need to be developed and produced. Since no special facilities are available for this work within the AEC, contracts were initiated with the Radio Corporation of America and A. B. DuMont Laboratories to develop and produce these tubes. The largest and most sensitive photomultipliers in existence were developed and manufactured under these contracts.

The work for specialized electron tube development continued to be reviewed periodically by a steering committee composed of representatives of various laboratory instrument groups. The committee coordinates and guides this developmental work toward current and future needs of the AEC program. This approach to the problem not only expedited the development of photomultiplier tubes, but effected certain savings, since the overall needs of various AEC sites could be treated as a single problem.

Radiation Telemetering

In recent years, research instrumentation has also been important in applications of test monitoring equipment for the detection of radioactivity which may result from atomic detonations. One of the major developments in this field was the completion of a radiological telemetering system successfully used in recent test experiments at Nevada.

The radiation telemetering system (a method of transmitting information by a remote control radio-frequency link) was developed through the joint efforts of the National Bureau of Standards, the Motorola Corporation, and the AEC. It was designed specifically for the monitoring of airborne radioactivity and meteorological data during the weapons test operations.

The measurement of radioactive fall-out from test detonations, an intricate and critical function, is expensive in terms of manpower and equipment. Highly trained personnel are required and the workload often is far in excess of available personnel. Radiation monitoring equipment also presents problems of handling and transportation. In recognition of this problem, efforts were directed to design suitable equipment and techniques to relieve some of the burdens imposed by test operations. The feasibility of adapting telemetry techniques and equipment appeared to offer some immediate advantages. A prototype system was developed and tested with favorable results at the Nevada Proving Ground during atomic detonations. The telemetering system employs a radio-frequency link making possible the transmission of information signals specifically for recording radiological and meteorological conditions. Basically, however, the system is capable of transmitting signals from a wider range of measurable phenomena.

During test operations at Nevada, three data stations to monitor fall-out activity were located in an area 10–20 miles downwind of the target area. As the data were transmitted the remotely controlled instruments at the stations telemetered the information by radio to a central control point. As a result where fall-out occurred in the vicinity of three experimental stations, accurate weather and fall-out data were reported in advance of reports received from mobile monitoring teams. Although the use of high frequencies required a line-of-sight from station to station, excellent reception was routinely obtained up to 25 miles from the control point, and under an experimental test transmission was recorded over a radio linkage totaling 90 miles.

Despite the line-of-sight limitation, however, relatively standard radio relay techniques will permit extended coverage of the entire area significant to the monitoring program. In the Nevada field tests of the prototype system, the three model data stations were controlled through a single repeater station at an elevation of 5,800 feet providing coverage to only a single quadrant in ranges of 10 to 20 miles relative to the target area. While only three stations have been employed in the experiment to date, multiplication of this number by a factor of three, or thirty, or a hundred is feasible. By the use of the appropriate relays, it would be possible to cover zones of 200 to 500 miles quite as effectively as the present high-cost multiple-manpower mobile teams.

The field testing program demonstrated the potential accuracy and

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dependability of the telemetering system for covering a wide range of measurable phenomena. Also, its use will enable the partial replacement of large participating groups and equipment normally required for test activities, reducing logistic support and manpower requirements. Further research to modify and improve the system is underway. Its adaption is envisioned for use at contractor or AEC installations where there are similar problems of detecting and measuring radioactive phenomena at remote and widespread locations.

Organization and Personnel

Review and Assistance Program

A series of studies of the organization and personnel functions in the Commission's operations offices was completed. The studies involved examination and analyses of the functions, organization structure, operations, and staffing established by each office to carry out its responsibility, with respect to contractor personnel operations, Federal personnel administration, and organization and methods work. Principal task of the review staff was an evaluation of program results rather than a mere enforcement of regulatory or procedural compliance. Special assistance, when requested or indicated by the review, was given to managers of operations offices and their organization and personnel staff in order to maintain a more effective program. In addition to studying and reporting on the qualitative aspects of organization and personnel functions at the various AEC offices, an analysis of total survey findings identified problem areas for possible policy and procedural development and standardization.

Management Improvement Program

This year AEC's management improvement program was guided by a steering committee of division directors or their assistants. A departure from usual practice, the committee type of operation provides a broad perspective for coordinated review of Commission management problems. It fixes responsibility for management improvement projects and facilitates coordination of the studies and action carried out under the General Manager's directives. The committee studies AEC problems of administrative and program management rather than substantive program policy, reports on management accomplishments, and determines future problem areas for investigation and analysis.

Atomic Energy Labor-Management Relations Panel

The Atomic Energy Labor-Management Relations Panel was established by the President on March 24, 1953. Its members are Cyrus S. Ching, industrial consultant, and former director, Federal Mediation and Conciliation Service, chairman; members, Thomas W. Holland, industrial consultant, and former professor of economics, University of Miami; the Rev. Leo C. Brown, director, Institute of Social Sciences, St. Louis University; Arthur M. Ross, professor of industrial relations at the University of California, Berkeley, Calif.; and O. S. Colclough, dean of faculties, George Washington University, Washington, D. C.

Eight cases were referred to the panel by the Director of the Federal Mediation and Conciliation Service during the period January through June 1954, bringing to ten the total of referrals since its establishment. These were:

1. The Peter Kiewit Sons' Co., prime construction contractor at the Pike County, Ohio, project, in dispute with the Office Employees International Union, AFL.
2. The Hanford Contractors Negotiating Committee, on behalf of construction contractors and subcontractors at the Hanford, Wash., project, in dispute with the United Brotherhood of Carpenters and Joiners of America, AFL.
3. The Kaighan and Hughes Co., mechanical subcontractor to the Maxon Construction Co. at Oak Ridge, Tenn., in dispute with the Sheet Metal Workers International Association, AFL.
4. The Carbide and Carbon Chemicals Co., operations contractor at Oak Ridge, Tenn., in separate disputes with three craft groups within the Atomic Trades and Labor Council with which Carbide bargains.
5. The Carbide and Carbon Chemicals Co., in dispute with the Atomic Trades and Labor Council, AFL, at Oak Ridge, and the United Gas, Coke and Chemical Workers, CIO, at both Oak Ridge and Paducah, Ky.
6. The American Car and Foundry Co., in dispute with the International Association of Machinists, AFL, at Albuquerque, N. Mex., growing out of negotiations on an initial bargaining agreement.
7. The Peter Kiewit Sons' Co., in dispute with United Brotherhood of Carpenters and Joiners, AFL, at Portsmouth, Ohio.
8. The Peter Kiewit Sons' Co., in dispute with the Operative Plasterers and Cement Masons International Association, AFL.

In the first three of the above cases, the panel issued substantive recommendations, which were accepted by the parties as the basis for agreement. In the issues in dispute between Carbide and Carbon

Chemicals Co. and the three craft groups, the panel did not recognize one, a jurisdictional issue, and dismissed the other two which were grievances. In the disputes between Carbide and the AFL Council at Oak Ridge and between Carbide and the CIO-represented employees at Oak Ridge and Paducah the union members rejected the panel's recommendations. In addition, the employees represented by the Chemical Workers Union, CIO, authorized their officials to call a strike, if acceptable agreements could not be negotiated. The dispute between American Car and Foundry Co. and the AFL Machinists had not been heard by the panel as of June 30, 1954.

The dispute between Kiewit and the carpenters was settled by the parties themselves in a meeting prior to scheduled panel hearings. Kiewit and the cement finishers, represented by the operative plasterers and cement masons union, presented arguments to the panel in their dispute but the panel had not taken action in formal recommendations by the end of June.

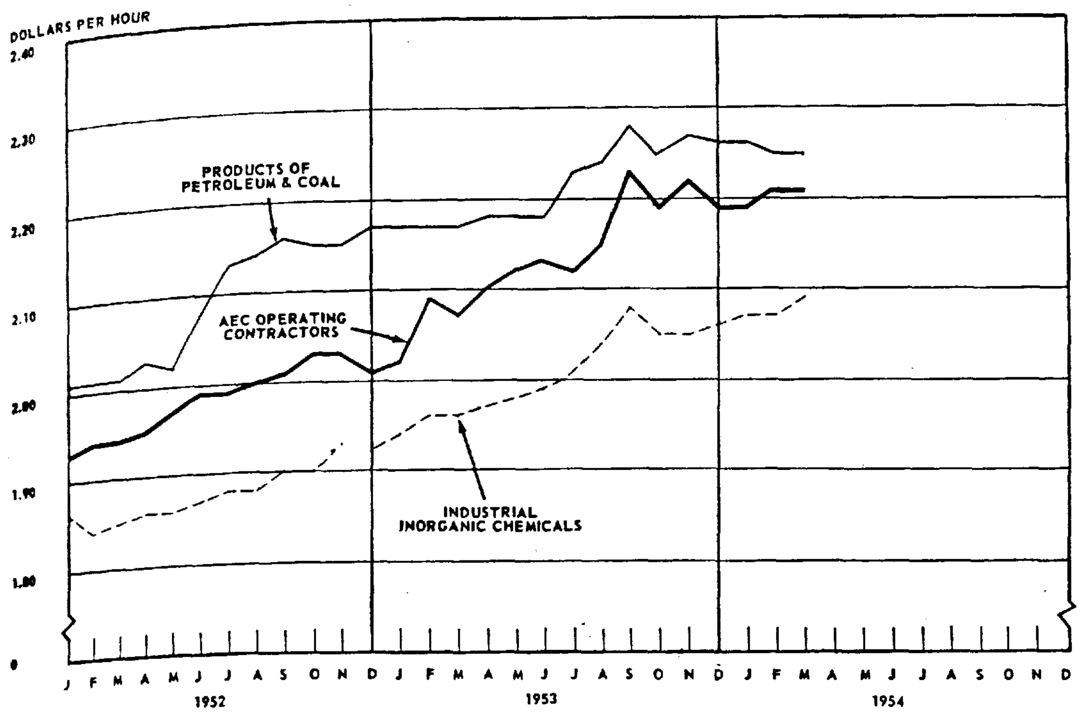
Labor Disputes

Work continuity throughout the atomic energy program continued at an exceptionally high level during the 7 months ending May 1954. There were no work stoppages in operations, research and development and maintenance activities. Construction and design were free of work stoppages 97.9 percent of the scheduled time. The Savannah River project established an AEC record for major construction by working a full year (over 40 million man-hours) without a stoppage. The Paducah project lost only 900 of a scheduled 10 million working hours during the past 7 months. Sheetmetal workers at Oak Ridge, in a dispute over travel pay allowance, accounted for the major time lost during this period. Other significant stoppages involved carpenters at Hanford and laborers at Portsmouth and Oak Ridge.

Hours and Earnings

Gross earnings (including overtime and other premium pay) of atomic energy production and maintenance workers averaged $2.21 per hour in March 1954, the latest month for which data are available. Earnings of these workers decreased during the 6-month period ending in March, due to a decrease in average hours worked. However, they continued during the period to fall in a position between earnings of workers in the petroleum and coal products and the industrial inorganic chemicals industries—industries most nearly comparable in process and equipment.

GROSS AVERAGE HOURLY EARNINGS



Reduction of Extended Workweeks

Progress in construction of facilities at the Savannah River project made possible a reduction in the workweek from 45 to 40 hours in March 1954. Similar progress at the Paducah, Ky. project permitted construction contractors to reduce the workweek from 45 to 40 hours in May 1954. With the elimination of extended workweeks at these locations, the Portsmouth, Ohio, and Oak Ridge, Tenn., projects are the only major AEC construction activities working in excess of 40 hours weekly. At Portsmouth, a 45-hour week is in effect, while at Oak Ridge, part of the construction force works a 48-hour week and part an alternate 40–48 hour week.

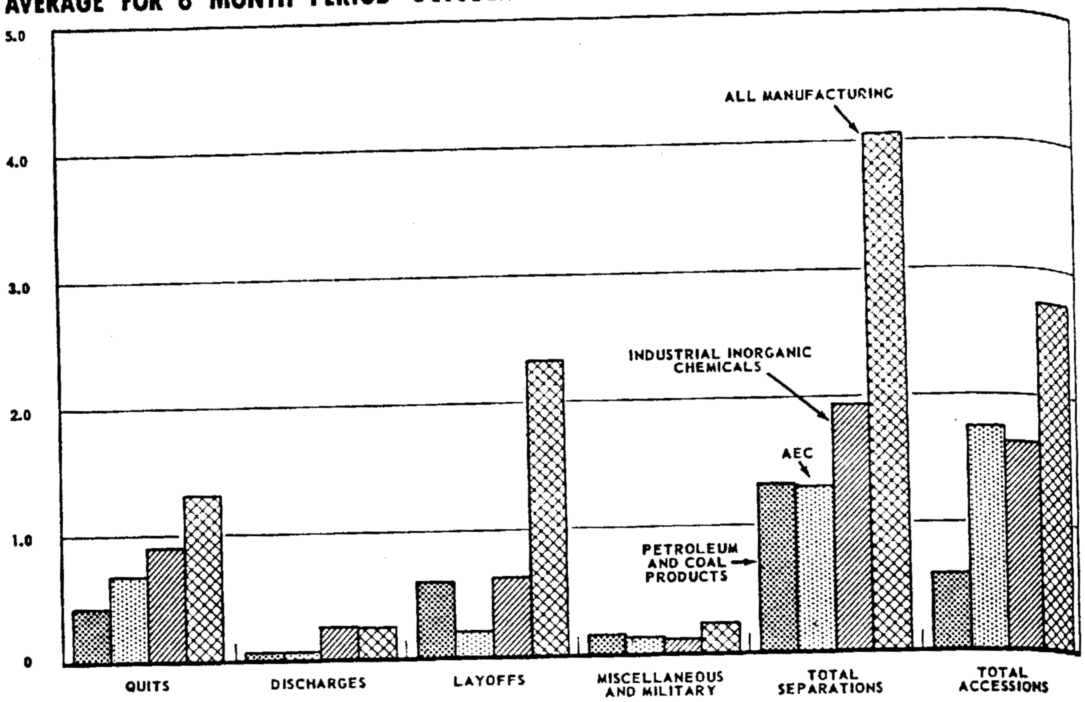
Labor Turnover

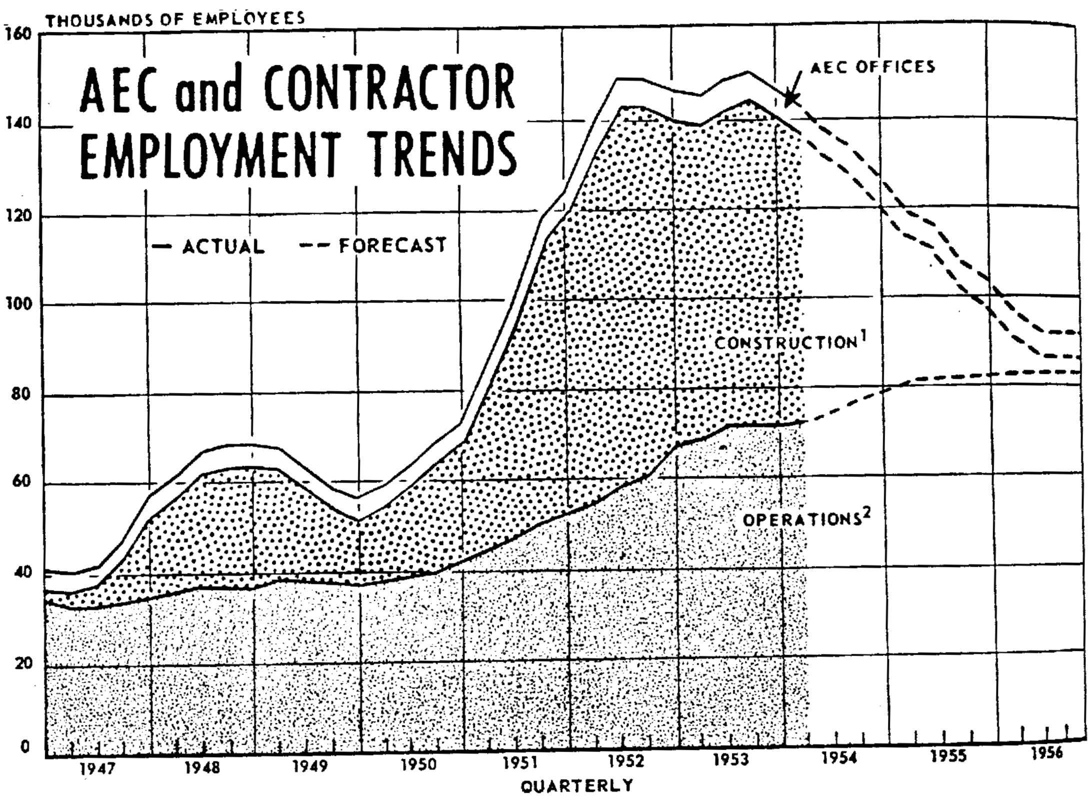
The chart on page 76 compares monthly turnover rates per 100 employees in atomic energy contractor operations (excluding construction contractors) with those of related industries during the 6-month period ending in March 1954.

Turnover rates of AEC operations contractors are comparable to or fall between those of the industrial inorganic chemicals and petroleum and coal products industries. Compared with the previous 6-month period more recent experience reveals a trend toward a more stable work force.

LABOR TURNOVER RATES (PER 100 EMPLOYEES)

AVERAGE FOR 6 MONTH PERIOD OCTOBER 1953 - MARCH 1954





[1] Includes Architect-Engineering.

[2] Includes Production, Research and Development, and Services.

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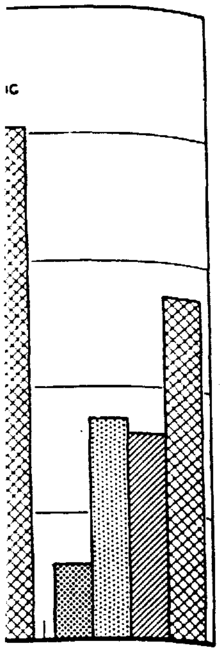

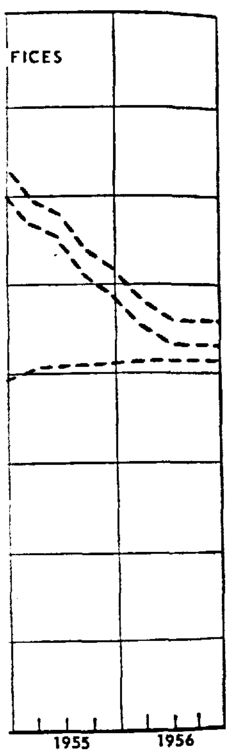

elopment, and Services.

AEC and Contractor Employment Trends

Employment by AEC and its contractors totaled 142,601 in March 1954. Of this total, 6,258 were AEC employees and 136,343 contractor employees—64,027 in construction and design, and 72,316 in operations. This represents a decline of 9,094 from the peak of 151,695 reached last August. Although there was a gain of 650 operating employees during this period, AEC employment declined about 350, and construction and design employment declined 9,400. As currently forecasted, operating employment will increase at the rate of 750 per month during the ensuing 12 months and slower thereafter until it levels off at about 82,000 in mid 1956. Conversely, forecasts of construction and design employment indicate a decrease of about 2,000 per month until mid-1956. (See chart on p. 76.)

Scientific and Engineering Employment Trends

Scientific and engineering staffs of the AEC and its operating contractors totaled 13,612 in March 1954, and were made up of the following occupational categories:

Biological and medical scientists	1,617
Chemists	2,411
Physicists	1,708
Other physical scientists	738
Chemical engineers	1,634
Electrical engineers	1,346
Mechanical engineers	1,843
Metallurgical engineers	408
Other engineers	1,907
TOTAL	13,612

The total represented an increase of less than 1 percent during the past 12 months. Unfilled vacancies in contractor scientific and engineering staffs totaled 533 as of March 1954.

Safety

The AEC accident-prevention program continues to compare favorably with similar programs in private industry. A rising trend in the frequency of injuries per million man-hours in the latter part of calendar year 1953—from 2.6 in August to 2.89 in December—was corrected and a frequency of 2.62 experienced for the period January–April 1954. However, such a slight rise in frequency may be expected as construction is completed and new types of facilities are started up. Accordingly, vigorous preventive action was taken during the past 6 months to minimize this tendency, and specific safety measures will be stressed in the field inspection program. The annual conference of AEC and contractor safety and fire protection personnel, held in Oak Ridge, Tenn., May 13–14, considered technical aspects of accident prevention and the importance of preevaluating risks.

Fire Protection

During 1953, AEC-owned industrial, construction and research facilities suffered $148,142 loss from 940 fires. This compares with $449,107 damage in 1952. The rate of annual fire loss during 1953 was 3½ mills per $100 of AEC-owned property, roughly one-eighth the loss rate of insurance companies handling "preferred" industrial fire risks. Fire loss during the first part of 1954 did not exceed damage experienced in 1953 and the loss rate remains comparatively low.

Despite increasingly high costs for firefighting services on construction activities, AEC recurring fire department expenditures were reduced by 25 percent during 1953.

The towns of Los Alamos and Oak Ridge experienced the lowest and the second lowest fire losses in their respective histories during 1953. However, a heavy loss from one fire brought Richland, and the record for all AEC operated communities, above the comparable national average for municipalities.

APPENDIX 1

Organization and Principal Staff of U. S. Atomic Energy Commission

Atomic Energy Commission	Lewis L. Strauss, *Chairman.*
	Joseph Campbell.
	Thomas E. Murray.
	H. D. Smyth.
	(Vacancy.)[1]
Assistant to the Chairman	John MacKenzie, Jr.
Assistant to the Chairman	David Teeple.
Special Assistant to the Chairman	McKay Donkin.
General Manager	Kenneth D. Nichols.
Special Assistant to General Manager	Edward R. Trapnell.
Special Assistant to General Manager	H. S. Traynor.
Special Assistant to General Manager	P. F. Foster.
Assistant General Manager for Administration	James L. Kelehan.
Assistant General Manager for Manufacturing	R. W. Cook.
Assistant General Manager for Research and Industrial Development	Alfonso Tammaro.
Controller	Don S. Burrows.
General Counsel	William Mitchell.
Secretary to Commission	Roy B. Snapp.
Director, Office of Classification	James G. Beckerley.
Director, Office of Intelligence	(Vacancy.)
Chief, Office of Operations Analysis	David P. Herron.
Director, Office of Special Projects	John A. Hall.
Director, Division of Biology and Medicine	Dr. John C. Bugher.
Director, Division of Engineering	Lawrence R. Hafstad, *Acting.*
Director, Division of Military Application	Brig. Gen. K. E. Fields.
Director, Division of Production	E. J. Bloch.
Director, Division of Raw Materials	Jesse C. Johnson.
Director, Division of Reactor Development	Lawrence R. Hafstad.
Director, Division of Research	Thomas H. Johnson.

[1] Eugene M. Zuckert signs this report since it covers a period of his incumbency which was concluded on June 30, 1954.

Director, Division of Construction and Supply	JOHN A. DERRY.
Director, Division of Information Services	MORSE SALISBURY.
Director, Division of Organization and Personnel	OSCAR S. SMITH.
Director, Division of Security	JOHN A. WATERS, Jr.
Managers of Operations Offices and Areas:	
Chicago (Ill.) Operations Office	JOHN J. FLAHERTY.
Ames (Iowa) Area	W. W. LORD.
Lockland (Ohio) Area	E. M. VELTEN.
Pittsburgh (Pa.) Area	LAWTON D. GEIGER.
Grand Junction (Colo.) Operations Office	SHELDON P. WIMPFEN.
Hanford (Wash.) Operations Office	DAVID F. SHAW.
Idaho (Idaho Falls) Operations Office	ALLAN C. JOHNSON.
New York (N. Y.) Operations Office	MERRIL EISENBUD.
Brookhaven (Long Island, N. Y.) Area	E. L. VAN HORN.
Oak Ridge (Tenn.) Operations Office	S. R. SAPIRIE.
Cleveland (Ohio) Area	BUFORD SPARKS.
Dayton (Miamisburg, Ohio) Area	JOHN H. ROBERSON.
Fernald (Cincinnati, Ohio) Area	C. L. KARL.
New Brunswick (N. J.) Area	C. J. RODDEN.
Paducah (Ky.) Area	FRED BELCHER.
Portsmouth (Ohio) Area	KENNETH A. DUNBAR.
St. Louis (Mo.) Area	J. PERRY MORGAN.
San Francisco (Calif.) Operations Office	H. A. FIDLER.
Santa Fe (Albuquerque, N. Mex.) Operations Office	DONALD J. LEEHEY.
Eniwetok (Albuquerque, N. Mex.) Field Office	PAUL W. SPAIN.
Kansas City (Mo.) Field Office	JAMES C. STOWERS.
Las Vegas (Nev.) Field Office	SETH R. WOODRUFF, Jr.
Los Alamos (N. Mex.) Field Office	FRANK C. DILUZIO.
Rocky Flats (Colo.) Field Office	GILBERT C. HOOVER.
Savannah River (Augusta, Ga.) Operations	CURTIS A. NELSON.
Dana (Terre Haute, Ind.) Area	CHARLES W. REILLY.
Wilmington (Del.) Area	S. D. CHITTENDEN, *Acting.*
Schenectady (N. Y.) Operations Office	JON D. ANDERSON.

APPENDIX 2

MEMBERSHIP OF COMMITTEES

STATUTORY COMMITTEES

Joint Committee on Atomic Energy—Eighty-third Congress

This committee was established by the Atomic Energy Act of 1946 (sec. 15) 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.

Representative W. STERLING COLE (New York), *chairman.*
Senator BOURKE B. HICKENLOOPER (Iowa).
Senator EUGENE D. MILLIKIN (Colorado).
Senator WILLIAM F. KNOWLAND (California).
Senator JOHN W. BRICKER (Ohio).
Senator GUY R. CORDON (Oregon).
Senator RICHARD B. RUSSELL (Georgia).
Senator EDWIN C. JOHNSON (Colorado).
Senator CLINTON P. ANDERSON (New Mexico).
Senator JOHN O. PASTORE (Rhode Island).
Representative CARL HINSHAW (California).
Representative JAMES E. VAN ZANDT (Pennsylvania).
Representative JAMES T. PATTERSON (Connecticut).
Representative THOMAS A. JENKINS (Ohio).
Representative CARL T. DURHAM (North Carolina).
Representative CHET HOLIFIELD (California).
Representative MELVIN PRICE (Illinois).
Representative PAUL J. KILDAY (Texas).
CORBIN ALLARDICE, *executive director.*

Military Liaison Committee

Under sec. 2 (c) of the Atomic Energy Act of 1946, as amended, "there shall be a Military Liaison Committee consisting of a chairman, who shall be the head thereof, and of a representative or representatives of the Departments of the Army, Navy, and Air Force, detailed or assigned thereto, without additional compensation, in such number as the Secretary of Defense may determine. Representatives from each of the three Departments shall be designated by the respective Secretaries of the Army, Navy, and Air Force. The committee chairman shall be appointed by the President, by and with the advice and consent of the Senate, and shall receive compensation at a rate prescribed by law for the Chairman of the Munitions Board. The Commission shall advise and consult with the committee on all atomic energy matters which the committee deems to relate to military applications, including the development, manufacture, use and storage of bombs, the allocation of fissionable material for military research, and the control of information relating to the manufacture or utilization of atomic weapons. The Commission shall keep the committee fully informed of all such matters before it and the committee shall keep the Commission fully informed of all atomic energy activities of the Department of Defense. The committee shall have authority to make written recommendations to the Commission on matters relating to military applications from time to time as it may deem appropriate. If the committee at any time concludes that any action, proposed action, or failure to act of the Commission on such matters is adverse to the responsibilities of the Department of Defense, derived from the Constitution, laws, and treaties, the committee may refer such action, proposed action, or failure to act to the Secretary of Defense. If the Secretary concurs, he may refer the matter to the President, whose decision shall be final."

HON. ROBERT F. LEBARON, *Chairman.*
Brig. Gen. KENNER F. HERTFORD, United States Army.
Brig. Gen. HARRY MCK. ROPER, United States Army.
Rear Adm. GEORGE C. WRIGHT, United States Navy.
Capt. PAUL H. RAMSEY, United States Navy.
Maj. Gen. HERBERT B. THATCHER, United States Air Force.
Maj. Gen. HOWARD G. BUNKER, United States Air Force.

General Advisory Committee

This committee was established by the Atomic Energy Act of 1946 (sec. 2 (b)). 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; the committee held its first meeting in January 1947, and to date has averaged six meetings a year.

Dr. I. I. RABI, chairman; professor of physics, Columbia University, New York, N. Y.
Dr. OLIVER E. BUCKLEY, former chairman, Bell Telephone Laboratories, New York, N. Y.
Dr. J. B. FISK, director of research—physical sciences, Bell Telephone Laboratories, Murray Hill, N. Y.
Dr. W. F. LIBBY, professor of chemistry, University of Chicago, Chicago, Ill.
EGER V. MURPHREE, president, Standard Oil Development Co., New York, N. Y.
Dr. JOHN VON NEUMANN, professor, school of mathematics, Institute for Advanced Studies, Princeton, N. J.
Dr. J. C. WARNER, president, Carnegie Institute of Technology, Pittsburgh, Pa.
WALTER G. WHITMAN, head, department of chemical engineering, Massachusetts Institute of Technology, Cambridge, Mass.
Dr. EUGENE P. WIGNER, professor of physics, Princeton University, Princeton, N. J.
Dr. RICHARD W. DODSON, secretary; chairman, department of chemistry, Brookhaven National Laboratory, Upton, Long Island, N. Y.

PATENT COMPENSATION BOARD

This board was established in April 1949 pursuant to section 11 of the Atomic Energy Act of 1946, which 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. To date the board has held 11 sessions; 17

cases have been filed, of which 10 have been finally determined by the board; 2 claims have been awarded and 1 claim has been withdrawn.

CASPER W. OOMS, chairman; firm of Casper W. Ooms, Chicago, Ill.
ISAAC HARTER, of Babcock & Wilcox Tube Co., Beaver Falls, Pa.
JOHN V. L. HOGAN, consulting engineer, Hogan Laboratories, Inc., New York, N. Y.

COMMITTEE OF SENIOR REVIEWERS

The Committee of Senior Reviewers studies the major technical activities of the Atomic Energy Commission program and advises the Commission on classification and declassification matters, making recommendations with respect to the rules and guides for the control of scientific and technical information. The committee consists of six members. At the present time there are only five members, the vacancy being created by the resignation of Dr. R. H. Crist. The committee members are appointed for a term of 5 years on a rotating basis.

Dr. WARREN C. JOHNSON, chairman; associate dean of physical sciences, University of Chicago, Chicago, Ill.
Dr. THOMAS B. DREW, head, department of chemical engineering, Columbia University, New York, N. Y.
Dr. ALVIN C. GRAVES, J division leader, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.
Dr. JOHN P. HOWE, section chief, reactor materials, North American Aviation, Inc., Downey, Calif.
Dr. J. R. RICHARDSON, associate professor of physics, University of California, Los Angeles, Calif.

ADVISORY BODIES TO THE ATOMIC ENERGY COMMISSION

Advisory Committee on Biology and Medicine

The Advisory Committee on Biology and Medicine was created in September 1947, on the recommendation of the Commission's Medical Board of Review. The committee reviews the AEC programs in medical and biological research and health and recommends to the Commission general policies in these fields.

Dr. CHARLES H. BURNETT, professor of medicine, University of North Carolina, Chapel Hill, N. C.
Dr. SIMEON T. CANTRIL, director, Tumor Institute of Swedish Hospital, Seattle, Wash.
Dr. EDWARD A. DOISY, director, department of biochemistry, St. Louis University School of Medicine, St. Louis, Mo.
Dr. GIOACCHINO FAILLA, director, department of radiology, Columbia University Medical School, New York, N. Y.
Dr. CURT STERN, professor of zoology, University of California, Berkeley, Calif.
Dr. SHIELDS WARREN, vice chairman; pathologist, New England Deaconess Hospital, Boston, Mass.

Advisory Board of Contract Appeals

This board was established in February 1950. One or more of its members hears contract appeals arising under the "disputes articles" of AEC contracts and subcontracts and makes recommendations to the General Manager concerning their disposition.

HENRY P. BRANDIS, Jr., dean of the law school, University of North Carolina, Chapel Hill, N. C.
SHELDON D. ELLIOTT, director of institute for judicial administration, New York University, New York, N. Y.
ROBERT KINGSLEY, dean, school of law, University of Southern California, Los Angeles, Calif.
EDMUND R. PURVES, executive director, American Institute of Architects, Washington, D. C.
HERBERT F. TAGGART, dean, school of business administration, University of Michigan, Ann Arbor, Mich.

Advisory Committee on Brazing

This committee was formed at AEC request by the Welding Research Council of the Engineering Foundation to serve in an advisory capacity on problems involving fabrication by brazing.

F. W. Davis, chairman; engineering division, AEC, Washington, D. C.
CHARLES D. COXE, assistant manager, metallurgical department, Handy and Harman, Bridgeport, Conn.
A. E. FOCKE, manager, materials development, Aircraft Nuclear Propulsion Project, General Electric, Cincinnati, Ohio.
FRANK G. HARKINS, chief welding engineer, Solar Aircraft Co., San Diego, Calif.
LT. T. HIKIDO, Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio.
G. O. HOGLUND, welding engineer, process and development laboratories, Aluminum Company of America, New Kensington, Pa.
T. E. KIHLGREN, welding section, research laboratory, International Nickel Co., Bayonne, N. J.
A. R. LYTLE, director of research, Union Carbide & Carbon Research Laboratories, New York, N. Y.
W. D. MANLY, head metallurgist, ANP division, ORNL, Oak Ridge, Tenn.
ROBERT L. PEASLEE, development engineer, Wall Colmonoy Corp., Detroit, Mich.
W. SPRARAGEN, secretary; director, Welding Research Council, New York, N. Y.
LYALL ZICKRICK, head, materials engineering unit, Knolls Atomic Power Laboratory, Schenectady, N. Y.

Advisory Committee on Chemistry

This committee was appointed in June 1949 to advise on policy concerning the AEC program of supporting basic unclassified chemistry research in universities, and the relationship of this program to the AEC's own chemistry research program. Most of the work of the committee is accomplished by individual consultation as specific problems arise.

Dr. FARRINGTON DANIELS, professor of chemistry, University of Wisconsin, Madison, Wis.
Dr. G. B. KISTIAKOWSKY, professor of chemistry, Harvard University, Cambridge, Mass.

Dr. JOSEPH E. MAYER, professor of chemistry, University of Chicago, Chicago, Ill.
Dr. DON M. YOST, professor of chemistry, California Institute of Technology, Pasadena, Calif.

Advisory Committee on Industrial Information

This committee was reconstituted and expanded in April 1952 to replace an ad hoc committee appointed in 1949 to advise the AEC on disseminating unclassified technological information to industry. The members are visiting AEC sites to identify information of use to industry which should be submitted for declassification and recommending arrangements for the widest possible publication and distribution of such declassifiable information.

SIDNEY D. KIRKPATRICK, chairman; vice president and director of editorial development, McGraw-Hill Book Co., Inc., New York, N. Y.
Dr. ALLAN G. GRAY, editor, Steel, Penton Publishing Co., Cleveland, Ohio.
EUGENE HARDY, National Association of Manufacturers, Washington, D. C.
KEITH HENNEY, editor, Nucleonics and Electronics, McGraw-Hill Publishing Co., Inc.; American Institute of Radio Engineers, New York, N. Y.
Dr. ELMER HUTCHISSON, editor, Journal of Applied Physics, American Institute of Physics, New York, N. Y.
NORMAN H. JACOBSON, editor, market issue, Electric Light and Power, Haywood Publishing Co., New York, N. Y.
WALTER E. JESSUP, editor, Civil Engineering, The American Society of Civil Engineers, New York, N. Y.
ANDREW W. KRAMER, editor, Power Engineering, The Technical Publishing Co., Chicago, Ill.
EVERETT S. LEE, American Institute of Electrical Engineers, New York, N. Y.
Dr. WALTER J. MURPHY, editor, Chemical and Engineering News, American Chemical Society, Washington, D. C.
FREDERICK A. PAWLEY, research secretary, American Institute of Architects, Washington, D. C.
EDWARD H. ROBIE, secretary, American Institute of Mining and Metallurgical Engineers, New York, N. Y.
KARL T. SCHWARTZWALDER, The American Ceramic Society, Inc., Columbus, Ohio.
GEORGE F. SULLIVAN, managing editor, The Iron Age, Chilton Publications, Inc., New York, N. Y.
E. E. THUM, editor, Metal Progress, American Society for Metals, Cleveland, Ohio.
OLIVER H. TOWNSEND, secretary, Atomic Industrial Forum, Inc., New York, N. Y.
S. A. TUCKER, publications manager, American Society of Mechanical Engineers, New York, N. Y.
F. J. VAN ANTWERPEN, editor, Chemical Engineering Progress, American Institute of Chemical Engineers, New York, N. Y.
Dr. ALBERTO F. THOMPSON, secretary; chief, technical information service, division of information services, AEC, Washington, D. C.

Advisory Committee on Isotope Distribution

This committee was originally appointed by the Manhattan District to advise on the off-project distribution of isotopes. The Commission approved its continuation in December 1947 to aid in establishing new policies on distributing radioactive materials and to review existing policies. The committee reviews all initial applications for use of radioisotopes in human beings, and all other requests for their use in research, education, and industry which are referred to it by the Commission.

Dr. DONALD E. HULL, chairman; research chemist, process division, California Research Corp., Richmond, Calif.

Dr. RICHARD CHAMBERLAIN, University of Pennsylvania Medical School, Philadelphia, Pa.

Dr. JOHN E. CHRISTIAN, associate professor, department of pharmaceutical chemistry, Purdue University, Lafayette, Ind.

Dr. SAMUEL E. EATON, A. D. Little, Inc., Cambridge, Mass.

Dr. STERLING B. HENDRICKS, head chemist, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture, Beltsville, Md.

Dr. LEON O. JACOBSON, associate dean, division of biological sciences, University of Chicago, Chicago, Ill.

Dr. EDITH H. QUIMBY, associate professor of radiology, College of Physicians and Surgeons, Columbia University, New York, N. Y.

Dr. HOWARD E. SKIPPER, associate director, Southern Research Institute, Birmingham, Ala.

Dr. JOHN E. WILLARD, professor of chemistry, University of Wisconsin, Madison Wis.

Dr. PAUL C. AEBERSOLD, secretary; chief, isotopes division, AEC, Oak Ridge, Tenn.

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, in its monthly meetings, 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; of Purcell & Nelson, Washington, D. C.

Dr. PAUL E. KLOPSTEG, associate director, National Science Foundation, Washington, D. C.

WILLIAM E. LEAHY, president, Columbus University, Washington, D. C.

AEC Computer Council

This group is appointed on a yearly basis to make a continuing review of the AEC computing requirements and facilities and to recommend the most advantageous apportionment of computer time on the AEC Computer at New York University. The following members were appointed to serve from July 1953 to July 1954.

Dr. EDWARD TELLER, chairman; professor of physics, University of California, Berkeley, Calif.

Dr. ELEAZER BROMBERG, institute for mathematics and mechanics, New York University, New York, N. Y.

Dr. RICHARD COURANT, institute for mathematics and mechanics, New York University, New York, N. Y.

Dr. ALSTON S. HOUSEHOLDER, mathematics panel, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. HENRY HURWITZ, Jr., theoretical physics division, Knolls Atomic Power Laboratory, Schenectady, N. Y.

Dr. GEORGE A. KOLSTAD, vice chairman; physics branch, division of research, AEC, Washington, D. C.

Dr. SIDNEY KRASIK, physics division, Westinghouse Atomic Power Division, Pittsburgh, Pa.

Dr. V. LAWRENCE PARSEGIAN, division of technical advisors, AEC, New York, N. Y.

Dr. ROBERT D. RICHTMYER, secretary; theoretical division, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. BERNARD SPINRAD, physics division, Argonne National Laboratory, Chicago, Ill.

Dr. IRA F. ZARTMAN, division of engineering, AEC, Washington, D. C.

Advisory Committee on Reactor Safeguards

The committee, formed in 1953 from the former Reactor Safeguard Committee and the Industrial Committee on Reactor Location Problems, serves in an advisory capacity to the AEC with regard to the hazards associated with the operation of reactor facilities. The committee reviews safety studies prepared by organizations planning to build or operate reactor facilities and appraises proposed reactor locations in terms of accepted industrial safety standards.

Dr. C. ROGERS MCCULLOUGH, chairman; general development department, Monsanto Chemical Co., St. Louis, Mo.

Dr. MANSON BENEDICT, professor of chemical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. WILLARD P. CONNER, manager, physics division, research department, Hercules Powder Co., Wilmington, Del.

Dr. R. L. DOAN, manager, atomic energy division, Phillips Petroleum Co., Idaho Falls, Idaho.

Dr. HYMER FRIEDELL, director, department of radiology, Lakeside Hospital, Western Reserve University, Cleveland, Ohio.

Dr. I. B. JOHNS, Monsanto Chemical Co., Everett, Mass.

Dr. MARK M. MILLS, radiation laboratory, University of California, Livermore, Calif.

K. R. OSBORN, manager of industrial development, general chemical division, Allied Chemical and Dye Corp., New York, N. Y.

D. A. ROGERS, manager, central engineering, Allied Chemical and Dye Corp., Morristown, N. J.

REUEL C. STRATTON, supervising chemical engineer, engineering and loss control division, the Travelers Insurance Co., Hartford, Conn.

Dr. EDWARD TELLER, professor of physics, University of California, Berkeley, Calif.

Dr. ABEL WOLMAN, head, department of sanitary engineering, Johns Hopkins University, Baltimore, Md.

Dr. HARRY WEXLER, chief, scientific services division, U. S. Weather Bureau, Department of Commerce, Washington, D. C.

Dr. C. R. RUSSELL, secretary; U. S. Atomic Energy Commission, Washington, D. C.

Advisory Committee on Stainless Steel

This committee, formed in 1950, by the Welding Research Council of the Engineering Foundation, in July 1951 at AEC request became advisory to the

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Commission in regard to research and development to improve the welding of type 347 stainless steel. All data resulting from these investigations are being made public. In October 1953 the scope of the Committee's services was enlarged to include the manufacture, fabrication, and use of all stainless steels.

Dr. V. N. Krivobok, chairman; development and research division, International Nickel Co., Inc., New York, N. Y.
W. O. Binder, research laboratory, Union Carbide and Carbon Co., Niagara Falls, N. Y.
F. W. Davis, engineering division, AEC, Washington, D. C.
W. B. DeLong, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
R. B. Gunia, Carnegie Illinois Steel Corp., Pittsburgh, Pa.
Lorin K. Poole, project engineer, Arcos Corp., Philadelphia, Pa.
Dr. M. A. Scheil, director, metallurgical research, A. O. Smith Corp., Milwaukee, Wis.
R. David Thomas, Jr., vice president & director, research & engineering, Arcos Corp., Philadelphia, Pa.

Committee on Raw Materials

This committee was appointed in October 1947 to review the Atomic Energy Commission's raw materials program and to advise on questions of exploration, development, and procurement. The committee has met 13 times since its formation.

Ira B. Joralemon, chairman; geologist, San Francisco, Calif.
Francis Cameron, vice president, St. Joseph Lead Co., New York, N. Y.
Everette L. DeGolyer, petroleum geologist; DeGolyer & McNaughton, Dallas, Tex.
Thorold F. Field, consulting mining engineer, Duluth, Minn.
Francis C. Frary, technical advisor, aluminum research laboratory, Aluminum Company of America, New Kensington, Pa.
J. K. Gustafson, consulting geologist, M. A. Hanna Co., Cleveland, Ohio.
Ernest H. Rose, chemical engineer, Tennessee Coal, Iron & Railroad Co.; Birmingham, Ala.
Walter O. Snelling, director of research and consulting chemist, Trojan Powder Co., Allentown, Pa.
Orvil R. Whitaker, consulting mining engineer, Denver, Colo.
Clyde E. Williams, director, Battelle Memorial Institute, Columbus, Ohio.

Industrial Information Committee

This committee, representing AEC operating divisions and offices of operations and the major contractors, was appointed in 1952 to guide the dissemination of AEC-developed information to industry. Meetings are held twice a year.

Dr. Alberto F. Thompson, chairman: chief, technical information service, division of information services, AEC, Washington, D. C.
H. C. Baldwin, director of information, Chicago Operations Office, AEC, Lemont, Ill.
Brewer F. Boardman, supervisor, technical information service, Phillips Petroleum Co., Idaho Falls, Idaho.

LEONARD M. BRENNER, chief, reports and analysis section, division of military application, AEC, Washington, D. C.

GEORGE L. BROWN, manager of public relations, General Electric Co., Hanford Works, Richland, Wash.

CHARLES W. CAMPBELL, superintendent of development staff services, Sandia Corp., Albuquerque, N. Mex.

DONALD D. COWAN, superintendent of the information and reports division, Oak Ridge National Laboratory, Carbide and Carbon Chemicals Co., Oak Ridge, Tenn.

Dr. F. L. CUTHBERT, technical director, National Lead Co. of Ohio, Cincinnati, Ohio.

H. W. DAVIS, Jr., deputy director, technical and production division, Savannah River Operations Office, AEC, Augusta, Ga.

W. E. DREESZEN, administrative aide to director, Ames Laboratory, Ames, Iowa.

R. G. ELLIOTT, director of information, Santa Fe Operations Office, AEC, Albuquerque, N. Mex.

LESTER C. FURNEY, assistant to director, Argonne National Laboratory, Lemont, Ill.

J. F. HAGGERTY, biochemist, medical branch, division of biology and medicine, AEC, Washington, D. C.

W. L. HARWELL, head, patents and declassification department, Carbide & Carbon Chemicals Co., division of Union Carbide & Carbon Corp., Oak Ridge, Tenn.

F. SEYMOUR HENCK, assistant to manager for public education, Oak Ridge Operations Office, AEC, Oak Ridge, Tenn.

EDWARD L. HILL, supervisor, technical services unit, General Electric ANP project, Cincinnati, Ohio.

T. O. JONES, assistant to deputy director, division of production, AEC, Washington, D. C.

DAVID P. KUNTZ, organization and methods examiner, division of raw materials, AEC, Washington, D. C.

ARTHUR R. LEE, division of information, Idaho Operations Office, AEC, Idaho Falls, Idaho.

FRANK R. LONG, supervisor, technical information group, atomic energy research department, North American Aviation, Inc., Downey, Calif.

Dr. GEORGE G. MANOV, staff specialist for industrial development, office of the assistant general manager for research and industrial development, AEC, Washington, D. C.

Dr. A. R. MATHESON, head, technical operations division, Schenectady Operations Office, AEC, Schenectady, N. Y.

Dr. DANIEL J. PFLAUM, chief, materials and information branch, division of research, AEC, Washington, D. C.

DENNIS PULESTON, head, technical information division, Brookhaven National Laboratory, Upton, Long Island, New York.

WAYNE RANGE, public information officer, Portsmouth Area Office, AEC, Portsmouth, Ohio.

Dr. H. W. RUSSELL, assistant director, Battelle Memorial Institute, Columbus, Ohio.

Dr. W. E. SHOUPP, assistant division manager, atomic power division, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. CHARLES SLESSER, director, division of technical information and declassification, AEC, New York Operations Office, New York, N. Y.

Dr. Ralph Carlisle Smith, assistant director for classification and security, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. Robert A. Staniforth, director of research, Mound Laboratory, Miamisburg, Ohio.

Dr. John R. Stehn, physicist, theoretical physics division, Knolls Atomic Power Laboratory, Schenectady, N. Y.

M. H. Wahl, atomic energy division, E. I. du Pont de Nemours & Co., Atlanta, Ga.

Dr. R. K. Wakerling, chief, information division, Radiation Laboratory, University of California, Berkeley, Calif.

J. W. Young, technical information officer, division of reactor development, AEC, Washington, D. C.

Edward J. Brunenkant, secretary; chief, industrial information branch, division of information services, AEC, Washington, D. C.

Nuclear Cross Sections Advisory Group

This group is appointed on a yearly basis to make a continuing review of the AEC program of nuclear cross section measurements, and to evaluate the needs for cross section information in the various activities of the AEC. The following members were appointed to serve from July 1953 to July 1954.

Dr. Richard F. Taschek, chairman; department of physics, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. Tom W. Bonner, department of physics, Rice Institute, Houston, Tex.

Dr. Joseph L. Fowler, physics division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. Herbert Goldstein, Nuclear Development Associates, Inc., White Plains, N. Y.

Dr. William W. Havens, Jr., department of physics, Columbia University, New York, N. Y.

Dr. Donald J. Hughes, department of physics, Brookhaven National Laboratory, Upton, Long Island, N. Y.

Dr. Alexander S. Langsdorf, physics division, Argonne National Laboratory, Chicago, Ill.

Dr. Carl O. Muehlhause, department of physics, Brookhaven National Laboratory, Upton, Long Island, N. Y.

Dr. Jack M. Peterson, cyclotron group, University of California Radiation Laboratory, Livermore, Calif.

Dr. Herbert S. Pomerance, physics division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dr. Thoma M. Snyder, physics division, Knolls Atomic Power Laboratory, Schenectady, N. Y.

Dr. Louis A. Turner, physics division, Argonne National Laboratory, Chicago, Ill.

Dr. George A. Kolstad, vice chairman; physics branch, division of research, AEC, Washington, D. C.

Dr. Ira F. Zartman, division of engineering, AEC, Washington, D. C.

Dr. Carroll W. Zabel, secretary; department of physics, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Patent Advisory Panel

This panel was appointed in January 1947 to make a general review and appraisal of the problems raised by the patent provisions of the Atomic Energy Act of 1946.

It makes informal reports and recommendations to the Commission and its staff on various questions of policy and procedure relating to patents and inventions.

H. THOMAS AUSTERN; of Covington & Burling, Washington, D. C.
WILLIAM H. DAVIS; of Davis, Hoxie & Faithfull, New York, N. Y.
JOHN A. DIENNER; of Brown, Jackson, Boettcher & Dienner, Chicago, Ill.
HECTOR M. HOLMES; of Fish, Richardson & Neave, Boston, Mass.
CASPER W. OOMS; firm of Casper W. Ooms, Chicago, Ill.

Stack Gas Problem Working Group

The appointment of this group was authorized in May 1948 to advise the Commission in connection with problems in the control of gaseous effluents from AEC installations. The group has held six formal meetings and has rendered assistance in the field of air cleaning through specific research and development projects directed by individual members and by individual consulting advice.

Dr. ABEL WOLMAN, chairman; head, department of sanitary engineering, Johns Hopkins University, Baltimore, Md.
Dr. PHILIP DRINKER, professor of industrial hygiene, Harvard University School of Public Health, Boston, Mass.
Dr. LYLE GILBERTSON, director, research and engineering department, Air Reduction Co., Murray Hill, N. J.
Dr. H. FRASER JOHNSTONE, professor of chemical engineering, University of Illinois, Urbana, Ill.
Dr. CHARLES E. LAPPLE, professor of chemical engineering, Ohio State University, Columbus, Ohio.
Dr. MOYER D. THOMAS, department of agricultural research, American Smelting & Refining Co., Salt Lake City, Utah.
Dr. WILLIAM P. YANT, director of research, Mine Safety Appliances Co., Pittsburgh, Pa.

Technical Information Panel

This panel, representing the major AEC research contractors, was appointed in June 1948 to advise the Commission on all aspects of its technical information services. Meetings are held twice a year to work out better methods of disseminating technical information.

Dr. ALBERTO F. THOMPSON, chairman; chief, technical information service, division of information services, AEC, Washington, D. C.
Dr. HENRY A. BLAIR, director, atomic energy project, University of Rochester, Rochester, N. Y.
BREWER F. BOARDMAN, supervisor, technical information service, Phillips Petroleum Co., Idaho Falls, Idaho.
CHARLES W. CAMPBELL, superintendent of development staff services, Sandia Corp., Albuquerque, N. Mex.
Dr. F. L. CU BERT, technical director, National Lead Co. of Ohio, Cincinnati, Ohio.
W. E. DREESZEN, administrative aide to director, Ames Laboratory, Ames, Iowa.
W. L. HARWELL, head, patents and declassification department, Carbide & Carbon Chemicals Co., div. of Union Carbide & Carbon Corp., Oak Ridge, Tenn.

EDWARD L. HILL, supervisor, technical services unit, General Electric ANP Project, Cincinnati, Ohio.

FRANK R. LONG, supervisor, technical information group, atomic energy research department, North American Aviation, Inc., Downey, Calif.

Dr. JAMES A. MERRILL, director, laboratory division, Goodyear Atomic Corp., Akron, Ohio.

Dr. JAMES W. MORRIS, technical division, Savannah River laboratory, E. I. du Pont de Nemours & Co., Augusta, Ga.

Dr. E. J. MURPHY, assistant to research director, Carbide & Carbon Chemicals Co., div. of Union Carbide & Carbon Corp. (ORNL), Oak Ridge, Tenn.

Dr. G. M. MURPHY, professor of chemistry, New York University, New York, N. Y.

Dr. DANIEL J. PFLAUM, chief, materials and information branch, division of research, AEC, Washington, D. C.

DENNIS PULESTON, head, technical information division, Brookhaven National Laboratory, Upton, Long Island, N. Y.

Dr. RICHARD F. RILEY, chief, radiation chemistry section, atomic energy project, University of California, Los Angeles, Calif.

D. P. RUDOLPH, director, technical services division, Chicago Operations Office, AEC, Lemont, Ill.

Dr. H. W. RUSSELL, assistant director, Battelle Memorial Institute, Columbus, Ohio.

Dr. W. E. SHOUPP, assistant division manager, atomic power division, Westinghouse Electric Corp., Pittsburgh, Pa.

Dr. CHARLES SLESSER, director, division of technical information and declassification, AEC, New York Operations Office, New York, N. Y.

Dr. RALPH CARLISLE SMITH, assistant director for classification and security, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

Dr. ROBERT A. STANIFORTH, director of research, Mound Laboratory, Miamisburg, Ohio.

Dr. JOHN R. STEHN, physicist, theoretical physics division, Knolls Atomic Power Laboratory, Schenectady, N. Y.

C. G. STEVENSON, head, technical information, technical section, engineering department, General Electric Co., Richland, Wash.

Dr. R. K. WAKERLING, chief, information division, radiation laboratory, University of California, Berkeley, Calif.

Dr. H. D. YOUNG, director, information division, Argonne National Laboratory, Lemont, Ill.

APPENDIX 3

MAJOR RESEARCH AND DEVELOPMENT INSTALLATIONS OF THE U. S. ATOMIC ENERGY COMMISSION

Ames Laboratory (Iowa State College, contractor), Ames, Iowa

Director .... Dr. FRANK H. SPEDDING
Associate Director .... Dr. H. A. WILHELM
Assistant to Director .... Dr. ADOLPH F. VOIGHT

Argonne Cancer Research Hospital (University of Chicago, contractor), Chicago, Ill.

The participating institutions associated with Argonne National Laboratory (listed immediately below) are also affiliated with the Argonne Cancer Research Hospital.

Director .... Dr. LEON O. JACOBSON
Associate Director .... Dr. ROBERT J. HASTERLIK

Argonne National Laboratory (University of Chicago, contractor), Chicago, Ill.

The participating institutions are:

- Battelle Memorial Institute
- Carnegie Institute of Technology
- Case Institute of Technology
- Illinois Institute of Technology
- Indiana University
- Iowa State College
- Kansas State College
- Loyola University (Chicago, Ill.)
- Marquette University
- Mayo Foundation
- Michigan College of Mining and Technology
- Michigan State College
- Northwestern University
- Ohio State University
- Oklahoma Agricultural and Mechanical College
- Purdue University
- St. Louis University
- State University of Iowa
- Washington University (St. Louis, Mo.)
- Wayne University
- Western Reserve University
- University of Chicago
- University of Cincinnati
- University of Illinois
- University of Kansas
- University of Michigan
- University of Minnesota
- University of Missouri
- University of Nebraska
- University of Notre Dame
- University of Pittsburgh
- University of Wisconsin

Director .... Dr. WALTER H. ZINN
Deputy Director .... Dr. NORMAN HILBERRY
Business Manager .... JOHN H. MCKINLEY
Associate Director, University Relationships .... Dr. JOSEPH C. BOYCE
Assistant Director, Technical Services .... JOHN T. BOBBITT

Bettis Plant (Westinghouse Electric Corp., Atomic Power Division, contractor), Pittsburgh, Pa.

Division Manager, Westinghouse Atomic Power Division	CHARLES H. WEAVER
Assistant Division Manager (Technical)	JOHN W. SIMPSON
Assistant Division Manager (Administrative)	EDMUND T. MORRIS
Assistant Division Manager (Development)	Dr. WILLIAM E. SHOUPP

Brookhaven National Laboratory (Associated Universities, Inc., contractor), Upton, Long Island, N. Y.

The participating institutions are:

- Columbia University
- Cornell University
- Harvard University
- Johns Hopkins University
- Massachusetts Institute of Technology
- Princeton University
- Yale University
- University of Pennsylvania
- University of Rochester

Chairman, Board of Trustees	THEODORE P. WRIGHT
President, AUI	LLOYD V. BERKNER
Vice President, AUI and Laboratory Director	Dr. LELAND J. HAWORTH
Deputy Laboratory Director	Dr. GERALD F. TAPE
Assistant Director, University Liaison	Dr. ROBERT A. PATTERSON

Knolls Atomic Power Laboratory (General Electric Co., contractor), Schenectady, N. Y.

General Manager, Operating Department	K. R. VAN TASSEL
Manager, Technical Department	Dr. K. H. KINGDON

Los Alamos Scientific Laboratory (University of California, contractor), Los Alamos, N. Mex.

Director	Dr. NORRIS E. BRADBURY
Technical Associate Director	Dr. DAROL K. FROMAN

Mound Laboratory (Monsanto Chemical Co., contractor), Miamisburg, Ohio

Project Director	Dr. N. N. T. SAMARAS
Laboratory Director	Dr. JOSEPH J. BURBAGE

Oak Ridge Institute of Nuclear Studies (contractor), Oak Ridge, Tenn.

The sponsoring universities of the Institute are:

- Agricultural and Mechanical College of Texas
- Alabama Polytechnic Institute
- Catholic University of America
- Clemson Agricultural College
- Duke University
- Emory University
- Florida State University
- Georgia Institute of Technology
- Louisiana State University & A. and M. College
- University of Georgia
- University of Kentucky
- University of Louisville
- University of Maryland
- University of Mississippi
- University of North Carolina
- Mississippi State College
- North Carolina State College
- Rice Institute
- Southern Methodist University
- Tulane University of Louisiana
- Tuskegee Institute
- Vanderbilt University
- Virginia Polytechnic Institute
- University of Alabama
- University of Arkansas
- University of Florida
- University of Oklahoma
- University of Puerto Rico
- University of South Carolina
- University of Tennessee
- University of Texas
- University of Virginia

Chairman of Council	Dr. GEORGE H. BOYD
Vice Chairman of Council	Dr. MARTEN TEN HOOR
President of Institute	Dr. PAUL M. GROSS
Vice President of Institute	Dr. C. K. BECK
Scientific and Educational Consultant	Dr. GEORGE B. PEGRAM
Executive Director of Institute	Dr. WILLIAM G. POLLARD

Oak Ridge National Laboratory (Carbide & Carbon Chemicals Co., div. of Union Carbide & Carbon Corp., contractor), Oak Ridge, Tenn.

Director	Dr. C. E. LARSON
Research Director	Dr. A. M. WEINBERG
Deputy Research Director	Dr. J. A. SWARTOUT
Assistant Research Director	Dr. E. H. TAYLOR
Assistant Research Director	Dr. E. D. SHIPLEY
Assistant Research Director	Dr. C. E. WINTERS

Radiation Laboratory (University of California, contractor), Berkeley, Calif.

Director	Dr. ERNEST O. LAWRENCE
Associate Director	Dr. DONALD COOKSEY
Business Manager and Managing Engineer	WALLACE B. REYNOLDS
Assistant Director	WILLIAM M. BROBECK
Director, Crocker Laboratory—Medical Physics	Dr. JOSEPH G. HAMILTON.
Director, Donner Laboratory of Medical Physics	Dr. J. H. LAWRENCE
Assistant Director, Donner Laboratory	Dr. HARDIN JONES

Raw Materials Development Laboratory (National Lead Co., contractor), Winchester, Mass.

Technical Director and Manager (Acting) .... JOHN BREITENSTEIN

Rochester Atomic Energy Project (University of Rochester, contractor), Rochester, N. Y.

Director .... DR. HENRY A. BLAIR
Assistant Director for Education .... DR. J. NEWELL STANNARD
Business Manager .... C. M. JARVIS

Sandia Laboratory (Sandia Corp., contractor), Sandia Base, Albuquerque, N. Mex.

President .... JAMES W. MCRAE

University of California, Los Angeles, Atomic Energy Project (University of California, contractor), Los Angeles, Calif.

Director .... DR. STAFFORD WARREN
Project Manager .... ROBERT J. BUETTNER

University of California Medical Center, Radiological Laboratory (University of California, contractor), San Francisco, Calif.

Director .... DR. ROBERT S. STONE

APPENDIX 4

Isotope Distribution Data

	Number of Shipments [1]		
	Aug. 2, 1946, Dec. 31, 1953	Jan. 1, 1954, May 31, 1954	Total to May 31, 1954
Shipments classified by kind of isotopes:			
Radioactive isotopes:			
Iodine 131	17,036	2,059	19,095
Phosphorus 32	11,073	998	12,071
Carbon 14	1,832	147	1,979
Sodium 24	1,589	181	1,770
Sulfur 35	860	109	969
Gold 198	1,533	260	1,793
Calcium 45	559	45	604
Iron 55	546	63	609
Cobalt 60	789	65	854
Potassium 42	656	82	738
Strontium 89, 90	364	50	414
Other	5,915	755	6,670
Total	42,752	4,814	47,566
Stable isotopes:			
Deuterium oxide	649	66	715
Deuterium	705	52	757
Boron	205	21	226
Helium 3	33	1	34
Oxygen 18	299	23	322
Electromagnetically concentrated	799	76	875
Argon 38	4	----------	4
Total	2,694	239	2,933
Shipments to AEC installations:			
Radioactive	7,250	452	7,702
Stable	1,667	43	1,710

[1] Shipments from Oak Ridge National Laboratory, Oak Ridge, Tenn.

LOCATION AND TYPE OF USERS [2]

JANUARY 1, 1954–MAY 1, 1954

States	Medical Institutions and Physicians		Colleges and Universities		Industrial Firms		Federal and State Labs.		Foundations and Institutions		Other		Total	
	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable
Alabama	2				1								3	
Arizona	1												1	
Arkansas	1												1	
California	9	1			16	3	5						30	4
Colorado	1	1			1				1				3	1
Connecticut					1			1					1	1
Delaware							1						1	
District of Columbia							2	2					2	2
Florida	4			1	1		1						6	1
Georgia	1				1								2	
Hawaii														
Idaho					1						1		2	
Illinois	11			1	7			1	2				20	2
Indiana														
Iowa	4				2								6	
Kansas														
Kentucky	1		1		1								3	
Louisiana	1				1		2						4	
Maine														
Maryland		1			1		1						2	1
Massachusetts			2	1	4	1	1		1				8	2
Michigan	1				1						1		3	
Minnesota				1										1
Mississippi	3				3								6	
Missouri														
Montana	2												2	
Nebraska														
Nevada														
New Hampshire	8				6	1	1	1					15	2
New Jersey				1										1
New Mexico	16		1	1	14	1	3		1				35	2
New York	3				3								6	
North Carolina	5	1	1	1	6		1						13	2
North Dakota	3				3								6	
Ohio	3										1		4	
Oklahoma														
Oregon														
Panama														
Pennsylvania	3	1			7		2						12	1
Puerto Rico	1												1	
Rhode Island	2												2	
South Carolina				1			1						1	1
South Dakota														
Tennessee	2				1								3	
Texas	5				11								16	
Utah														
Vermont														
Virginia	1				1	1							2	1
Washington	1				2		2						5	
West Virginia	2												2	
Wisconsin			1	2	4								5	2
Wyoming														

Missouri														
Montana														
Nebraska	2												2	
Nevada														
New Hampshire														
New Jersey	8				6	1	1	1					15	2
New Mexico				1										1
New York	16		1	1	14	1	3		1				35	2
North Carolina	3				3								6	
North Dakota														
Ohio	5	1	1	1	6		1						13	2
Oklahoma	3				3								6	
Oregon	3										1		4	
Panama														
Pennsylvania	3	1			7		2						12	1
Puerto Rico	1												1	
Rhode Island	2												2	
South Carolina				1			1						1	1
South Dakota														
Tennessee	2				1								3	
Texas	5				11								16	
Utah														
Vermont														
Virginia	1				1	1							2	1
Washington	1				2		2						5	
West Virginia	2												2	
Wisconsin			1	2	4								5	2
Wyoming														
Total	97	5	6	10	100	7	23	5	5		3		234	27

[2] Users are either institutions or individuals receiving isotopes authorized through the Commission's distribution program.

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LOCATION AND TYPE OF USERS

AUGUST 1946–MAY 31, 1954

States	Medical Institutions and Physicians		Colleges and Universities		Industrial Firms		Federal and State Labs.		Foundations and Institutions		Other		Total	
	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable	Radio	Stable
Alaska	1		1				1						3	
Alabama	7		2	1	10	1	3	1	2	1			24	4
Arizona	3		1	1			2						6	1
Arkansas	6		1	1	2		1						10	1
California	100	5	15	11	94	16	40	4	10	1	1		260	37
Colorado	16	1	3	2	6	1	4		2		2		33	4
Connecticut	11	1	5	3	26	3	2	1					44	8
Delaware	1		1	1	8	3	1		1	1			12	5
District of Columbia	8	4	3	4	5		14	7			1		31	15
Florida	14		6	2	2		4				1		27	2
Georgia	7		4	3	4		6						21	3
Hawaii	3		1				1		2				7	
Idaho	1		1		2						1		5	
Illinois	50	3	7	7	57	8	13	2	4	1	2		133	21
Indiana	11		3	4	22	3					1		37	7
Iowa	7	1	3	2	7								17	3
Kansas	11		2	2	3								16	2
Kentucky	6		2	1	8		2		1		1		20	1
Louisiana	9	1	3	2	7	2	3						22	5
Maine	3		3	1	8		1						15	1
Maryland	12	5	5	3	14	3	13	5					44	16
Massachusetts	28	7	15	9	59	10	7	2	3	1	1		113	29
Michigan	18	1	7	3	27	5	1				1		54	9
Minnesota	8	2	5	2	8		1						22	4
Mississippi	2		1	1	2		3	1					8	2
Missouri	26	2	4	4	8		1						39	7
Montana	6	2	1	1			1						8	3
Nebraska	5		1				1						7	
Nevada	2				2		1						5	
New Hampshire	2		2	2	3		2						9	2
New Jersey	18		4	2	70	13	7	2	6	1	1	2	106	20
New Mexico	5		2	2	1		3						11	2
New York	114	12	27	19	112	14	15	2	8		2		278	47
North Carolina	11	1	5	3	7		5						28	4
North Dakota	6		2				1						9	
Ohio	33	3	9	8	77	6	10	2	3	2	1		133	21
Oklahoma	9		1	1	19	6	1		3				33	7
Oregon	6	1	3	3	2		3				1		15	4
Panama							1						1	
Pennsylvania	42	6	11	6	89	13	11	2	4	2	1		158	29
Puerto Rico	4						2						6	
Rhode Island	3		2	1	7		1						13	1
South Carolina	3		2	2	1		2						8	2
South Dakota	2		2										4	
Tennessee	21	1	4	3	8	1	5	1					38	6
Texas	44	6	5	4	56	6	5		3	1		1	113	18
Utah	3	1	3	1	2		2						10	2
Vermont	3				1								4	
Virginia	7		4	1	9	2	8						28	3
Washington	11		4	3	[illegible]	[illegible]	[illegible]							

New Jersey	18		4	2	70	13	7	2	6	1	1	2	106	20
New Mexico	5		2	2	1		3						11	2
New York	114	12	27	19	112	14	15	2	8		2		278	47
North Carolina	11	1	5	3	7		5						28	4
North Dakota	6		2				1						9	
Ohio	33	3	9	8	77	6	10	2	3	2	1		133	21
Oklahoma	9		1	1	19	6	1		3				33	7
Oregon	6	1	3	3	2		3				1		15	4
Panama							1						1	
Pennsylvania	42	6	11	6	89	13	11	2	4	2	1		158	29
Puerto Rico	4						2						6	
Rhode Island	3		2	1	7		1						13	1
South Carolina	3		2	2	1		2						8	2
South Dakota	2		2										4	
Tennessee	21	1	4	3	8	1	5	1					38	6
Texas	44	6	5	4	56	6	5		3	1		1	113	18
Utah	3	1	3	1	2		2						10	2
Vermont	3				1								4	
Virginia	7		4	1	9	2	8						28	3
Washington	11		4	3	9	1	6						30	4
West Virginia	9		2	1	2	1	2						15	2
Wisconsin	9	1	3	3	27		4						43	4
Wyoming	1		1	1			1						3	1
Total	748	67	204	137	893	118	224	32	52	12	18	3	2, 139	369

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NTRIES

'54, .954	Total to May 31, 1954
13	118
1	104
0	1
6	137
0	16
0	0
18	229
0	1
147	567
6	85
0	5
0	0
40	173
7	214
0	1
1	2
0	0
4	135
1	14
9	99
8	14
0	0
0	1
6	9
0	0
0	5
2	14
0	3
0	0
0	6
4	32
36	263
0	6
17	64
1	54
0	11
1	43
0	5
0	0
4	17
2	2
0	5
0	5
1	183
2	53
0	0
0	0
0	3
0	5
0	28
0	10
0	1
0	0
337	2,743
44	817
152	787
14	265
7	110
7	91
18	156
11	64
6	84
78	369
337	2,743

APPENDIX 5

AEC Owned Patents

PATENTS ISSUED TO THE COMMISSION WHICH ARE AVAILABLE FOR LICENSING [1]

The following 37 U. S. Letters Patents owned by the United States Government as represented by the United States Atomic Energy Commission, are in addition to the 117 patents listed in the 15th Semiannual report. The patents listed have been made available for licensing at periodic intervals. Licenses are granted on a non-exclusive, royalty-free basis. Abstracts of patents available for licensing are published in the Patent Office Official Gazette.

Patent No.	*Title*	*Patentee*
2,662,001	Plate Design for Pulse Columns	W. A. Burns and W. F. Johnson, Richland, Wash.
2,663,801	Transmission Fluorimeter	M. Slavin, East Setauket, N. Y., M. H. Fletcher, Alexandria, Va., and I. May, Washington, D. C.
2,663,802	Neutron Detector	P. E. Ohmart, Dayton, Ohio
2,664,449	Pyrolysis of Trifluorochloroethylene Polymers.	W. T. Miller, Ithaca, N. Y.
2,664,515	Magnetic Electron Multiplier	L. G. Smith, Center Moriches, N. Y.
2,664,998	Container for Neutron Irradiated material.	J. F. Gifford, Richland, Wash., and N. B. Garden, Berkeley, Calif.
2,665,384	Ion Accelerating and Focusing System.	H. P. Yockey, Berkeley, Calif.
2,666,147	Spectrometer	L. B. Borst, Oak Ridge, Tenn.
2,666,539	Rapid Operation Air Lock for Closed Vessels.	R. T. Avery, Oakland, Calif.
2,666,865	Survey Instrument	C. J. Borkowski, Oak Ridge, Tenn.
2,667,104	Light Valve	W. E. Buck, Los Alamos, N. Mex.
2,667,178	Liquid Level Control	M. S. Fred, Chicago, and E. G. Rauh, Minsdale, Ill.
2,667,474	Heat Treatment of Polytrifluorochloroethylene.	W. T. Miller, Ithaca, N. Y.
2,667,582	Mass Separator	J. G. Backus, Los Angeles, Calif.
2,668,260	Ion Source	C. F. Barnett and C. B. Mills, Oak Ridge, Tenn.
2,668,272	Voltage Regulator	E. J. Groth, Jr., Woods Hole, Mass.

[1] Patents listed as of April 27, 1954. Applicants for licenses should apply to Chief, Patent Branch, Office of the General Counsel, U. S. AEC, Washington 25, D. C., identifying the subject matter by patent number and title.

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APPENDIX 6

PUBLICATIONS OF THE U. S. ATOMIC ENERGY COMMISSION [1]

The AEC encourages project scientists to make their own arrangements for the publications of nonsecret research results in the established scientific and technical journals. Guides to such publications may be found in *Nuclear Science Abstracts* (see p. 108). There are, however, a number of special publications which the AEC has sponsored or helped sponsor.

SEMIANNUAL REPORTS TO CONGRESS [2]

The AEC semiannual reports to Congress on the progress of the Commission's program are published and made available to the public by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. An alternate title, indicating the principal subject of the report, has been given to each of the later reports. Indexes to the semiannual reports are also available from the Superintendent of Documents.

First Semiannual Report, January 1947.

Second Semiannual Report, July 1947.

Third Semiannual Report, January 1948.

Fourth Semiannual Report, *Recent Scientific and Technical Developments in the Atomic Energy Program of the United States*, July 1948. 35 cents.

Fifth Semiannual Report, *Atomic Energy Development, 1947–1948*, January 1949. 45 cents.

Sixth Semiannual Report, *Atomic Energy and the Life Sciences*, July 1949. 45 cents.

Seventh Semiannual Report, *Atomic Energy and the Physical Sciences*, January 1950. 50 cents.

Eighth Semiannual Report, *Control of Radiation Hazards in the Atomic Energy Program*, July 1950. 50 cents.

Ninth Semiannual Report, *AEC Contract Policy and Operations*, January 1951. 40 cents.

Tenth Semiannual Report, *Major Activities in the Atomic Energy Programs, January–June 1951*, July 1951. 35 cents.

Eleventh Semiannual Report, *Some Applications of Atomic Energy in Plant Science*, January 1952. 50 cents.

Twelfth Semiannual Report, *Major Activities in the Atomic Energy Programs, January–June 1952*, July 1952. 35 cents.

Thirteenth Semiannual Report, *Assuring Public Safety in Continental Weapons Tests*, January 1953. 50 cents.

Fourteenth Semiannual Report, *Major Activities in the Atomic Energy Programs, January–June 1953*, July 1953. 30 cents.

Fifteenth Semiannual Report, *Major Activities in the Atomic Energy Programs, July–December 1953*, January 1954. 45 cents.

Index to the Semiannual Reports to Congress, January 1947–January 1951. 20 cents.

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[1] Listed as of April 30, 1954.

[2] Available from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Index to the Tenth Semiannual Report to Congress, January–June 1951. 10 cents.
Index to the Eleventh Semiannual Report to Congress, July–December 1951. 10 cents.
Index to the Twelfth Semiannual Report to Congress, January–June 1952. 10 cents.
Index to the Thirteenth Semiannual Report to Congress, July–December 1952. 15 cents.
Index to the Fourteenth Semiannual Report to Congress, January–June, 1953. 10 cents.
Index to the Fifteenth Semiannual Report to Congress, July–December 1954. 15 cents.

GENERAL PUBLICATIONS

The following is a list of nontechnical publications pertaining to atomic energy or the administration of the AEC programs, and available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Selected Readings on Atomic Energy, August 1951, a bibliography of official publications, books, magazines, pamphlets and teaching units for educators, and indexes and bibliographies on atomic energy, 23 pages, 15 cents. Revised 1954 issue in process.

Isotopes—A 5-Year Summary of Distribution, August 1951, a detailed account of isotope utilization during the first 5 years of the Commission's distribution program. It is in part a supplement of the 3-year report of similar title issued by the Commission in 1949. This report is a useful reference to investigators using or contemplating the use of isotopes, and documentary evidence of the value of radioactive and concentrated stable isotopes to modern research and technology in science, medicine, agriculture and industry, 451 pages, $1.

Prospecting for Uranium, revised October 1951, a nontechnical booklet prepared by the United States Geological Survey and AEC describing the uranium-bearing minerals, where to look for them, and instruments to use in prospecting and in laboratory testing and analysis of ores. It contains six color plates of principal minerals. Laws, regulations, and price schedules for uranium-bearing ores are included, 128 pages, 55 cents.

Prospecting with a Counter, revised July 1954, a summary of information on field counters, their operation, use, abuse, and their application to prospecting, mining and geologic problems, 68 pages, 30 cents.

Selling to AEC (supersedes *Contracting and Purchasing Offices and Types of Commodities Purchased*) revised 1953, provides certain basic information helpful to those who want to do business with AEC or its contractors. It indicates who does the buying, what is bought, where procurement offices are located, and other general information, 25 pages, 15 cents.

A Guide for Contracting of Construction and Related Engineering Services, revised January 1951, gives AEC policy on awarding contracts for construction and architect-engineering services, procedures followed when requests for bids are formally advertised and when contracts are negotiated. Operations offices and officials responsible for letting such contracts are listed, 16 pages, 15 cents.

TECHNICAL PUBLICATIONS

The items listed below, together with the National Nuclear Energy Series described in the next section, are the publications of scientific and technical interest. In addition, articles numbering in the thousands may be found in the scientific and technical journals, and hundreds of reports, not published elsewhere, may be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Lists of titles and prices of these reports are available from the Office of Technical Services.

Books

The Elements of Nuclear Reactor Theory, Samuel Glasstone and Milton C. Edlund, D. Van Nostrand Co., N. Y., 1952, is written for scientists, engineers and advanced students interested in the field of nuclear reactors. It explains the physical concepts and processes involved in a nuclear chain reaction and the methods for calculating critical conditions for chain reacting systems, 416 pages, $4.80.

Sourcebook on Atomic Energy, Samuel Glasstone, D. Van Nostrand Co., N. Y., 1950, presents a comprehensive, technical description of the theory, history, development, and uses of atomic energy. Chapters are included on the structure of the atom, radioactivity, isotopes, neutron research, acceleration of charged particles, and other phases of nuclear science, 546 pages, $3.75.

Energy in the Future, Palmer Cosslett Putnam, D. Van Nostrand Co., N. Y., 1953, presents a study of the problem of where we can find sources of low-cost energy in an abundance equal to the maximum plausible demands by the expanding and industrializing populations of the future, and what is the maximum plausible role that nuclear fuels may be called on to play in the next 50 years, or so, 556 pages, $12.75.

The Effects of Atomic Weapons, 1950, prepared for the Department of Defense and the AEC by a board of editors under the direction of the Los Alamos Scientific Laboratory, presents a technical summary of the results to be expected from the detonation of atomic weapons, with chapters describing an atomic explosion, the shock from air, underwater, and underground bursts; blast, radiation, and fire effects; methods of protecting personnel; and decontamination methods, 456 pages, $1.25.[2]

Manuals, Handbooks and Reports

Nuclear Power Reactor Technology, reports to the U. S. Atomic Energy Commission by the Industrial Study Group, May 1953, appraising the prospect for private industrial participation in joint production of electric energy and fissionable material from reactors. The appraisals included examination of both technical and economic problems involved in production from nuclear reactors of electrical energy for industrial and commercial use, 88 pages, 25 cents.[2]

Handbook on Aerosols, 1950, contains chapters from the National Defense Research Committee Summary Technical Report, Division 10, declassified by the Army at the request of AEC, on the properties and behavior of aerosols, principals and instruments used in meteorology studies, and information useful in studies of the disposal of gaseous radioactive wastes, the dispersal of insecticides, the disposal of industrial gases, etc., 147 pages, 70 cents.[2]

Handbook on Air Cleaning—Particulate Removal, Sheldon K. Friedlander, Leslie Silverman, Philip Drinker and Melvin W. First, Harvard University, September 1952, a compilation of data resulting from the study of air cleaning equipment and procedures. Such studies applied principally to the removal of radioactive dust and contamination from exhaust gases, etc., 89 pages, 45 cents.[2]

[2] Available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Liquid Metals Handbook, second edition (revised) January 1954, R. N. Lyon et al., compiled by the Department of the Navy and AEC, summarizes current information on the physical and chemical properties of liquid metals, their present industrial uses, and their use and potentialities as heat-transfer media, 269 pages, $1.25.[1]

Neutron Cross Sections (AECU 2040), May 15, 1952, a compilation of data in tabular and graphic form prepared by the AEC Neutron Cross Section Advisory Group. Cross section values for a number of nuclides, elements and compounds are given for neutrons ranging in energy from 0.0001 electron volts to 100 Mev., $1.[2]

Handling Radioactive Wastes in the Atomic Energy Program, revised August 1951, reports on the sources and types of radioactive wastes in atomic energy operations, methods developed for their safe handling and disposal, and methods specified for the safe handling of radioisotopes by private users, 30 pages, 15 cents.[2]

Trilinear Chart of Nuclear Species, W. H. Sullivan, John Wiley & Sons, Inc., N. Y., 1949, shows physical data for all the nuclear species known as of June 1949, $2.50.

Periodicals and Catalogs

Nuclear Science Abstracts, issued twice a month by the AEC Technical Information Service, contains abstracts of all current AEC declassified and unclassified reports, of non-AEC reports related to atomic energy, and of articles appearing in both the foreign and domestic periodical literature, $6 per year. ($8 per year foreign.)[2]

Isotopics, a quarterly journal of announcements issued by the Isotopes Division, AEC, Oak Ridge, Tenn., concerning the availability, utilization, and handling of isotopes, 35 cents per copy, $1 per volume.[2]

Isotopes—Catalog and Price List, Oak Ridge National Laboratory, Oak Ridge, Tenn., July 1952, lists and describes radioactive and stable isotopes available from ORNL and includes prices and instructions for ordering the isotopes, $1 per copy.

THE NATIONAL NUCLEAR ENERGY SERIES

These volumes were written by the scientists who performed the research and development on the atomic energy enterprise under the Manhattan Engineer District and later under the Atomic Energy Commission. The following volumes have been published for the AEC project by the McGraw-Hill Book Co., New York, N. Y.

Division I: The Electromagnetic Separation Process

Vacuum Equipment and Techniques, vol. 1, edited by A. Guthrie and R. K. Wakerling, 1949, describes the development and study of high vacuum equipment and high vacuum systems for the large-scale separation of isotopes by the electromagnetic process, 264 pages, $3.75.

The Characteristics of Electrical Discharges in Magnetic Fields, vol. 5, edited by A. Guthrie and R. K. Wakerling, 1949, cover most of the significant studies by the University of California Radiation Laboratory on electrical discharges with emphasis on studies of electrical discharges in vapors of uranium compounds, 376 pages, $5.

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[1] Available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.
[2] Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D.C.

The Chemistry and Metallurgy of Miscellaneous Materials; Thermodynamics, vol. 19B, edited by L. L. Quill, 1949, contains 10 research papers on the thermodynamic properties of the elements and several of their compounds, 329 pages, $4.50.

Industrial Medicine on the Plutonium Project, vol. 20, edited by R. S. Stone, 1951, describes the medical program established for the care and protection of workers on the plutonium project, 511 pages, $7.

Biological Effects of External X- and Gamma Radiation, part I, vol. 22B, edited by R. E. Zirkle, 1954, deals with radiological research and investigations performed at the National Cancer Institute of the effects of continuous X- and gamma irradiation on life span, weight, blood picture, and breeding behavior of small laboratory mammals, 530 pages, $7.25.

Biological Effects of External Beta Radiation, vol. 22E, edited by R. E. Zirkle, offers a collection of original reports on the effects of beta rays applied to the surface of the mammalian body, 242 pages, $3.50.

Histopathology of Irradiation from External and Internal Sources, vol. 22I, edited by W. Bloom, 1948, is an advanced treatise on the histopathological and cytological effects of total-body irradiation, 808 pages, $10.75.

Toxicology of Uranium, vol. 23, edited by A. Tannenbaum, 1950, describes the studies made on the distribution, accumulation, excretion, and chemical and physiological effects of uranium and uranium compounds in the animal body, 323 pages, $4.75.

Division V: Los Alamos Project

Electronics: Experimental Techniques, vol. 1, edited by W. C. Elmore and M. L. Sands, 1948, describes a number of complete circuits and circuit elements developed at Los Alamos for making nuclear and other physical measurement, 417 pages, $5.50.

Ionization Chambers and Counters: Experimental Techniques, vol. 2, edited by B. Rossi and H. Staub, 1949, describes the physical principles of ionization chambers and counters, and includes previously unpublished project developments by scientists at the Los Alamos Laboratory, 243 pages, $3.25.

Miscellaneous Physical and Chemical Techniques of the Los Alamos Project, vol. 3, edited by A. C. Graves and D. K. Froman, describes a variety of laboratory techniques used at Los Alamos in early studies. Drawings and diagrams of the laboratory and apparatus are given, 323 pages, $4.25.

Division VI: University of Rochester Project

Pharmacology and Toxicology of Uranium Compounds, vol. 1, edited by C. Voegtlin and H. C. Hodge. Parts I and II, published in 1949, summarize the results of 3 years' research on the toxicity of various uranium compounds and the mechanism of uranium poisoning. 1,084 pages (in 2 parts), $14.25.

Parts III and IV, published in 1953, continues from Parts I and II, with results of long-term studies, mainly on the chronic inhalation toxicity of uranium compounds. Major problems considered are bone deposition of uranium and carbohydrate metabolism. Bibliography, index. 1,381 additional pages (in 2 parts), $18.

Biological Effects of External Radiation, vol. 2, edited by Henry A. Blair, 1954, reports the studies made during the war period at the University of Rochester on the biological effects of X-radiation along with a collaborative study of the chronic effects of neutron irradiation made with the Biochemical Foundation, Newark, Del. Included in the volume are the effects of single doses of whole-body X-radiation, chronic X-radiation, and fractionated doses of fast neutrons, 508 pages, in press, about $6.50.

Biological Studies with Polonium, Radium and Plutonium, vol 3, edited by R. M. Fink, 1949, describes the studies made of the biological effects of these alpha-emitting elements in the animal body, air monitoring precautions, and equipment used in atomic energy laboratories where work with these elements is carried on, 411 pages, $5.50.

Division VII: Materials Procurement Project

Preparation, Properties, and Technology of Fluorine and Organic Fluoro Compounds, vol. 1, edited by C. Slesser and S. R. Schram, describes development in the large-scale manufacture of fluorine, and purifying and handling fluorine. It describes the preparation and the chemical and physical properties of various fluorocarbon compounds, 868 pages, $11.50.

Division VIII: Manhattan Project Chemistry

Analytical Chemistry of the Manhattan Project, vol. 1, edited by C. J. Rodden, 1950, describes methods of analyzing the many different materials used in the atomic energy project—with emphasis on analytical methods for the determination of uranium and thorium, 748 pages, $10.00.

Chemistry of Uranium. Part I. The Element, Its Binary and Related Compounds, vol. 5, by J. J. Katz and E. Rabinowitch, 1951, is a detailed discussion of the physical and chemical properties of uranium, its occurrence in nature and extraction from ores, and preparation and physical properties of its binary compounds, 609 pages, $8.25.

DEPOSITORY LIBRARIES

In order to make the nonclassified results of AEC research and development available to the public, the following libraries serve as depositories for essentially all of the Commission's nonclassified reports. A number of other university and public libraries also receive from the AEC copies of the reports that are sold by the Office of Technical Services.

CALIFORNIA
- Berkeley, University of California General Library
- Los Angeles, University of California Library

COLORADO
- Denver, Denver Public Library

CONNECTICUT
- New Haven, Yale University Library

DISTRICT OF COLUMBIA
- Washington, Library of Congress

GEORGIA
- Atlanta, Georgia Institute of Technology Library

ILLINOIS
- Chicago, John Crerar Library
- Chicago, University of Chicago Library
- Urbana, University of Illinois Library

INDIANA
- Lafayette, Purdue University Library

IOWA
- Ames, Iowa State College Library

KENTUCKY
- Lexington, University of Kentucky Library

LOUISIANA
- Baton Rouge, Louisiana State University Library

MASSACHUSETTS
- Cambridge, Harvard University Library
- Cambridge, Massachusetts Institute of Technology Library

MICHIGAN
- Ann Arbor, University of Michigan Library
- Detroit, Detroit Public Library

MINNESOTA
- Minneapolis, University of Minnesota Library

MISSOURI
- Kansas City, Linda Hall Library
- St. Louis, Washington University Library

NEW JERSEY
- Princeton, Princeton University Library

NEW MEXICO
- Albuquerque, University of New Mexico Library

NEW YORK
- Buffalo, Lockwood Memorial Library
- Ithaca, Cornell University Library
- New York, Columbia University Library
- New York, New York Public Library
- Troy, Rensselaer Polytechnic Institute Library

NORTH CAROLINA
- Durham, Duke University Library
- Raleigh, North Carolina State College Library

OHIO
- Cincinnati, University of Cincinnati Library
- Cleveland, Cleveland Public Library
- Columbus, Ohio State University Library

OKLAHOMA
- Stillwater, Oklahoma Agricultural and Mechanical College Library

OREGON
- Corvallis, Oregon State College Library

PENNSYLVANIA
- Philadelphia, University of Pennsylvania Library
- Pittsburgh, Carnegie Library of Pittsburgh

TENNESSEE
- Knoxville, University of Tennessee Library
- Nashville, Joint University Libraries

TEXAS
- Austin, University of Texas Library

UTAH
- Salt Lake City, University of Utah Library

WASHINGTON
- Seattle, University of Washington Library

WISCONSIN
- Madison, University of Wisconsin Library

INDUSTRIAL DEPOSITORIES

To provide industry with specialized industrial information materials and to facilitate inspection of such materials, the AEC has set up special depositories at the Atomic Industrial Forum, Inc., in New York City, at the John Crerar Library in Chicago, in the Stanford Research Institute, Stanford, Calif., and Office of Technical Services, U. S. Department of Commerce, Washington, D. C. Initially, industrial depository collections will be comprised of some 700 nonclassified "basic science" reports which have been found to contain technological developments of special value to American industry not directly connected with the U. S. Atomic Energy program. Abstracts of these reports were published in a series of special bibliographies entitled, "Selected AEC Reports of Interest to Industry," which is also available at the depositories. A modest program for making unclassified engineering drawings available for inspection at industrial depositories has also been initiated.

APPENDIX 7

REGULATIONS OF THE U. S. ATOMIC ENERGY COMMISSION [1]

PART 30—RADIOISOTOPE DISTRIBUTION

MISCELLANEOUS AMENDMENTS

Pursuant to the Atomic Energy Act of 1946, as amended (Pub. Law 585, 79th Cong.; 60 Stat. 755 ff) and section 4 (a) of the Administrative Procedure Act of 1946, as amended (Pub. Law 404, 79th Cong.), additional amendments to Title 10, Chapter I, Part 30, Code of Federal Regulations, entitled "Radioisotope Distribution", promulgated April 9, 1951, and published in Volume 16, Pages 3251 et seq. of the FEDERAL REGISTER, are set forth hereunder to be effective January 15, 1954.

1. Amend § 30.2 to read as follows:

§ 30.2 *Definitions.* As used in this part:

(a) *Commission.* "Commission" means the United States Atomic Energy Commission created by the Atomic Energy Act of 1946, or its duly authorized representative.

(b) *Distributor.* "Distributor" means any person to the extent that such person is engaged in operating Commission-owned laboratories, plants or other facilities under a contract with the Commission and is engaged in the distribution of radioisotopes for the Commission.

(c) *Fissionable material.* "Fissionable material" means fissionable material as defined in section 5 (a) (1) of the Atomic Energy Act of 1946 and in the regulations contained in Part 70 of this chapter.

(d) *General authorization.* "General authorization" means an authorization that is issued for the procurement of any quantity of any radioisotope of atomic number 3 to 83 for the use or uses designated therein.

(e) *Human use.* "Human use" means the internal or external administration of radioisotopes, or the radiation therefrom, to human beings.

(f) *One millicurie.* "One millicurie" means that amount of radioactive material which disintegrates at the rate of 37 million atoms per second.

(g) *Person.* "Person" means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, the United States or any agency thereof, any government other than the United States, any political subdivision of any such government, and any legal successor, representative, agent, or agency of the foregoing, or other entity, but shall not include the Commission or officers or employees of the Commission in the exercise of duly authorized functions.

(h) *Radioisotope.* "Radioisotope" means any radioactive material yielded in or made radioactive by exposure to the radiation incident to the processes of producing or utilizing fissionable material. Radioisotope also means any other radioactive material.

(i) *Research and development.* "Research and development" means theoretical analysis, exploration, and experimentation, and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes. "Research and development" as used in this part does not in-

[1] Policies and regulations of the U. S. AEC announced prior to July 1954 can be found in Appendix 4, Fifth Semiannual Report; Appendix 10, Sixth Semiannual Report; Appendix 4, Ninth Semiannual Report; Appendix 6, Tenth Semiannual Report; Appendix 6, Eleventh Semiannual Report; Appendix 6, Twelfth Semiannual Report; Appendix 6, Thirteenth Semiannual Report; Appendix 5, Fourteenth Semiannual Report; Appendix 6, Fifteenth Semiannual Report; and in the Federal Register.

clude the internal or external administration of radioisotopes, or the radiation therefrom, to human beings.

(j) *Roentgen* (=*r*). "Roentgen" (=r) means that quantity of X- or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying 1 electrostatic unit of electricity of either sign.

(k) *Roentgen-equivalent-man* (=*rem.*). "Roentgen-equivalent-man" (=rem) means that quantity of radiation that, when absorbed by mammalian tissue, produces an effect equivalent to the absorption by this tissue of one roentgen of X- or gamma radiation.

(l) *Roentgen-equivalent-physical* (=*rep*). "Roentgen-equivalent-physical" (=rep) means that dose of ionizing radiation that is capable of producing energy absorption of 93 ergs per gram of tissue.

(m) *Service irradiation.* "Service irradiation" means the exposure of materials of any kind to radiation in accordance with instructions and at the request of some person.

(n) *Source material.* "Source material" means source material as defined in section 5 (b) (1) of the Atomic Energy Act of 1946 and in the regulations contained in Part 40 of this chapter.

2. Amend § 30.13 by deleting paragraph (a) and substituting therefor the following new paragraph:

§ 30.13 *Items and quantities.* (a) Section 30.20 through 30.53, inclusive, do not apply to any item listed in § 30.70 *Schedule A*, nor to any quantity listed in § 30.71 *Schedule B: Provided*, That no person shall, except as otherwise permitted by the regulations contained in this part, effect an increase in the radioactivity of said scheduled items or quantities by adding other radioactive material thereto, by combining the radioisotopes from two or more such items or quantities, or by altering them in any other manner so as to increase thereby the rate of radiation exposure of himself or others above the original rate therefrom: *Provided further*, That no person shall administer externally or internally, or direct the administration of, said scheduled items or quantities to a human being for any purpose, including but not limited to diagnostic, therapeutic, and research purposes, except as permitted by a valid authorization.

3. Amend § 30.21 to read as follows:

§ 30.21 *Requirements for the approval of applications*—(a) *Requirements of general applicability.* A domestic application for radioisotopes procurement will not be approved unless:

(1) The radioisotope is requested for one or more of the following purposes: Research or development, human use (including medical therapy), industrial uses, processing or making of compounds, or such other useful applications as may be developed;

(2) The applicant has suitable equipment and facilities for the protection of health and safety (such as handling devices, work areas, shields, measuring and monitoring instruments); and

(3) The applicant has suitably trained and experienced personnel and is otherwise qualified to use radioisotopes for the requested purpose.

(b) *Special requirements applicable to human uses by institutions.* An application by an institution for authorization to procure radioisotopes, other than sealed sources, for human use will not be approved unless:

(1) The applicant satisfies the general requirements specified in paragraph (a) of this section;

(2) The institution has appointed a medical isotopes committee of at least three members to evaluate all proposals for research, diagnosis, and therapeutic use of radioisotopes within that institution. Membership of the committee should include physicians expert in internal medicine, hematology, therapeutic radiology, and a person experienced in assay of radioisotopes and protection against ionizing radiations;

(3) The institution possesses adequate facilities for the clinical care of patients;

(4) The physician designated on the application as the individual user is licensed by a state or territory of the

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United States or the District of Columbia to dispense drugs in the practice of medicine, and has substantial experience in the proposed use, the handling and administration of radioisotopes and where applicable, the clinical management of radioactive patients; and

(5) The applicant, if the application is for a general authorization, has also (i) previously received a reasonable number of authorizations for radioisotope procurement for a variety of radioisotopes for a variety of human uses; (ii) appointed a radiological safety officer who will advise on or be available for advice and assistance on radiological safety problems; and (iii) appointed a medical isotope committee (see subparagraph (2) of this paragraph) which will review and approve, in advance of purchase of radioisotopes, proposals for human uses.

(c) *Special requirements applicable to human uses by individual physicians.* An application by a physician for authorization to procure radioisotopes, other than sealed sources, for human use will not be approved unless:

(1) The applicant satisfies the general requirements specified in paragraph (a) of this section;

(2) The applicant is a physician licensed by a state or territory of the United States or the District of Columbia to dispense drugs in the practice of medicine;

(3) The applicant has access to a hospital possessing adequate facilities to hospitalize and monitor the applicant's radioactive patients whenever it is advisable; and

(4) The applicant has extensive experience in the proposed use, the handling and administration of radioisotopes, and where applicable, the clinical management of radioactive patients. (The physician shall furnish suitable evidence of such experience with his application. A statement from the medical isotope committee in the institution where he acquired his experience, indicating its amount and nature, may be submitted as evidence of such experience.)

(d) *Special requirements applicable to human use of sealed sources.* An application for authorization to procure radioisotopes in sealed sources for human use will not be approved unless:

(1) The applicant satisfies the general requirements specified in paragraph (a) of this section; and

(2) The applicant or, if the application is made by an institution, the individual user (i) has specialized training in the therapeutic use of the radioactive device considered (teletherapy unit, beta applicator, etc.) or has experience equivalent to such training; and (ii) is a physician licensed by a state or territory of the United States or the District of Columbia to dispense drugs in the practice of medicine.

(e) *Special requirements applicable to general authorizations for use in research and development.* An application for a general authorization to procure radioisotopes for use in research and development will not be approved unless:

(1) The applicant satisfies the general requirements specified in paragraph (a) of this section;

(2) The applicant has received a reasonable number of authorizations for radioisotopes procurement for a variety of radioisotopes for a variety of research and development uses;

(3) The applicant has established an isotope committee (composed of such persons as a radiological safety officer, a representative of the business office, and one or more persons trained or experienced in the safe use of radioactive materials) which will review and approve, in advance of purchase of radioisotopes, proposals for such uses; and

(4) The applicant has appointed a radiological safety officer who will advise on or be available for advice and assistance on radiological safety problems.

(f) *Special requirements applicable to general authorizations for processing.* An application for a general authorization to procure radioisotopes for use in processing for distribution to other

(f) *Royalty and rentals.* Leases under this section will be on a royalty-free basis. Rental shall be ten dollars ($10) per lease year per tract of 1,500 feet by 600 feet, or fraction thereof, payable in advance by certified check or money order made payable to Treasurer of United States, at the time of application for a lease and prior to the beginning of each lease year thereafter. No refund of rental will be made by the Commission to the lessee or lessees should the lease be relinquished or canceled as provided for in paragraphs (k) and (l) of this section. If an insufficient rental payment is made, the Commission may, at its discretion, select the tracts under the lease to which the payment is applicable.

(g) *Work requirements.* A condition of every lease entered into under this section will be the conduct on the leased premises of exploration, development or mining activities with reasonable diligence, skill and care for the purpose of achieving and maintaining maximum production of uranium ore consistent with good mining practice and the size of the deposit, unless other arrangements are specified in writing by the Commission. In any event, but not in limitation of the lease condition set forth in the preceding sentence, such activities must include for each 1,500 feet by 600 feet tract, or fraction thereof constituting a tract, one hundred dollars ($100) worth of labor performed or improvements made on or beneath the surface of the leased premises during each lease year. Labor performed or expenditures made in marking or posting the tract or tracts comprising the leased premises, expenditures attributable to travel of personnel to and from the premises and acquisition cost of equipment may not be applied to satisfy work requirements of the lease. A statement signed by the lessee or lessees must be submitted to the Commission within fifteen (15) days after the close of each lease year listing the work performed under the lease as measured in lineal feet of each type of drilling, cubic yards of surface excavation in rock, gravel, earth or other material, cubic feet of underground excavation, indicated by type, or other work performed or improvements made on the leased premises. Whenever cost of labor is used as a measure of work performed, the statement must include the name or names of the workmen performing the labor, date or dates on which work was performed and a description of the work performed. In determining the cost of labor, actual wage rates shall be used unless they are in excess of rates prevailing in the area for similar work at the time the work was done, in which case the prevailing rates shall be used for the purposes of this computation. Labor performed or improvements made on any one tract may be applied to not more than nine (9) additional contiguous tracts under the same lease in the order designated by the lessees. Labor performed or improvements made under one lease may not be applied to satisfy work requirements under any other lease issued under this section.

(h) *Size of lease.* Ordinarily no lease containing in excess of 100 tracts will be issued.

(i) *Lands to be in a reasonably compact body.* The area covered by a lease under this section should be in a reasonably compact body and will ordinarily consist of adjoining tracts or tracts closely situated to each other. No lease under this section shall convey extralateral rights.

(j) *Term of lease.* A lease issued under this section ordinarily will be for a term of five (5) years and renewable as to any or all of the tracts for not more than five (5) additional periods of three (3) years each upon written application made by a lessee or lessees in good standing within sixty (60) days prior to expiration of the lease or any extension thereof. If a tract leased under this section becomes open in whole or in part to location of mining claims under the United States mining laws during the lease term, the Commission may refrain from thereafter extending such lease as to the land so opened to such entry.

(k) *Relinquishment.* A lease or any of the tracts under a lease may be relinquished by the lessee or lessees by written notification sent to the Commission at its Grand Junction, Colorado, office. Relinquishment shall take effect on the date such notification is received by the Commission as evidenced by the written acknowledgment of the Commission. The lessee or lessees within fifteen (15) days of receipt of the Commission's acknowledgment of relinquishment shall file the acknowledgment in the office of the county recorder for the county in which such leased tracts are located.

(l) *Cancellation.* Should the lessee or lessees fail to comply with any of the terms and conditions of the lease within thirty (30) days after receipt of written notice from the Commission specifying such failure and requesting compliance, or should there be any falsification or misrepresentation of a material fact, whether or not intentional, in the notice of lease application or in the application for uranium mining lease, the Commission shall have the right to terminate such lease in whole or in part and the Commission shall then be entitled and authorized to take immediate possession of the affected land and dispossess all persons occupying the same under the authority of the lease.

(m) *Effective date of lease.* A lease issued under this section will ordinarily be effective as of the date it is signed by the Commission.

(n) *Assignment.* Leases issued under this section may be assigned as to all or any of the leased tracts subject to approval by the Commission. To procure such approval, all instruments of transfer of the lease must be filed at the Commission's Grand Junction, Colorado, office and must contain all of the terms and conditions agreed upon by the parties thereto. The application for approval of assignment must be accompanied by a statement of the assignee or assignees setting forth his or their qualifications to hold a lease and that he or they accept and agree to be bound by the terms and conditions of the lease, provided the assignment is approved by the Commission. No assignment of a lease will be approved which provides for royalties on uranium-bearing ore production from the leased premises which amount to more than fifteen percent (15%) of gross ore receipts, or which when added to royalties already created amount to more than fifteen percent (15%) of gross ore receipts. In calculating gross ore receipts for the purpose of this paragraph, development and haulage allowances payable pursuant to § 60.5 (Commission's Domestic Uranium Program Circular 5, Revised) or any further revision thereof or equivalent allowances will be first excluded. With the approval of the Commission, less than all the tracts described in the lease may be assigned. In such an event the Commission may require the execution of a new lease by the assignor or assignee or both. The Commission will not grant approval if it determines that the terms and conditions of the proposed assignment do not embody terms and conditions equivalent to those of the original lease to the extent applicable. After the effective date of approval, the assignee or assignees will be responsible for the performance of all such obligations.

(o) *Designation of representative.* When leases are issued or assigned under this section to a group of two or more persons or legal entities, they shall designate one person to represent them for the receipt of communications or notices or to make reports or statements on their behalf, together with the address of the representative. This designation shall be binding on the lessees until the Commission has received notice in writing from the lessees of a new designee and his address.

(p) *Initial production bonus.* The provisions of § 60.6 (Domestic Uranium

APPENDIX 8

Probable Course of Industrial Development of Economic Nuclear Power

(Excerpt of Statement by AEC Before the Joint Committee on Atomic Energy at Hearings on Proposed Amendments to the Atomic Energy Act, June 2, 1954)

In considering the proposed legislation, certain essential factors must be clearly recognized, namely:

1. That nuclear power is not yet an economic reality in the competitive cost sense, and
2. That the big job of driving costs down to levels competitive with conventional electric energy can best be accomplished by joint effort of both industry and Government as a working team.

Now, in order to gauge the size of the cooperative effort and the additional legislative authority required to establish a new atomic power industry, we should look ahead—as judiciously as we can—over the next 10 to 20 years to visualize what the probable course of development will be and what economic benefits seem likely to come with competitive nuclear power. No one, of course, can say with any assurance now how long it will take and how much effort will actually be needed to convert the present technical feasibility of nuclear power into future economic reality. Nor can anyone foresee now the shape of industrial development and the extent of benefits that may come from economic nuclear power.

These are strictly speculative subjects, about which there are certainly wide ranges of opinion. Yet, they are worth considering because the major changes in the basic legislation presuppose the desirability of accomplishing economic nuclear power soon, establishing a new source of electric energy, and doing this in the traditional framework of free, competitive enterprise.

It is proposed to state at length the results of our preliminary thinking and speculation on the probable pattern of industrial development and economic benefits. The results of our speculation are, of course, transient and replete with broad guesses, plausible presumptions, and personal judgments. No one, therefore, will take these comments as either predictions or considered judgments. They are neither. They are simply some working ideas presented to illustrate what may be in store, if nuclear power becomes economically worthwhile.

In summary fashion these are the key factors of national interest over the next 20 years or more in achieving and applying economic nuclear power:

First, is the matter of time. We are only now in the development stage. We have not yet reached the phase of competitive, commercial application. This is some years ahead. As mentioned earlier, the 5-year reactor program submitted to the committee is aimed at making competitive nuclear power a reality. If the goal is accomplished, our feeling is that only a small number of full-scale privately owned and operated power reactors are likely to be on the line before 1965—in other words over 10 years from now. Faster introduction may be possible, but without extraordinary measures of Government assistance, which we are not recommending, this time scale seems reasonable on economic grounds.

Second, is the Nation's future energy resource base. In the United States, the mounting demands for energy in all forms, the unpredictable long-term supply of fuels now in use (particularly oil and natural gas), and the limited number of

Division II: Gaseous Diffusion Project

Engineering Developments in the Gaseous Diffusion Process, vol. 16, edited by M. Benedict and C. Williams, 1949, describes a number of mechanical, electrical, and chemical engineering developments related to the operation and handling of materials used in the gaseous diffusion process—principally special plant instruments, vacuum engineering, development of heat-transfer equipment, and absorption of uranium hexafluoride and fluorine, 129 pages, $2.

Division III: Special Separations Project

The Theory of Isotope Separation, vol. 1B, by Karl Cohen, 1951, presents the theory of cascades as generally applicable to the problems of isotope separation. Different types of centrifuges and other methods of separation are also discussed, 165 pages, $2.50.

Spectroscopic Properties of Uranium Compounds, vol. 2, edited by G. H. Dieke and A. B. F. Duncan, 1949, presents data compiled from a comprehensive study of the absorption and fluorescence spectra of uranium compounds and describes the experimental techniques used in the studies, 290 pages, $4.25.

Physical Properties and Analysis of Heavy Water, vol. 4A, by I. Kirschenbaum, 1951, describes the physical properties of heavy water, chemical equilibria or exchange reactions and methods of isotopic analysis, 438 pages, $6.

Bibliography of Research on Heavy Hydrogen Compounds, vol. 4C, compiled by A. H. Kimball, edited by H. C. Urey, and I. Kirschenbaum, 1949, contains about 2,000 references to published literature on research with heavy hydrogen. References are arranged by subject with an index of the hydrogen compounds and authors, 350 pages, $4.75.

Production of Heavy Water, vol. 4F, edited by G. M. Murphy, is being compiled from works of other authors. It will present laboratory pilot-plant studies for various separation processes investigated and engineering surveys of actual production plants with descriptions of their operations. (In process.)

Division IV: Plutonium Project

Optical Instrumentation, vol. 8, edited by G. S. Monk and W. H. McCorkle, 1954, contains useful and practical techniques and methods of optical instrumentations in nuclear research. It is a summary of the optics work carried out as part of the plutonium project, 262 pages, $3.75.

Radiochemical Studies: The Fission Products, vol. 9, edited by C. D. Coryell and N. Sugarman, 1951, presents 336 original research papers on the techniques and results of radiochemical studies of uranium and plutonium fission products, 2,086 pages (in 3 parts), $27.75.

The Actinide Elements, vol. 14A, edited by G. T. Seaborg and J. J. Katz, 1954, is a companion volume to vol. 14B, Division IV, NNES, *The Transuranium Elements*, published in 1949, and summarizes available information on the elements in the actinide series. Also included is an Index for the Transuranium Elements, 870 pages, $11.75.

The Transuranium Elements, Research Papers, vol. 14B, edited by G. T. Seaborg, J. J. Katz, and W. M. Manning, 1949, includes 163 research papers on neptunium, plutonium, americium, curium, and several of the heavy elements related to them, and historical summaries of transuranium element research, 1,733 pages (in 2 parts), $23.75.

remaining major hydroelectric sites make the mastering of a new source of energy an essential goal. (In many other countries, where fuel for generating electricity is not available locally or is nearing depletion, the need for a new, economical energy source is even more pressing than in the United States.)

The principal effect of realizing economic power from nuclear fuel will be to establish a strong restraining force against the pressures toward higher cost of power owing to rising fuel costs. Any savings which use of nuclear power might bring over present power costs, particularly in high cost areas, would be valuable, but the prime contributions of nuclear power would be to help hold power costs down, to provide a new source of energy to meet, and perhaps help stimulate, rising demands in the last quarter of the century, and thus to assure that adequate electric power is available at reasonable rates to sustain continued national growth and well-being.

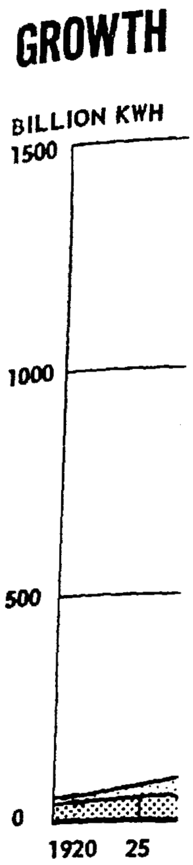
Third, we must consider what economically competitive nuclear power means in the United States, compared with other forms of energy, and how large the market for it may be. Reduction of costs of generating nuclear power is the key to emerging nuclear power in the next 20 years, or as long as fossil fuels remain cheap and abundant in this country. Unless generating costs can, by successful development work and operating experience of industry and Government be brought down to about 8 mills per kilowatt-hour, nuclear power would find little market on economic grounds in the United States. Even at a level of about 8 mills, the market would be confined to regions with high power costs, but these relatively high cost regions might provide locations for the first competitive nuclear power plants. To become widely competitive with efficient new steam electric plants in the United States, nuclear power generating costs would have to be reduced to the range of 4 to 7 mills per kilowatt-hour. Achieving such cost levels is not certain at this state in development, but the probability of success is good.

Fourth, is the question of displacement and impact on existing plants, labor, and capital investment. This is chiefly a matter of timing and the extent of cost reduction within the competitive range.

If cost reductions to the 4 to 7 mills per kilowatt-hour range are accomplished, say by 1965–70, several million kilowatts of nuclear power plant capacity could be placed in service by 1975. Projections of United States power demand by the Paley Commission indicate that total demand for electricity in 1975 will be about 1,400 billion kilowatt-hours, an increase of some 900 billion kilowatt-hours from present levels. (See Chart I.) In such a growth of generating capacity, from nearly 100 million kilowatts now to about 300 million kilowatts in 1975, tens of millions of kilowatts of nuclear power capacity could be absorbed without displacing any existing capacity.

The actual share of the increasing demand for electricity in the United States which may be supplied by nuclear power by 1975 will be directly affected by many factors, including the progress of the development effort, the level of costs achieved, and acceptance by industry. We believe that nuclear power can supply a portion of the growth of electric generating capacity. The Commission's staff has prepared studies showing results of nuclear power development at a moderate rate (2 percent of total electrical energy needed in 1975) and at a rather rapid rate (10 percent of total electrical energy needed in 1975). Today, no one can predict whether nuclear power in 1975 will represent 10 percent, 2 percent, or some other share of United States electrical output. But these illustrations indicate the scale that might be achieved if development is pushed successfully.

The gradual integration of nuclear power into the Nation's electric generating industry is not likely to be accompanied by significant dislocations. Even with



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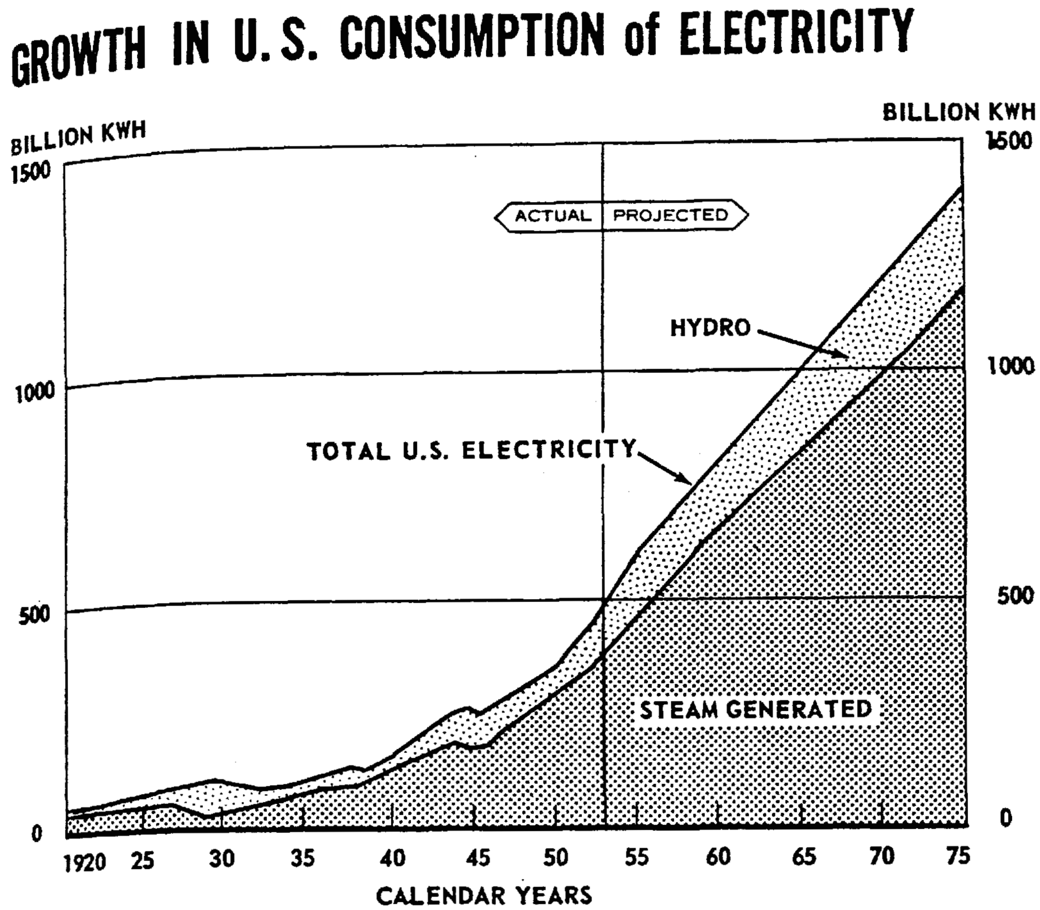

CHART I

nuclear power, consumption of coal for generating electricity is expected to triple by 1975, and demands on coal and on oil and natural gas in other industries and domestic uses will far outweigh any share of their market met by nuclear power.

Heavy power-consuming industries (such as aluminum and other electro-process industries) may find nuclear energy to have major direct significance, provided generating costs can be brought down to the low 4 to 5 mills level. The result then would be not to compete with present low-cost hydroelectric or gas-fueled power, but to enable continued growth as additional low-cost gas or hydroelectric sources become no longer available.

Fifth, nuclear fuel has certain technical characteristics that can yield strategically and economically unique benefits. The development of nuclear power can make special contributions to the national security and welfare. Existing differentials in energy cost between regions might be reduced, the availability and geographical dispersions of supplemental sources of nuclear weapons materials might be assured in wartime, and dependence of electric power generation in vital areas on vulnerable fuel transportation facilities would be reduced.

Finally, we must consider the possibilities of nuclear power in foreign countries. In many countries energy sources are scanty, more costly, or more nearly depleted than in the United States. The economic benefits of nuclear power in some foreign countries thus may appear earlier and be more pervasive than initially in the United States.

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Industrially underdeveloped countries, whose future economic growth is being hampered by inadequate or high cost fuels and electric energy, might benefit significantly if the technical and financial problems can be overcome. For the industrially advanced nations, encountering difficulty in continuing to secure adequate supplies of cheap fuel and electric energy in the face of diminished reserves and mounting costs for local or imported fuel, nuclear power development may prove to be a key element in future industrial growth.

The International Atomic Energy Agency proposed by President Eisenhower in his speech of December 8, 1953, before the United Nations General Assembly, offers a route whereby both industrially developed and underdeveloped nations can find help to overcome the technical and other barriers to the utilization of economic nuclear power. Progress of the United States in its development program, therefore, will be significant for other nations as well as the United States.

We would like to elaborate on some of these points, and others as well, which seem to warrant further comment, devoting special attention to the possible market for nuclear power to 1975, the economic effects on other fuels, on future electric energy supply, on employment opportunities, and the possible effect of peacetime atomic energy on our basic institutions.

Effect on Our Institutions

At present, atomic energy is a Government-owned industry. This departure from the normal pattern of industrial enterprise in the country was not undertaken capriciously or with intent to alter our institutions. It was deemed necessary to cope with the unique and unfamiliar characteristics of atomic energy and because its products then went almost entirely into our military arsenals. Continuance of complete Government dominance into the period of major peacetime applications, involving as it would a basic change in the fundamental roles of Government and of private individuals and firms, could produce a change in our society as significant in its way as any that might accrue from the technical novelty of nuclear power.

In order that the principal effect of realizing nuclear power may be to confirm and strengthen rather than to change our economic institutions and our way of life, we believe that nuclear power as it becomes economically attractive, should be integrated into the existing power economy of the nation; that nuclear power should be produced and distributed by the private and public power systems and not by the Commission.

The potentialities of atomic energy continue to be attended by problems of control which call for an unusual degree of Federal participation. Nevertheless, we are confident that the inescapable restrictions and safeguards which society must impose on the utilization of atomic energy can be made consistent with allowing freedom of initiative to power producers; that the special problems of atomic energy can, without risk to security or safety and without unfair advantage to any group be reconciled with the proper roles of industry and Government as conceived in this country.

The legislation which has been proposed has as its objective, as we see it, not only drawing on the skill and resources of American industry, but also integrating atomic energy with the established institutions of the Nation. Its provisions call for recognition of private ownership qualified only by the reservations necessary to protect the national security and the public health and safety and to assure that the advantageous position of individuals and firms already in the program is not a bar to widening future participation by others.

Obtaining full participation of the Nation's electric energy producers and equipment manufacturers in the development and production of nuclear power is in our judgment the best way of securing the maximum return on the public investment in this phase of the atomic energy program. The accumulated scientific and technical knowledge, as well as the accumulated stockpile of fissionable materials, now in the hands of the Government, are a national resource. Putting this resource to work, through continued Government development where necessary, and through private industry, to strengthen the economy—to create power for industry and homes, open up jobs, create new sources of revenue—will most quickly and surely achieve and spread its benefits.

Time-Scale for Realization of Economic Nuclear Power

Ultimate solution of the long and difficult problems standing in the way of economical nuclear power cannot be safely disassociated from the assistance industry is prepared to give. The reactor program would be in serious danger, in our judgment, if accomplishment of competitive atomic power costs were dependent solely upon the efforts of scientists and technicians in Government-owned facilities. The contributions of industry, sparked by the profit incentive, should be particularly great at the present stage of development where the task is to cut costs by experienced engineering and managerial judgment.

While the problems referred to will be difficult and costly to solve, their solution is foreseeable if they are attacked vigorously. Indeed, recent analysis of the potentialities of several different reactor powerplant designs indicates that, when reactors no longer require abnormal development costs and when costs of manufacturing nuclear plant equipment have been reduced, several reactor systems have a good chance of producing power at from 4 to 7 mills per kilowatt-hour in large 300,000-kilowatt plants. Such costs would be well within the range of existing generating costs.

Achieving such costs may be a matter of 10 to 20 years, and assumes operating and manufacturing experience, as well as successful design and testing. The first central station size reactor plant, recently authorized, will generate power at several times the 4- to 7-mill range.

The period until nuclear power becomes an economical competitor with traditional fuels and is chosen for this purpose by management, will be of indeterminate length. When this period will end will depend largely upon the degree of effort which is expended in Government and industry. If the effort is great enough, the development period will be as short as technological progress and its assimilation by power producers and equipment manufactures will permit. If the effort lags, we may not see economic nuclear power until the last quarter of this century.

But the achievements of 10 years in the atomic energy program to date make it possible to assume that after 10 years nuclear power will begin in the mid-1960's to be available from new nuclear plants at costs comparable to those to be encountered with new conventional plants in the higher cost power areas of the Nation.

This initial period of 10 years, we may also assume, will be sufficient not only for the accumulation of operating and cost data from the reactors in the current development program, but also for the financing, design, engineering, and construction of the first group of power-producing reactors.

The reactors which will produce this power at 7 mills per kilowatt-hour or less are likely to be 100,000 kilowatts of electrical generating capacity or larger. Small reactors—below 50,000 kilowatts and down to the 10,000- to 5,000-kilowatt range—are technically feasible, but are less likely to become sources of competitive central station power, since unit costs of generating power will be harder to bring down to competitive levels. Reactors of small size are most apt to come into use as "package plants" for isolated or strategic sites. In response to military interest, the Commission is now investigating the possibility of obtaining a fixed price bid to construct a small nuclear powerplant as the prototype of a "package" power-plant. Costs of power from such small reactors in time may be reduced to the level necessary for them to find a market outside of special strategic applications.

The Market for Nuclear Power

Reduction in the cost of nuclear power is the key to its place in our economy in the next 2 or 3 decades. Present energy sources, though not unlimited, are capable of meeting our expanding needs for energy for many years barring the unpredictable demands of war. After the development period, nuclear power will have to earn its way under competitive conditions. The Paley Commission, which foresaw a doubling of all United States energy requirements in the 25 years from 1950 to 1975 (see Chart II), and more than a trebling in consumption of electricity, concluded that these rising demands could be met with little or no increase in real costs, provided all conventional energy resources are used advantageously

But beyond 1975, the picture is more uncertain; it may be that approaching exhaustion of other energy sources will make atomic energy an indispensable alternate and make cost differences measured in 1 or 2 mills quite unimportant. Coal in the United States is abundant, but its cost and quality cannot be expected to remain at present levels in the face of indicated increases in demands of industry and utilities. Proved reserves of oil and gas are only 12 and 27 times present annual consumption, respectively, and in recent years the United States has drawn on imports for part of its petroleum supply.

Speculations about the future differ as to the exact timing and severity of the shortage of fuels; but there is no dispute that we are using them at a faster and

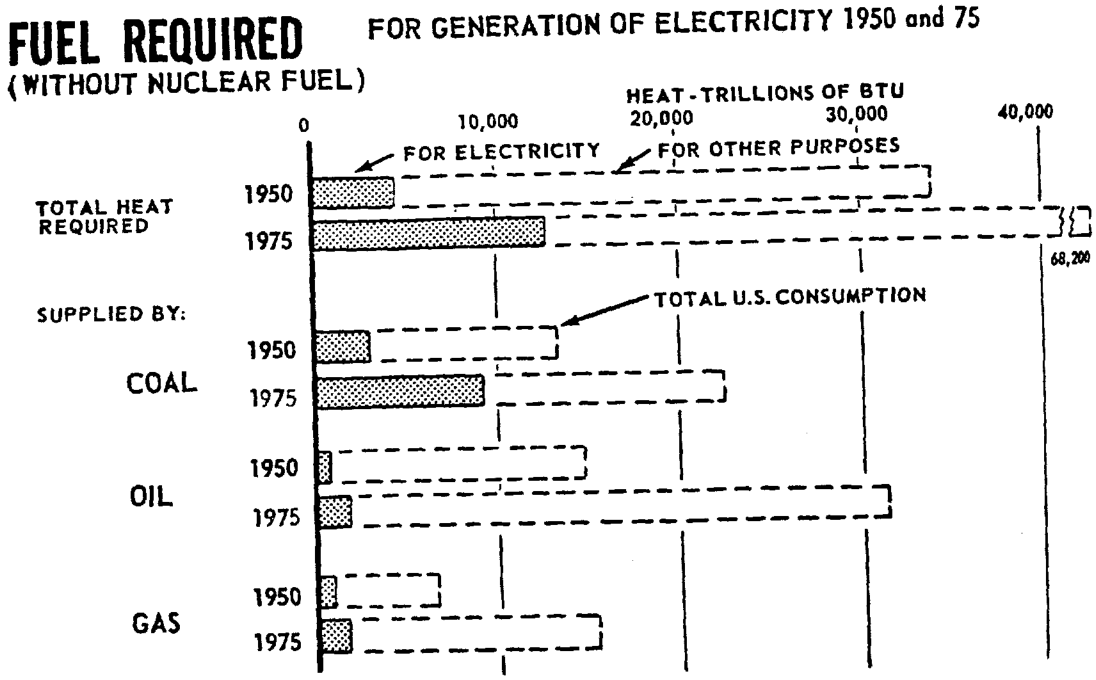

CHART II

faster rate. United States annual consumption of the primary sources of energy—fossil fuels, wood, and waterpower—quadrupled during the first half of the 20th century and is expected to double again before 1975. The energy potentially available in the world's recoverable reserves of uranium has been estimated as perhaps 23 times the energy from world reserves of fossil fuels: petroleum, natural gas, and coal.

Consumption of fuels in the United States, for all purposes, is expected to rise sharply between now and 1975: coal, from 522 million tons in 1950 to 815 million in 1975; oil, from 2.4 billion barrels to 5 billion; and natural gas from 6.3 trillion cubic feet to 15 trillion.

The fluid fuels, oil and natural gas, now furnish the major part of our total energy requirements, and by 1975 the proportion may be as high as 70 percent if supply permits. Demands on this scale, accompanied by gradually rising prices, might mean that oil from shales or synthetic fluids from coal would become competitive within the next 20 years. Such demands may not lead to early exhaustion of our energy resources, but they seem likely to affect in varying degrees the cost of fuels—more so for gas and oil than for coal. Coal reserves are ample to meet projected consumption far beyond 1975, but rapidly rising rates of consumption may require us to turn in the last quarter of the century to higher cost and lower quality coal.

In the face of the mounting pressure on our present energy sources, mastering of a new and potentially very large source cannot prudently be deferred.

The rapidly expanding market for fuels for the generation of electricity and other purposes, and the time required for nuclear power development, should allay fears that competing fuels, particularly coal, may be hurt by the entry of nuclear power into the market. The contribution that nuclear power can reasonably be expected to make toward total requirements for electric power by 1975 would do no more than moderate the already rapidly rising demand for conventional fuels.

Because fuel supplies to meet the future generation of electricity may have to be doubled or trebled, at the same time that demands on fuel for other purposes (heating, vehicles, manufacture, etc.) are also rising sharply, nuclear power is not a threat to the existing market for other fuels. Continually rising amounts of coal will be needed to supply electric generating facilities already in operation when nuclear power first becomes competitive and to fuel the larger share of new plants for an indefinite time thereafter.

Within the period until 1975, nuclear fuel can expect vigorous competition from other fuels for generation of electricity, and the market for nuclear power will be limited chiefly by the comparative cost at which it is available. To see just how important reduction of costs will be for the competitive position of nuclear power, we have examined the costs of generating power from new conventional steam plants, and can compare these with the range of 4 to 7 mills which is sought from nuclear plants. Clearly 4- to 7-mill nuclear power would be widely competitive: The Federal Power Commission computed for the joint committee that in 1952 the average production cost of steam-generated electric power in the United States was 7.4 mills per kilowatt-hour for the major utility systems. Such an average includes a wide range of costs for individual plants, varying with size, age, and efficiency of the plants and the extent to which they are used, the cost of fuel, and other factors. To see the competition nuclear plants must face, one must look not at this general average, but at the maximum performance of efficient new conventional steam plants, in comparison with which a nuclear plant would be evaluted by any management considering the kind of plant to build.

The range of generating costs in new postwar utility steam plants is wide—from just under 3 mills per kilowatt-hour to over 12 mills per kilowatt-hour. (See Table I.) But very little of the capacity (4 percent) in these new plants produces at more than 8 mills per kilowatt-hour, and the plants that do are relatively small, the largest being 80,000 kilowatts and most of them much smaller. Similarly, a minor part of the capacity (3 percent) can generate at less than 3 mills. Over 90 percent of the competition for nuclear power falls in the 3- to 8-mill range, and 70 percent falls in the 4- to 7-mill range which it is hoped will be achieved from nuclear plants.

TABLE I

Costs for Generating Electricity From New Postwar Utility Thermal Plants

Cost of generation (mills per kw.-hr.)	Capacity (000 kw.)	Percent of total	Cumulative (percent)
12–13	49	0.4	0.4
11–12	20	.2	.6
10–11	68	.6	1.2
9–10	67	.6	1.8
8–9	282	2.3	4.1
7–8	1,242	10.3	14.4
6–7	3,153	26.1	40.5
5–6	3,307	27.3	67.8
4–5	2,009	16.6	84.4
3–4	1,527	12.6	97.0
2–3	358	3.0	100.0
TOTAL	12,082	100.0	100.0

NOTES.
1. To put plants on a uniform capability basis, unit generating costs are computed on 12½ percent fixed charges, 95 percent plant factor.
2. Not reflected is the market now served by internal combustion units. While generating costs from such units, representing about 2 percent of total United States production of electricity in 1952, are generally above 8 mills and run as high as 20 mills or more, the plant size is under 10,000 kilowatts and usually much smaller.

SOURCE.—Prepared by AEC staff from data in *Steam-Electric Plant Construction Cost and Annual Production Expenses*, Fifth Annual Supplement, 1952, Federal Power Commission. All *new* postwar steam plants (but not additions to old plants) were included in the computation.

If these cost ranges are applied to the expected growth in demand for electricity, we can obtain a picture of the market into which nuclear power will enter between now and 1975. The amount of electricity to be required is the consumption forecast by the Paley Commission, or 1,400 billion kilowatt-hours in 1975, an increase to three and one-half times the 1950 consumption of 390 billion kilowatt-hours. The potential market for nuclear power within this overall total is considered to be a share of the new demand to be supplied by steam plants, plus a share of the steam-generating capacity to be built to replace wornout equipment. (See Chart III and Table II, p. 130.) Stability of generating costs is assumed, relying on continued increase in efficiency of conventional generating plants to offset rising costs of fuel. Examination of the potential market in this manner shows the importance of generating costs for the entry and rate of growth of nuclear power.

According to Federal Power Commission regions, the 1952 generating costs per kilowatt-hour in large new postwar steam plants fall in the following ranges:

Northeast	5½–8½ mills
East Central	4–7 mills
Southeast	3½–8½ mills
North Central	5–7½ mills
South Central	2½–5½ mills
West Central	4½–6 mills
Northwest	4–6½ mills
Southwest	5½–7 mills

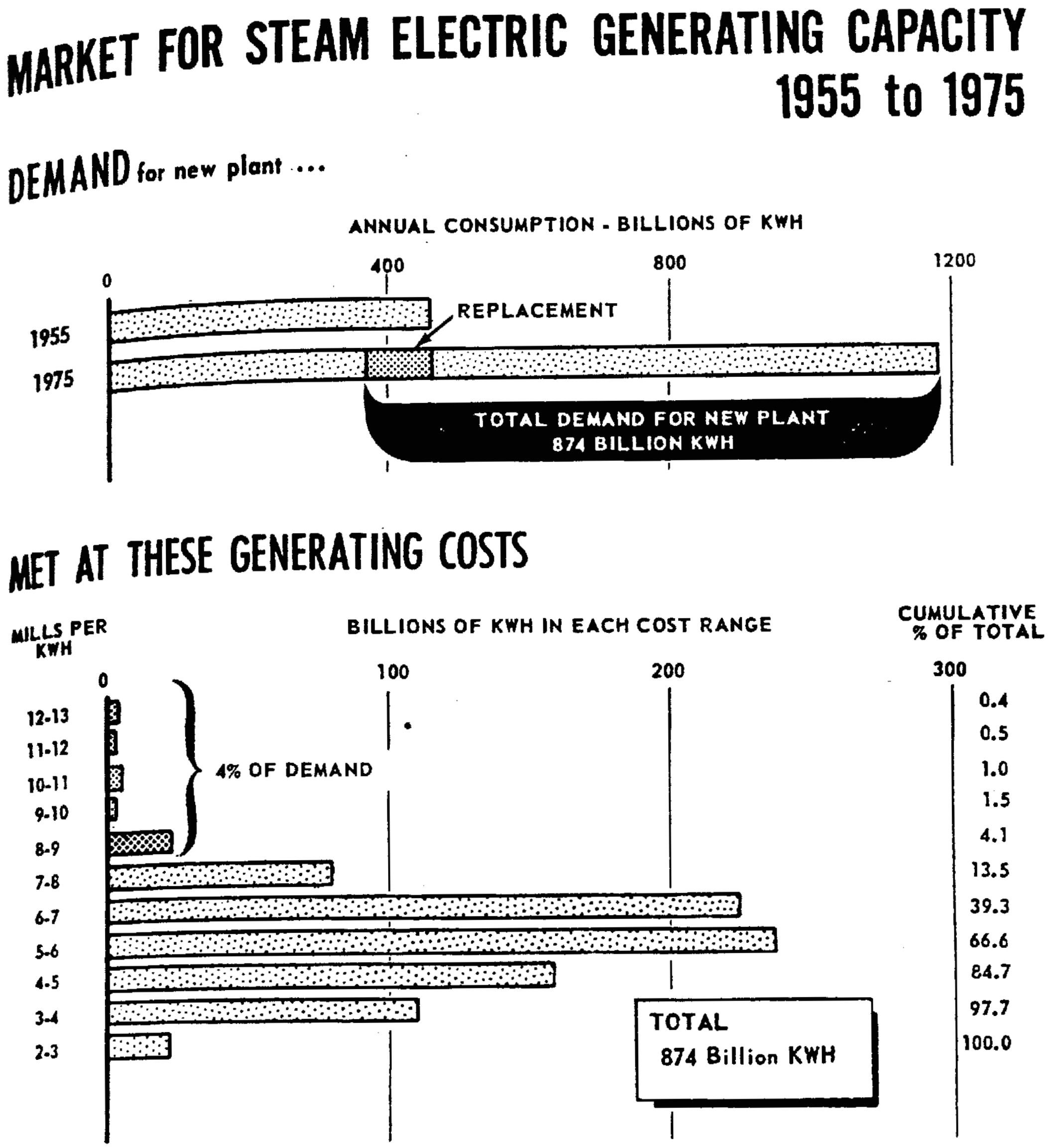

CHART III

Nuclear power at 7 mills would at most be competitive for part of the market in the Northeast, Southeast, and North Central regions of the United States Nuclear power at 4 mills, on the other hand, would be competitive, everywhere except for a part of the Southeast and South Central regions fueled with low-cost coal and natural gas. Even in the natural gas areas, future new generating plants may not be able to buy quantities of natural gas at the low prices that have in recent years made it possible to generate power at less than 4 mills.

It is clear that nuclear power will be able to compete more widely if rising fuel costs push up conventional generating costs; its potential market will be smaller if demand for new electric generating capacity rises less sharply and steadily than projected.

Possible Rates of Growth of Nuclear Power in the United States Economy

Within the range of possible costs for nuclear power, and the range of expected costs for generating power from conventional energy sources which have now been described, there are possibilities for widely varying rates of introduction of com-

TABLE II

Estimated Energy From New Steam Generating Capacity

(Generation from internal-combustion units, which comprise about 3 percent of capacity and 2 percent of total electric output, is ignored in this projection, since generating units are no larger than 10,000 kilowatts and are predominantly less than 5,000 kilowatts. Costs for utility plants from Table I are assumed to be applicable also to industrial power plants.)

1955–75

(Billions of kw.-hr.)

Mills per kw.-hr.	1950–55	1955–60	1960–65	1965–70	1970–75	1955–75 Billion kw.-hr.	1955–75 Percent
12–13	--------	1.0	0.7	0.8	0.7	3.2	0.4
11–12	--------	.3	.3	.3	.3	1.2	.1
10–11	--------	1.2	1.2	1.2	1.2	4.8	.5
9–10	--------	1.2	1.0	1.1	.9	4.2	.5
8–9	--------	5.5	5.7	5.7	6.0	22.9	2.6
7–8	--------	22.5	20.8	19.8	18.9	82.0	9.4
6–7	--------	58.5	56.0	54.9	56.2	225.6	25.8
5–6	--------	65.0	58.3	56.9	57.7	237.9	27.3
4–5	--------	40.2	38.3	38.9	41.0	158.4	18.1
3–4	--------	25.8	27.8	29.3	31.0	113.9	13.0
2–3	--------	4.8	4.9	5.1	5.1	19.9	2.3
Total energy from new capacity	--------	226.0	215.0	214.0	219.0	874.0	100.0
Energy from capacity at beginning of period	288	465	647	819	989	465	--------
TOTAL	--------	691	862	1,033	1,208	1,339	--------
Less retired capacity	--------	44	43	44	42	173	--------
Energy from total steam generating capacity at end of period	465	647	819	989	1,166	1,166	--------

petitive nuclear power into our energy economy, and widely varying rates of growth of a new nuclear power industry.

It is well to bear in mind also that the growth of the nuclear power industry, no matter how rapid, will happen case by case, as individual decisions to build plants are reached on developmental or economic grounds. In such decisions, the needs of particular areas and the characteristics of existing generating systems will be decisive, and an array of technical and economic factors will be balanced in each case.

The effects of competitive nuclear power will be closely related to its scale and rate of growth.

If we assume that our domestic technical program will be pushed and will be successful, what may be the impact on electric energy output between now and 1975?

Our staff has made studies of two specific cases for purposes of illustration. Both assume that a development program, including construction of several large nuclear power plants by the mid-1960's, will lead to the building of a growing number of nuclear plants generating power at competitive costs. The two illustrative cases differ with respect to certain other assumptions.

Case 1 assumes nuclear power costs at 7 mills per kilowatt-hour in 1963 falling to 4 mills by 1975. It further assumes that as power plants are built in different parts of the country, giving power at different costs, one-half will be nuclear if the costs are the same.

Case 2 assumes 7 mills per kilowatt-hour in 1965 falling to 5 mills in 1975. It further assumes that nuclear power plants will be built only if they have an advantage of 1 mill per kilowatt-hour over conventional plants.

Under these assumptions, the first competitive plants under case 1 would be producing power in 1963, and in case 2 in 1966.

In case 1, by 1975 the nuclear power component of the electric generating industry would have an installed capacity of 21 million kilowatts. On an 80 percent plant factor, such a capacity might generate 147 billion kilowatt-hours out of 1,166 billion to be generated from all steam plants in 1975. The share of nuclear power in the total projected electric generation of 1,400 billion kilowatt-hours in that year would thus be about 10 percent.

In case 2, with its less optimistic assumptions, the nuclear power share is, of course, smaller. About 5 million kilowatts of nuclear capacity would be in operation in 1975, generating about 35 billion kilowatt-hours. The share of nuclear power in total United States electrical output would be about 2 percent.

No one can say whether these or some other ratios will prove correct. Either case represents a sizable nuclear capacity: in one case 140 reactors, and in the other case 33 reactors, of 150,000 kilowatts average capacity would be in operation. Moreover, nearly half the new plants might be nuclear fueled on the more optimistic assumption, and one-sixth on the less optimistic. At such rates of building new nuclear capacity, the share of nuclear power in the generation of electricity would increase rapidly in subsequent years. To achieve such a place in electric generation in the United States, however, would, as these cases show, require reduction of costs for nuclear power to the low 4- to 5-mill level. At higher costs a much smaller share of the electrical output would be nuclear, on cost considerations alone.

Economic considerations will not, of course, operate by themselves in the development of nuclear power. The compactness of nuclear fuel, and its weapons importance, lead to special benefits for the national security and welfare. These special advantages may well justify the construction of the first nuclear power reactors in the initial development period when the competitive position of nuclear power on strictly economic grounds is uncertain. Looked at from the point of view of national security, for example, nuclear power plants would have the advantage over other power plants of being able to produce additional weapons material on need; they would not require extensive and vulnerable rail or pipeline facilities for fuel transport; they would facilitate strategic dispersal and decentralization of vital facilities.

Another factor which could affect both the time-scale and the benefits of nuclear power is the nonpower uses of reactors. Nuclear power involves using the heat released in the course of nuclear fission for the production of steam and the generation of electrical power. Reactor heat may have other uses, and the neutrons and radiation produced during nuclear fission may yield byproducts, of value in themselves or as byproducts reducing the net cost of nuclear power. Reactor heat may, for example, prove useful for heating buildings, or for industrial processes. Radiation either from reactor operation or from fission products may find commercial applications in industrial chemical processes or in the sterilization and preserving of foods. Neutrons from fission are now used in production reactors to produce plutonium; fissionable material could also be produced in power reactors. If, due to international conditions, national defense requirements for weapons material were to warrant a long-term Government market for byproduct fissionable material, the credit might make nuclear power commercially competitive even earlier than otherwise assumed, and would facilitate the initial growth of the industry.

The Pattern of the Nuclear Power Industry

The nuclear power facilities foreseen in these speculations would be an integral part of the electric generating activities of the country, not a separate new industry. The emergence and growth of nuclear power plants would occur in a period of general industrial expansion, in which generation of electric power would be expanding even more rapidly than the rest of the economy, in continuance of the trends toward use of a larger part of our energy as electric power and toward use of more electric power for each worker. New nuclear plants would thus not have to overcome the obstacles in the way of a technological innovation which displaces existing facilities.

It is to be expected that nuclear power plants would tend to find their chief markets in those regions of the country having relatively high power costs. While regional differences in construction and operating costs for reactors of the same type would exist and would prevent the cost of power from nuclear fuel from being absolutely uniform throughout the country, the regional differences in cost from nuclear plants should not be great, and should be far less than the present variations, mentioned earlier.

Nuclear powerplants, because of their size and the importance of high plant factors for low unit generating costs, are likely to be built first near heavy power consuming centers. Assimilation of nuclear plants with their large size (100,000 to 300,000 kilowatts or more) will be facilitated by the trend in the electric generating industry in recent years toward larger generating units and stations. Much development work will need to be done before small nuclear plants producing at competitive costs can be built to meet small loads, and if fixed charges constitute a relatively large part of generating costs for such plants, their economics will be unfavorable as compared with conventional plants wherever plant factors are low.

Nuclear power may provide utility systems with somewhat more flexibility in some respects in selecting sites for new generating stations, if we assume that safety considerations and exclusion areas are not more restrictive than for conventional plants. Because nuclear plants do not require shipment of bulky fuel, they can be located at sites for which solid fuel transportation would be a restricting influence. Aside from the coal transportation factor, however, nuclear power plants will be subject to most of the predominant plant site factors that determine the location of conventional plants, such as adequate quantities of cooling water, local ordinances for health and safety, cost of land, and proximity to load. The probable future pattern of plant location in most metropolitan and industrial centers may, therefore, not be greatly modified by the introduction of nuclear power. Competitive nuclear powerplants, installed to meet the large power demands characteristic of metropolitan and industrial centers, would be located, as is true of most new conventional generating capacity, near but not in such centers.

Electric energy from nuclear reactors will probably be distributed over the same facilities as other power. The use of nuclear fuel rather than conventional fuel will cause differences for the utilities and supporting industries rather than the consumer. The principal new elements for the electric generating industry will include:

a. *Byproducts.* Reactors for generating power will also produce fissionable material. This material will have a value either as a fuel or as a weapons material which may contribute significantly to reducing the net cost of power.

   Other byproducts with commercial value might be heat for industrial or residential uses, radiation, and fission or other products. Development of important uses of byproduct heat and radiation would affect location of power reactors and the appearance of associated industries.

b. Raw materials. Adequate supplies of uranium and thorium are essential to the growth of nuclear power. It appears that the supply of such raw materials should be ample to establish and maintain a nuclear power industry of the magnitude described in this report, unless military requirements go far beyond those now foreseen. Emergence of a growing nuclear power industry is a matter of direct interest to the uranium mining industry of the nation, as a potential market for its product.

c. Supporting industries. Special materials will be required for construction of reactors; among these are zirconium, graphite, and heavy water. Until the preferred types of reactors are determined in the course of development, however, it is not possible to specify which of these materials will feel the heaviest demands on its growth capabilities.

Service industries will probably be established to perform in common certain highly technical functions, such as fabrication of fuel elements, disposition of radioactive wastes, and chemical separation and recovery of fissionable materials and fission products from power reactors. Initially, existing Government facilities may perform these services, charging fees which will not discourage the development of private facilities independent of the Commission.

Effects on Economic Growth and Power Consuming Industries

In turning to the effects of the emergence of a nuclear power industry, we are considering the impact within the established electric power industry of a new fuel which, beginning in about 10 years and growing steadily in importance, may be supplying on the order of 2 percent to 10 percent of the electricity generated in 1975. If power from other fuels rises more rapidly in cost than has been expected, the entry of nuclear fuel would, of course, be encouraged. It may also exert a strong restraining force on the trend toward rising power costs due to fuel charges.

The value of a restraining force exerted against rising power costs is difficult to measure, since we cannot be sure how far costs might rise without a new fuel. The size of the stake can be indicated, however, by considering the fact that 1,400 billion kilowatt-hours may be required in 1975, so that if nuclear power were capable by that time of reducing the average cost of electricity by only one-quarter of a mill (or of forestalling an increase of this amount) the saving would be $350 million annually. Even more difficult to measure is the loss of industrial output and other goods that would result from regional shortages of power. It is in countering such events as rising costs and stringency in power supplies that nuclear power can be expected to be most useful, rather than in any sharp reduction of present electric bills.

For the great majority of electric-power consumers, nuclear power promises to put a brake upon power costs which might otherwise rise due to rising fuel costs, and to give added assurance of the availability throughout the nation of adequate power supply at reasonable cost. In some areas where the level of fuel costs is so high as to require high retail rates with accompanying low consumption, nuclear power can, by cutting fuel costs, stimulate the growth of new power consumption and thus lead to reduced unit transmission and distribution costs as well.

Only for industries in which power is a large element of cost, mainly the electro-process, chemical and primary light metal producing industries, does it seem possible that nuclear power could have (given success in reducing costs) a substantial impact on industrial location of future new plants, by releasing these industries from orientation to existing areas with low-power costs. In addition, as cheap hydroelectric power becomes no longer available for continued expansion of the aluminum industry or other electroprocess industries, cheap nuclear power may help sustain further growth without sharp increases in the total cost of production in these industries.

For industry generally the effect of nuclear power seems likely to be to reduce further the declining importance of power cost as a factor in plant location as geographical variations in cost of electric energy are reduced by nuclear power. Power costs and their effect upon net income will, of course, be carefully evaluated by management, but other important factors influencing industrial location will also weigh heavily. That these other factors will often outweigh power cost considerations is indicated by the small part which power costs, essential though power is, represent in the overall costs of business. For example, in 1951 the cost of purchased electric energy by all manufacturing industries totaled $1,458 million for 146.5 billion kilowatt-hours, and was equivalent to only 1.4 percent of the total value added by manufacture, $102,085 million.

As we consider the technical development which must still be carried to success, and the expanding need for power in the United States, we see no basis for fear of revolutionary impact on the nation's economy. We have given attention in particular to the concern expressed in 1946 by the Senate Special Committee on Atomic Energy, in explaining the inclusion of Section 7 (b) in the draft Atomic Energy Act: the fear that

> ". . . the sudden introduction of certain devices utilizing the power released by nuclear fission might precipitate profound economic disorganization. Great industrial installations representing nationwide investments employing many thousands of workers might be rendered obsolete." (Senate Report No. 1211, 79th Cong., p. 20.)

Stringencies in the United States economy are, in fact, likely to come from too little low-cost power, rather than from introduction of a new fuel. The generation of electric energy has to more than triple to support a doubling of gross national output by 1975 according to the Paley Commission's estimates.

Employment Opportunities

The availability and steady expansion of low-cost power is crucial to maintaining high employment levels, for industrial production cannot increase without power. Just as maintenance of our standard of living is dependent upon industrial expansion supported by great increases in power facilities, so increasing employment and labor productivity over the next several decades will be dependent upon a continually rising level of industrial activity. Rapid development of nuclear power provides one more assurance that new investment in power capacity will contribute to the creation of jobs and to higher output and earnings per worker. Nuclear power will add to, rather than detract from, job opportunities.

Adverse effects, if any, on existing labor skills will be small. Unconventional materials, equipment, and operating techniques will require new skills, but these new demands on labor should be readily met during the gradual course of development. The 10-year experience in building and operating major atomic energy facilities illustrates labor's ability to direct existing skills quickly to this new technology with no adverse effects. In view of future rapidly rising demands for power and for conventional fuels, labor dislocations are unlikely from nuclear power.

With our continuously increasing population and labor force, the United States must maintain an ever-increasing level of production, employment and income. The rate of production of goods and services, and the supply of power to feed production, must be kept rising more rapidly than the rate of increase in our labor supply if we are to avoid unemployment. Nuclear power can contribute in some measure to this end, by helping to assure that low-cost power is available to support continued industrial expansion.

The Long View

It is evident from the preceding discussion that, even on the challenging assumptions we have made as to the growth of nuclear power, we must look beyond 1975 for the full contribution nuclear power may make to the economy. A 20-year projection, while as long as is prudent on the basis of available data and the uncertainties of technical development, is a short period for an industry like the power industry where plant life may be 40 or more years.

The benefits of nuclear power ultimately to be expected will be measured in other ways in addition to the possible dollar savings in cost of industrial production or in fuel costs of electric utilities. While the more remote and indirect benefits cannot be assessed now, we are confident that if nuclear power reaches the low-cost range of four to five mills, it will lead ultimately to a variety of economic and attendant social benefits, some of which may be striking individually and all of which would be significant taken together. These benefits might include the following examples:

1. Nuclear power may help make it possible to undertake large new industrial activities at sites that would otherwise be uneconomic in the face of punishing transportation charges or the absence of transport facilities for conventional fuels.
2. It may provide an economic solution to the problem of providing additional cheap electric energy in locations where the demand is expected to outrun the availability of hydroelectric power and fossil fuels are lacking.
3. It may permit and perhaps encourage the development of strategically decentralized areas of industrial production requiring low-cost electric energy.
4. It may provide blocks of electric energy for Government and military installations where the cost of power is important, but not controlling in site selection.
5. It may help electric utility systems in metropolitan areas to adjust to such limiting factors as rail transportation and smoke nuisance arising from a major increase in electric energy generation from coal.
6. It may contribute in some measure to the introduction of new production techniques in electroprocess industries.
7. It may become technically feasible and economic for commercial propulsion purposes, such as for powering merchant ships.
8. It will take on increasing importance as a strong force both in holding down energy costs as exhaustible resources are used up and in assuring the availability of fuel for continued economic growth.
9. It may stimulate consumption of electricity beyond present projections and accelerate the trend toward using a larger portion of our energy in the form of electricity.
10. A sound basis will be established for assisting other nations in applying nuclear power for economic development.

Power in Other Nations

Thus far our comments have been directed almost exclusively to the effects of competitive nuclear power in this country. For many other nations, the need for a supplementary fuel is more immediate than for the United States. The cost and difficulty of the development work which must be done to realize economic nuclear power are barriers to the hopes of other countries for early benefit from nuclear power, though the proposals made by the President in his speech of December 8, 1953, before the United Nations General Assembly offer a possible way of helping overcome these barriers.

We can mention only briefly here what nuclear power might mean to other nations, and some of the problems of financing and of general economic development which industrially underdeveloped nations in particular will have to solve to take advantage of nuclear power when it becomes available.

Electric power is essential to modern industry and living in all nations who have undertaken industrialization. Expansion of generating capacity to meet mounting demands is proceeding at a more rapid rate in the rest of the world than in the United States. Between 1948 and 1951, electric generation rose by 29 percent in the United States, by 36 percent in Europe, and by 33 percent in the world as a whole.

Continuation of such a rate of increase in generation of electricity, together with rising demands for fuel for transportation and industry, is putting growing pressure on the energy resources of many nations. Reserves of coal, oil and natural gas are unevenly distributed throughout the world. Among consuming nations able to meet less than half of their consumption of coal and oil from indigenous sources are: Italy, Portugal, Greece, Norway, Sweden, Denmark, Finland, Argentina, Algeria and French Morocco, Ceylon, and Pakistan. A few of these fuel-deficit countries, such as Norway and Sweden, are utilizing waterpower to meet part of their present electric energy needs. However, as demands continue to grow and the best hydroelectric sites are fully developed, these countries, too, will need to begin importing increasing tonnages of fuels.

In other areas, coal and oil are as yet being produced in sufficient tonnage to meet the bulk of local requirements and also to satisfy the export market. Nevertheless, since exploitation of lower cost, better quality, and more accessible deposits have already in some cases proceeded to an advanced stage, many coal producing countries are themselves facing problems of rising production cost. Examples are such coal producers as Belgium and the United Kingdom.

In addition to the growing needs for a supplementary fuel, cost considerations thus underlie the interest of many countries in nuclear power. While precise cost data are difficult to obtain, imported or low-quality fuels are usually high power-cost fuels, and power is thus more costly in many nations than in the United States. Even in the United Kingdom, for example, to mention a nation with an efficient and large scale generating system, the newest and most efficient plants can generate electric power at 6.6 mills per kilowatt-hour in areas with low-cost coal. In the highest delivered coal cost areas, the newest and most efficient plants are now producing power at approximately 7 mills per kilowatt-hour. These best costs, which have the advantage of a low tax burden, are significantly above the low-cost modern gas- or coal-fired plants in the United States, many of which generate power for from 3 to 5 mills per kilowatt-hour even with a higher tax burden.

In less highly industrialized countries, high present costs of generation may often be traced to small or inefficient plants or to low, irregular loads which result in high unit costs. In such cases, of course, nuclear plants would not operate at full economy, and indeed might not prove feasible.

For underdeveloped countries power supply represents only one of a number of problems accompanying efforts to achieve greater industrialization and economic diversification. Even where fuel resources are available, there arise difficulties in obtaining investment capital and foreign exchange to support the import or equipment for establishing power systems. Problems also arise of keeping power development and the development of local markets in balance.

In view of the worldwide potential importance of nuclear power as a supplementary source of power, the progress of the United States in its development program can be significant for other nations as well as ourselves. President Eisenhower's proposal to the United Nations General Assembly offers hope to other nations of the world that, while their own efforts will be crucial to the mastery of nuclear power for the service of their own economies, they will not have to make their way alone in this complex and costly field. Supported by a free and vigorous private and Government development effort in this country, the International Atomic Energy Agency proposed by the President can demonstrate anew that the creative energy of the American system can contribute to the development of other nations as well as our own.

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