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PUBLIC WORKS APPROPRIATIONS FOR 1969

FOR WATER AND POWER RESOURCES DEVELOPMENT AND THE ATOMIC ENERGY COMMISSION

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HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

NINETIETH CONGRESS

SECOND SESSION

SUBCOMMITTEE ON PUBLIC WORKS

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EUGENE B. WILHELM, *Staff Assistant to the Subcommittee*

PART 3

U.S. ATOMIC ENERGY COMMISSION

Printed for the use of the Committee on Appropriations

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THE ATOMIC ENERGY COMMISSION

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PUBLIC WORKS APPROPRIATIONS FOR FISCAL YEAR 1969

TUESDAY, APRIL 23, 1968.

U.S. ATOMIC ENERGY COMMISSION

WITNESSES

GLENN T. SEABORG, CHAIRMAN
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VICTOR CORSO, ASSISTANT CONTROLLER FOR BUDGETS
ROBERT H. BAUER, DEPUTY ASSISTANT CONTROLLER FOR BUDGETS

Mr. KIRWAN. Gentlemen, we have before us today the Atomic Energy Commission and are pleased to welcome Dr. Seaborg and his associates.

Do you have a statement, Doctor?

Dr. SEABORG. Yes, sir.

Mr. KIRWAN. Please proceed.

Dr. SEABORG. Thank you.

GENERAL STATEMENT

Dr. SEABORG. Mr. Chairman and members of the Appropriations Committee, the members and the staff of the Atomic Energy Commission are pleased to appear once again before you to present our fiscal year 1969 budget request.

Since the Commission's program directors in presenting their programs to the committee will be prepared to discuss the details of our budget estimates, I would like to concentrate in this statement on major program considerations underlying the budget.

Before talking about dollars, however, I would like to point out the heavy defense orientation of this year's budget. Almost 80 percent of the increase over 1968 appropriations results from increases in weapons operating costs and construction funding. Our weapons and naval reactors operating programs account for over 40 percent of our total operating appropriation request. If one prorates the portion of our special nuclear materials which will be applied to military purposes, this percentage becomes even greater. Also, planned obligations in fiscal year 1969 for only one construction project—additions to weapons production facilities—in the amount of $184.5 million are more than one-half of our total 1969 appropriation request for new construction funds.

The budget document before you reflects our appropriation request as submitted to Congress. We requested appropriations in fiscal year 1969 totaling $2,754,600,000, or $245,467,000 more than the amount appropriated for fiscal year 1968. Our appropriation request included $2,225,600,000 for operating expenses, an increase of $85,600,000 above the 1968 appropriations and $529 million for plant and capital equipment, an increase of $159,867,000 over the 1968 appropriations.

Recent passage of our authorization act has affected our appropriation request as follows. The total appropriation request for fiscal year 1969 is reduced $75,299,000 to $2,679,301,000. Our adjusted appropriation request includes $2,174,550,000 for operating expenses, a decrease of $51,050,000, and $504,751,000 for plant and capital equipment, a decrease of $24,249,000. I will call your attention to specific changes made in the authorization process as I come to the appropriate programs.

The major increases in our appropriations request result from our weapons program activities. Operating costs for the weapons program increase about $118 million with well over one-half of the increase being in support of increased test activities at the supplemental test sites and the Nevada test site in support of laboratory development effort. The remaining portion of the increase is for weapons production and research and development activities. Also, the construction estimates include $184.5 million to provide additional new weapons production facilities, largely for the Poseidon and Sentinel programs. This amount is in addition to the $100.5 million appropriated in fiscal year 1968 for new weapons production facilities.

The authorization legislation added $8,500,000 for naval propulsion reactors to enable the Commission to proceed with the design and development of an advanced nuclear propulsion plant for a new class of attack submarines.

I also should mention fiscal year 1968 reductions made as part of the Government-wide effort and their effect on our fiscal year 1969 appropriation request. We made reductions and deferrals of Commission fiscal year 1968 obligations which totaled $269.6 million and were required to meet the ceiling on AEC's fiscal year 1968 obligations as established by Public Law 90–218. The reductions were made in operating expenses in the amount of $69.7 million, and our fiscal year 1969 appropriation request has been reduced by this amount through the application of the unused funds to our request. The deferrals were made in equipment obligations in the amount of $36.6 million and in planned obligations for line item construction projects in the amount of $163.3 million. These deferrals impose difficult but manageable scheduling problems on our various offices and contractors. These deferred funds are required to support authorized programs of the Commission.

I would now like to talk briefly about each of the various budget programs.

RAW MATERIALS

Fiscal year 1969 operating costs for the raw materials program are estimated at $112.5 million. This represents a decrease of $15.3 million or 12 percent from the fiscal year 1968 level. Procurement of uranium concentrates in 1969 is currently projected at about 8,000 tons and will be obtained exclusively from domestic producers. Purchases during the first half of the fiscal year will be at the present price of $8 per pound of U_3O_8. As a result of negotiation of the stretchout contracts, the price will drop during the second half of the year to an average of about $5.90 per pound.

The raw materials program budget also includes an item of $600,000 to fund selective research and development contracts in uranium geology, geophysics, geochemistry, and uranium extraction techniques. Current nuclear power projections indicate that requirements for uranium will increase very rapidly in the future. Industry is responding to this challenge with a substantial exploration effort which we expect to be fruitful. However, in view of the expected growth in uranium requirements, we believe it important to continue to carry out a program of investigation of the scientific aspects of uranium deposition and ore discovery techniques to help assure an adequate and economic nuclear fuel supply.

SPECIAL NUCLEAR MATERIALS

Operation of the Commission's production complex for converting source materials to special nuclear materials and for producing other products for military and peaceful programs is estimated to cost $334.3 million in fiscal year 1969. This is about $6.4 million below the fiscal year 1968 estimate and reflects a continuation of the downward trend in costs for this program. The estimate includes funds for the purchase of plutonium produced in domestic power reactors, chemical processing of spent reactor fuels in commercial facilities, and continuation of research and development efforts directed toward achieving program objectives in a safe, economic, and efficient manner as well as for improvement of existing products and processes and development associated with production of new materials of national importance. The estimate also includes about $2.5 million for safeguards and materials management activities reflecting an increased emphasis and effort toward achieving an effective safeguards program.

The 1969 estimates take into account the shutdown of two more production reactors—one at Richland and one at Savannah River—this past February. This cutback action, which results in an estimated $16.5 million savings in 1969, followed a review of projected military and civilian requirements and a determination that currently projected requirements could be met with the seven reactors remaining in operation—four at Richland and three at Savannah River. On January 1, 1969, the combined usage of electric power at the diffusion plants at Oak Ridge, Paducah, and Portsmouth will be reduced to the previously announced level of 2,000 megawatts.

The budget also provides for the startup of the UF_6 feed plant at Paducah early in the fiscal year to convert production reactor tails to UF_6 for use as feed to the diffusion plants. To the extent economically justifiable, we have been using during the past 3 or 4 years our inventory of partially depleted diffusion plant tails as the cascade feed. This source of feed will be exhausted in early fiscal year 1969. The feed plant to be put back in service at Paducah is the one that was shut down in June 1964 as a result of the production cutback announced in January 1964.

Obligations for plant and capital equipment in 1969 were estimated at $34.8 million. Included were a powder metallurgy facility and waste storage tanks at Savannah River for $700,000 and $3.5 million, respectively; an equipment test facility at Oak Ridge for $3.9 million; $2.1 million for calcined waste storage facility additions at Idaho; $6.7 million for general plant projects; and $17.9 million for capital equipment not related to construction. The latter two estimates provide only for the most essential plant modifications, minor construction projects, and equipment replacements and additions needed for continued safe and efficient operation of the overall production complex. The equipment test facility at Oak Ridge was not provided for in the authorization act.

WEAPONS

The weapons program operating costs for fiscal year 1969 are estimated at $840.8 million. This is an increase of $118.3 million over the estimate for fiscal year 1968. This increase is made up of $25.9 million

for production and surveillance activities, $20.6 million for research and development programs, and $71.8 million for testing of atomic weapons.

The amount budgeted for production and surveillance is $270.7 million. This is the estimated amount required to produce new weapons for the stockpile as determined by the Department of Defense (DOD) and approved by the President, and for surveillance and maintenance of the nuclear weapons stockpile. The increase in the production estimate over fiscal year 1968 is required to support production activities necessary for new weapons required by the DOD.

The operating cost of $250 million budgeted for the weapons research and development program will provide the weapons development activities required to meet current DOD requirements, the advanced research needed to extend weapons technology to maintain the Nation's nuclear weapons superiority and to maintain viable laboratories, one of the basic safeguards under the limited test ban treaty.

The budget amount for weapons testing activities is $320.1 million, an increase of $71.8 million over the fiscal year 1968 level. This estimate includes funds for the underground testing program at the Nevada test site, the continuation of the testing program at the supplemental test sites, the maintenance of our atmospheric test readiness posture, and the test detection activities under the Vela program. Of the $71.8 million increase, $40 million is for the increased activity at the STS. This is consistent with the plan we discussed with the committee last year for the development and use of sites at Amchitka Island in Alaska and in central Nevada. The remainder of the increase is needed primarily to provide underground testing at NTS in support of the laboratory development effort.

The weapons program request for new obligational authority under plant and capital equipment totals $294.7 million of which $215.4 million is required for new construction projects and $79.3 million for capital equipment not related to construction. The amount requested for new construction projects includes $184.5 million to provide additinal new weapons facilities at the present production plants to produce weapons of new types and designs, including the Poseidon and Sentinel systems. This is being added to the $100.5 million project for new production facilities approved in fiscal year 1968. The increase in this project is related to the decision last September to deploy a thin ABM system (Sentinel) and a better definition of the design parameters related to the Poseidon and other systems.

The capital equipment estimate of $79.3 million includes $18.1 million for production, $35.2 million for research and development, $14.5 million for full-scale testing, and $11.5 million for general support equipment. Included in the total amount is $20.7 million for computers needed for the increased program activities.

REACTOR DEVELOPMENT

The 1969 reactor development operating cost estimate of $509.5 million was $27.4 million above the 1968 estimate of $482.1 million. The authorization process has reduced our budget by $7.3 million to $502.2 million. I will briefly summarize the major programs and amounts proposed for fiscal year 1969 including changes resulting from the authorization legislation.

Civilian power reactors

For the civilian power reactor program, our fiscal year 1969 estimate was $132 million, an increase of $13.5 million over the $118.5 million for fiscal year 1968. The authorization process has reduced our request by $1.4 million to $130.6 million. These estimates indicate the high priority the Commission has assigned to its national responsibility of making the most effective use of energy available in nuclear fuels.

Research and development will continue on advanced converter-low gain breeder reactors. Funds are included to initiate fabrication of an advanced light water breeder reactor (LWBR) core to demonstrate breeding in a light water reactor system. It is planned to install this core in the existing Shippingport reactor plant. The LWBR program is an approach for significantly increasing the fuel utilization of light water thermal reactors based on the proven technology of the pressurized light water system. In fiscal year 1969 we are also increasing selected efforts and studies on future molten salt breeders. The objective of this effort is the development of molten salt breeder reactor systems to the extent required for realistic evaluation of their industrial potential for producing economic power while operating with low fuel doubling times. The molten salt concept may be able to operate with good neutron economy and, when combined with onsite fuel reprocessing, have a potential for attractive fuel costs.

In further implementing the most effective use of energy available in nuclear fuels, a substantial increase of $16.9 million is provided to the Commission's highest priority civilian nuclear reactor program, the fast breeder program (FBR). A most important objective of this program is to foster the development of a competitive and self-sustaining fast breeder reactor industry. This objective will require strong industrial understanding of the many interrelated FBR technological and in-depth design problems. The increased program will provide nuclear fuel procured from industry for the experimental breeder reactor-II. It will also continue the fuel development for the fast flux test facility, a primary facility in the FBR program that will provide a controlled and instrumented fast flux environment for testing of fuels and materials. Other increases will provide industrial involvement in specific engineered components and experimental testing facilities along with continued procurement from industry of plutonium fuel for critical physics facilities.

Cooperative studies on combination nuclear power desalting plants will continue along with studies of industrial and agro-industrial complexes using nuclear energy centers.

Cooperative power reactor demonstration program

The fiscal year 1969 estimate for the cooperative power reactor demonstration program is $27.7 million, a slight increase over fiscal year 1968. Again this year, approximately half of the estimate provides for the cooperative arrangement with the Public Service Co. of Colorado for the high-temperature, gas-cooled reactor authorized in fiscal year 1966. Support of the nuclear power desalting arrangement with the Metropolitan Water District of Southern California which was authorized last year is also provided. In addition, costs for the initial dismantling of the Piqua facility are included.

Naval propulsion reactors

The fiscal year 1969 operating cost request for the naval propulsion reactors program was $115.3 million. The objective of the research and development carried out in this program is to provide advanced nuclear propulsion plants for installation in Navy ships ranging in size from small submersibles to large combatant surface ships, and to develop reactor cores of higher energy density and longer life which will ultimately last the lifetime of a ship.

Work will continue in fiscal year 1969 on development of a longer fuel life reactor for application to dual-reactor, nuclear-powered aircraft carriers, and on an advanced destroyer-type core for present and improved destroyer plants. Since January, when the budget was submitted, the Department of Defense has agreed to go ahead with the nuclear frigate (DLGN–37) which Congress authorized last year. This is a major step forward in the application of nuclear power to escort ships for nuclear aircraft carriers.

The authorization legislation added $8.5 million in fiscal year 1969 to initial funding for the research, development, design, fabrication, and testing of an advanced nuclear propulsion plant for a new class of higher performance attack submarines. These funds were added by the JCAE following hearings held on the status of United States and Soviet nuclear submarine programs. With respect to the current year, we have proposed reprograming $3 million to AEC research and development activities in the interest of accelerating work on this concept.

Space propulsion systems

The fiscal year 1969 operating expenses budget request for the Rover program was $72 million. The Authorization Act has reduced our request by $3 million to $69 million. The program is proceeding with the development of an approximately 75,000-pound-thrust, 1,500-megawatt NERVA I engine and the completion of the technology phase with the testing of the XE–2 experimental engine scheduled in late fiscal year 1969. The testing of the NRX–A6 reactor in December 1967 for 60 minutes at full power represents the achievement of a major milestone. The technology program has provided the basis of design information for the engine development program.

The development program in fiscal year 1969 will concentrate on the design, fabrication, and testing of NERVA I engine system components. Systems studies and design effort is being initiated in fiscal year 1968.

Space electric power development

The space electric power development program budget for fiscal year 1969 before passage of authorization legislation was $52.7 million; slightly below the 1968 level of $55.5 million. In the area of radioisotope thermoelectric generator development, the first radioisotope thermoelectric generator to be used by NASA (SNAP–19B) is being readied for flight on the Nimbus–B weather satellite which is currently planned for launch next month. The development of the radioisotope power source (SNAP–27) for the Apollo lunar surface experiment package (ALSEP) is proceeding satisfactorily, and the first flight system was delivered to NASA earlier this month.

In fiscal year 1969, the SNAP-27/ALSEP effort will be completed with the delivery of four additional flight systems to NASA. System development will begin in response to a request from the DOD for a lightweight radioisotope thermoelectric generator for use aboard operational Navy navigational satellites. We also plan to strengthen the technological effort aimed at extending the utility of radioisotope systems into significantly higher power ranges.

In the space reactor effort, fabrication and assembly of a zirconium hydride ground test reactor will be completed in fiscal year 1968 and operational demonstration will begin in fiscal year 1969, as will nonnuclear testing of a thermoelectric converter, a solid-state power conversion device for ultimate use with a zirconium hydride reactor. The development of thermionic converter components for reactor application and system design studies are continuing. In fiscal year 1968, the program has emphasized development of a long-lived thermionic fuel element. In fiscal year 1969, it is anticipated that the first long-term in-pile tests will be completed on diodes which incorporate the features required in a thermionic reactor. These activities are the necessary precursors to a reactor experiment which we expect to initiate in the early 1970's.

The authorization legislation reduced the budget request by $5 million; principally by postponing development of a 250-watt generator and by terminating the high-power liquid metal-cooled reactor project at the Lawrence Radiation Laboratory, Livermore.

Other reactor development programs

We are requesting $9.4 million for other reactor programs, approximately the same level as last year. Grouped under this activity is our work in the terrestrial electric power development for $6.8 million, Euratom for $2.5 million, and merchant ship reactor programs for $100,000.

Primary emphasis in fiscal year 1969 will be directed at the development of advanced terrestrial raidoisotope power systems to satisfy a demand for unattended long-lived power systems. In fiscal year 1969, effort will be intensified with the fabrication and testing of a radioisotope surface generator. Selected experimental efforts under the Euratom program will also continue during the fiscal year.

Supporting technology

Included under supporting technology are the budgets for general reactor technology, advanced systems research and development, and nuclear safety. Again this year, I cannot stress too strongly the need for these efforts to assure experimental success and provide adequate understanding of reactor system safety. Continued support of these objectives is required in order to strengthen our highest priority programs by resolving critical technology problems and providing a base for major reactor projects. It is also necessary in order to discharge our responsibilities in our regulatory functions.

Our budget reflects a request for $50 million in fiscal year 1969 for general reactor technology, an increase of $1 million over fiscal year 1968. The authorization act has reduced our request by $2 million to $48 million. This activity, as you know, develops base technology on reactor fuels and materials, reactor engineering, physics and chemistry. Irradiation of fuels and materials in our new advanced test reactor will require additional funding.

Eight million dollars is requested for advanced systems R. & D., a slight decrease from fiscal year 1968. However, the authorization act reduced our request by $1 million to eliminate the R. & D. associated with the Argonne advanced research reactor which was rescinded by that act. Continued support of experimental technology will continue in fiscal year 1969 on the ultra-high-temperature reactor experiment and the advanced plutonium fuels programs.

For fiscal year 1969 we requested $40.4 million for nuclear safety, an increase of $7.1 million over 1968. The authorization process has reduced this activity by $3.4 million to $37 million. Our priority objective under this program is improved safety assurance of reactor systems. Increases are required to provide for continued demonstration of the reliability and integrity of engineered safety features directed to central station nuclear powerplants; augmented development of standards, codes and specifications; the procurement of fuels for both the loss of fluid test program and the power burst facility; and safety efforts in support of the advanced reactors programs, particularly for the fast breeder reactor.

Reactor development construction and equipment

Total new obligations for plant and capital equipment for the reactor development program were estimated at $99.5 million, which included $60.9 million for construction projects and $38.6 million for capital equipment not related to construction. I have referred previously to the fast flux test facility for which we are requesting appropriation of $35 million in fiscal year 1969. This amount when added to prior year appropriations will total $63.5 million for this key fast flux environmental test facility of the FBR program. The objectives for the fast flux test facility are to provide an adequately controlled and instrumented environment in a fast flux for testing instrumented fuel specimens, fuel rods, fuel subassemblies, and clad material with capabilities to test fuel for short periods and up to and including failure. Closed and open test loop facilities, interim nondestructive examination facilities and a nuclear proof test facility are also envisioned in the overall complex. We are also requesting $10 million for an urgently needed multianalytical examinations facility for candidate FBR fuels and materials at Idaho; $2 million to provide such items as a failed fuel locator system, nuclear core instrumentation and a package loop for fuel testing in EBR–II; $11.4 million for general plant projects; and $1 million each for Rover test plants and modifications to existing reactors. The authorization legislation does not provide for a proposed $525,000 project at Argonne National Laboratory for conversion of the heating plant to natural gas. The $38.6 million proposed for capital equipment is necessary to support the various reactor research and development programs discussed.

PHYSICAL RESEARCH

Basic research in the physical sciences is supported under the physical research program. Our objectives are to develop a deeper understanding of natural phenomena, and to reduce them to fundamental principles through which known facts can be understood and new principles can be predicted. As you know, research investigations are conducted in the fields of high-energy physics, medium-energy physics, low-energy physics, mathematics and computers, chemistry, metal-

lurgy and materials, and controlled thermonuclear research. The knowledge we gain through the support of research in these areas is the foundation upon which our technological and engineering advances are built.

Operating

Our fiscal year 1969 request for operating costs was $280 million, which was an increase of $15 million, or about 5.7 percent, over fiscal year 1968.

The authorization process reduced operating costs by $3 million—$1 million for high energy physics, $1.3 million for chemistry research, $300,000 for metallurgy and materials research, and $400,000 for controlled thermonuclear research—leaving a total program increase of $12 million. About one-half of the increase ($6 million) is related to the high-energy physics program. Of this amount, $2,750,000 is earmarked to permit the Stanford linear accelerator, which became operational in fiscal year 1967, to be brought up to normal utilization. Based on the improved level of operations reached during the latter half of this fiscal year, we hope to achieve an operating schedule of approximately 15 shifts per week during fiscal year 1969. An increase of $1,450,000 is for research and development activities on the 200 Bev accelerator, which will include fabrication and evaluation of models, and computations, experimentation, and measurements required to develop specifications for the accelerator subsystems. Increases requested for the alternating gradient synchrotron (AGS) at Brookhaven, the zero gradient synchrotron (ZGS) at Argonne, the Princeton-Pennsylvania accelerator (PPA), and the Cambridge electron accelerator (CEA), will permit operation at about the fiscal year 1968 level, with emphasis on newly developed research capabilities.

In medium-energy physics, we are requesting a net increase of $500,000. Within this category, an increase of $600,000 is planned for research and development work on the Los Alamos Meson physics facility (LAMPF). Major tasks to be undertaken include extensive life testing of the radio frequency system, assembling a prototype injector, and developing target area systems. An increase of $300,000 is requested for preresearch buildup to prepare for experimental utilization of the 400 Mev electron linac at MIT, which is scheduled for completion in fiscal year 1970. Phaseout of the synchrocyclotrons at Rochester and Carnegia-Mellon Universities, together with other minor changes, will result in a net savings of $445,000.

In the controlled thermonuclear research program, we are requesting an increase of $2.1 million over the $24.9 million level for fiscal year 1968. Included in the request is a $700,000 increase in normal or base program operating funds and $1.4 million (for a total $2 million) for the fabrication of major new experimental devices including (1) the Scyllac at the Los Alamos Scientific Laboratory, (2) the superconducting multipole at the Princeton Plasma Physics Laboratory, (3) a superconducting open system device at the Lawrence Radiation Laboratory, and (4) the first phase of improvements to the Astron device.

The balance of our program includes an increase of $3.4 million for low energy physics, mathematics and computers, chemistry, and metallurgy and materials. In all of these programs, we are eliminating less productive research activities to permit higher priority projects to move forward. However, considering the effects of inflationary trends

and increasingly sophisticated experimentation, we believe this increase will just about enable us to maintain the level of activity attained in the previous fiscal year.

Plant and capital equipment

Our request for plant and capital equipment obligations totaled $89,075,000. Of this amount, $30,850,000 was proposed for capital equipment not related to construction, a decrease of $8,450,000 from the fiscal 1968 estimate. Construction items make up the balance of $58,225,000. We requested $7 million to provide for necessary accelerator and reactor improvements, for general plant projects, and for air pollution control modifications to the heating plant at the Brookhaven National Laboratory, and $26.2 million to continue the scheduled construction work on the Los Alamos Meson physics facility which was authorized in fiscal year 1968 at a total estimated cost of $55 million. An $800,000 project for modifications to the heating plant at the Brookhaven National Laboratory was not provided for in the recently enacted authorization act for fiscal year 1969.

200 Bev accelerator

The final construction item provides $25 million of new obligational authority to continue design and to begin construction of the proposed 200 Bev accelerator laboratory. We are also requesting $4.1 million of operating funds and $700,000 of capital equipment funds for research and development in support of the construction of the accelerator and the laboratory.

I am pleased to be able to report that the design which was evolved for the 200 Bev accelerator is a very ingenious and economical one. Last year in hearings before this committee, we were talking about a 200 Bev accelerator having an intensity of about 1.5×10^{12} protons per second, one-tenth the intensity we felt the machine should ultimately have, and having the built-in, optional capability of increasing both its intensity and its energy at a later time. Encouraged by Congress to assure the higher intensity and to strive for energy expansibility, and recognizing the current fiscal stringencies, the designers sought for the most economical design consistent with these goals. They developed a new, highly efficient magnet design which results in a smaller, lighter magnet which can be housed in a smaller tunnel, and which results in significant cost savings in both the magnet and the tunnel.

The lighter magnet and tunnel, together with a newly developed automatic alinement system, obviates the need for supporting piles and results in further savings. As a consequence of these and other economies, within an estimated construction cost of $250 million, the designers have been able to propose a design for the accelerator which provides (1) an energy of 200 Bev (2) the full intensity of 1.5×10^{13} protons per second and (3) the potential to increase the energy of the accelerator to about 400 Bev with only minimal incremental expenditures at a later time.

This work is being carried out at the National Accelerator Laboratory (NAL), which is utilizing resources of the Lawrence Radiation Laboratory (LRL) in Berkeley, Calif. NAL is presently located at Oak Brook, Ill., near the site chosen for the accelerator, and is managed by the Universities Research Association, Inc. (URA).

The response of the scientific community to the challenge of the new accelerator has been gratifying. Dr. Robert R. Wilson, Director of NAL, has succeeded in assembling an outstanding staff recruited from many of the high-energy laboratories in the United States. R&D models of magnets and accelerating systems have been fabricated and are under test at both NAL and LRL. The design of the linear accelerator injector, which will be very similar to that of the Brookhaven AGS conversion injector, has progressed to an advanced state, and plans call for procurement in the next weeks of an engineering prototype of the low-energy accelerating cavity with its associated equipment. This prototype, costing about $1 million, is necessary to finalize design parameters for the whole linear accelerator injector.

200-BEV ACCELERATOR—LINAC PROTOTYPE

I would like to emphasize this point. Procurement of these components is essential to the successful design effort of the whole linear accelerator project. Under ordinary circumstances we would have no hesitation in proceeding with this procurement under our AE authorization.

However, in view of the action of this committee to limit our fiscal year 1968—200-Bev effort to AE only, when we had requested authority last year to initiate procurement, we want to be especially sure that the committee clearly understands that the procurement involved is truly a part of the AE effort and not an attempt to circumvent the intent of the committee in acting on our fiscal year 1968 request.

Mr. MORRIS. You are speaking now about the prototype, is that correct?

Dr. SEABORG. Yes; that is right. We have now reached the point in our architect-engineering work for this facility where construction should go forward. New obligational authority of $25 million in fiscal year 1969 will permit NAL to proceed with construction on an economical and timely schedule.

BIOLOGY AND MEDICINE

Research to answer questions about the biological effects of radiation on man and his environment is of increasing importance because of the growing number of practical applications of nuclear energy including civilian power. We requested operating costs of $92.1 million for the biology and medicine program, an increase of about $3.6 million over 1968. The authorization process reduced our request by about $2.6 million to $89.5 million.

AEC programs in environmental quality control contribute substantially to the national effort in this important area. We hope to strengthen these programs and to increase the effective use of facilities and talents at AEC laboratories to achieve national goals in pollution control. Particular attention will be given to problems associated with the exposure of uranium miners to radiation and to other studies of the long-term effects of low levels of radioactivity. These studies will be expanded as necessary within the available funds, and we are maintaining close liaison with the Public Health Service, and the U.S.

Bureau of Mines to assure that the related objectives of these agencies are carried out in conjunction with our own program.

Our program on the effects of radiation on human beings is being examined in context with other programs to determine whether proper balance and adequate levels of support are being maintained. This program includes the Atomic Bomb Casualty Commission, the radium exposure cases, uranium miners, workers exposed to plutonium, and persons exposed accidentally or therapeutically to high doses of external radiation. Expansion of these important projects is most difficult under a stringent budget. We are actively studying alternative methods for reducing the level of overseas spending in support of the Atomic Bomb Casualty Commission. We feel strongly that the reduction must not compromise the scientific excellence of this program.

It is impossible to interpret the effects of radiation on plants, animals and man without an understanding of the way in which radiation interacts with living organisms to produce damage at the molecular and cellular level. An example of new insights being gained from such basic research is the recent discovery of a long-lived, highly reactive, excited state of oxygen ("singlet oxygen") produced by radiation. This discovery elucidates a mechanism by which damage occurs and provides a rational basis for attempted intervention to prevent damage. Basic studies of this type will be pursued as vigorously as possible.

We also hope to take advantage of important new developments in nuclear medicine, including the availability of short-lived isotopes for diagnosis and the use of fast neutrons for cancer therapy. In planning these new developments, it is to be noted that over the years the review process of the biology and medicine program has resulted in support of the most worthwhile projects of direct relationship to AEC's programmatic mission. An even more stringent review will be applied in keeping with the planned level for fiscal year 1969.

The budget for 1969 includes $5 million for capital equipment, a reduction of $1 million below last year's level. There are no major construction projects but approximately $1 million is requested for general plant projects.

TRAINING, EDUCATION, AND INFORMATION

The estimated operating costs for this program were $17 million, an increase of about $0.6 million over fiscal year 1968. This proposed increase was eliminated in the authorization process and fiscal year 1969 operating costs will be held to the fiscal year 1968 level. The primary purposes of this program are to increase the number of trained people in the nuclear field and to disseminate information related to nuclear science and technology.

Included in the training and education area of this program are provisions for specialized courses, postdoctoral fellowships and traineeships, graduate fellowships, faculty training institutes, use of AEC laboratories for educational purposes, nuclear training equipment grants, nuclear materials assistance for universities, operation of the Puerto Rico Nuclear Center and assistance to State and local governments in radiation control.

The objective of the information activity is to effectively communicate scientific and technical information throughout the Atomic

Energy Commission, to its contractors, to other Government agencies and their contractors, and to students, private industry and the general public.

The objectives of such communication are to increase the effectiveness of Government-sponsored research and development, to promote commercial use of innovations resulting therefrom, to encourage interest and confidence in the peaceful uses of nuclear energy in the United States and abroad, and to stimulate the purchase and use of U.S. nuclear equipment and materials by foreign countries. I know of no activity, which over the long run offers so much hope for the expansion of scientific knowledge as the contined development of more effective techniques of communication of scientific and technical information about nuclear science and technology.

The estimated plant and capital equipment obligations for fiscal year 1969 of $820,000 include $225,000 for general plant projects at the Puerto Rico Nuclear Center and $595,000 for capital equipment not related to construction.

ISOTOPES DEVELOPMENT

The isotopes development program is concerned with the development of beneficial uses of radioisotopes and radiation. Operating costs requested for 1969 were $7.2 million, or $190,000 less than estimated for the current year.

The Congress, in authorizing our fiscal year 1969 program, increased operating costs by $800,000 to provide for the initiation of the second phase effort toward the development of an implantable radioisotope heat engine for powering a heart pump. The prospects for developing such an engine within the current state of the art appear to be good. It is estimated that of the tremendous number of American fatalities per year due to heart disease approximately 100,000 of these could be helped if circulatory support systems were available.

Emphasis within our proposed program in 1969 will be on nuclear techniques directed to environmental control problems, including water management and pollution. Also, the following major projects will continue to be emphasized: (1) development of ultrapure fuels for isotopically powered circulatory support systems; (2) development of methods for identifying the origin and determining the fate of atmospheric sulfur pollutants; (3) investigation of the basic properties of thulium-170 as a potential fuel for space nuclear auxiliary power; and (4) systems development for the application of radioisotope decay heat to spacecraft life support needs.

Other areas of program effort will be continued in 1969 at approximately the same level of effort. These include applications of radioisotope tracer and analytical techniques to marine, national security, and aerospace problems, and the use of radiation as a source of energy for the production and processing of materials. Fundamental efforts to develop radioisotope production and materials technology, and work on the radiation preservation of foods, will continue at a somewhat reduced level.

Obligations for capital equipment estimated at $1 million are included in the budget in 1969. No new construction projects are included for this program.

PLOWSHARE

A total of $14.5 million was requested in the operating budget for the civilian applications of nuclear explosives program, also known as Plowshare. These funds support activities directed toward developing and demonstrating peaceful applications for nuclear explosions in civil works, industrial uses, and scientific studies. The fiscal year 1969 estimate of $14.5 million for operating costs was a decrease of $3.5 million from the fiscal year 1968 estimate of $18 million. The fiscal year 1969 estimate of $14.5 million will permit the program to continue to advance the technological progress achieved in fiscal year 1968 which included the successful execution of three major projects: Gasbuggy, Cabriolet, and Buggy–I. The Joint Committee in its report on our fiscal year 1969 authorization, recommended an increase in operating costs of $2.5 million to $17 million for this program in support of excavation activities.

The successful execution—on December 10, 1967—of the 26-kiloton Gasbuggy experiment highlighted Plowshare's industrial applications effort during fiscal year 1968. As was expected, Gasbuggy has heightened industrial interest in the natural gas stimulation technique and in other possible underground engineering applications of Plowshare. In fiscal year 1969, we are requesting $100,000 to conclude Gasbuggy and an additional $1.4 million to allow the Commission to embark—with private industry—on at least one, and possibly two, other joint projects from among those already proposed. These include experiments to study further natural gas recovery, to create underground storage, to fracture oil shale in-place to permit retorting, and to fracture low-grade copper ore bodies to permit in-place leaching.

About $7 million, or approximately half of the operating budget is planned to support the nuclear excavation program. The fiscal year 1969 cratering activities are aimed at extending the results of the fiscal year 1968 Cabriolet and Buggy–I experiments to develop a further understanding of cratering phenomenology and a capability to accurately predict the size and shape of craters. The major fiscal year 1969 activity in this area is planned to be Project Schooner, a nuclear point charge cratering explosion in hard rock at a yield of tens of kilotons to 100 kilotons. This project and the rest of the AEC's excavation effort is oriented and timed to contribute to the Atlantic-Pacific Interoceanic Canal Study Commission's assessment of the feasibility and costs of excavating a sea-level canal across the American Isthmus employing nuclear explosives.

I have here some preliminary results from the Cabriolet and Buggy–I cratering experiments which this committee might find of interest. We also plan to provide photographs to the committee of the two craters during the detailed program discussion.

Project Cabriolet, a 2.5-kiloton nuclear cratering experiment in hard rock, was conducted on January 26, 1968, on the Nevada Test Site (NTS). Preliminary evaluations indicate that the explosive performed as expected, successfully creating a crater approximately 360 feet across and 120 feet deep. The amount of radioactivity released beyond the throwout areas was very small. Data were acquired in most of the associated experimental programs, but complete evaluation and analyses will take several more months.

94–075 O—68—pt. 3——2

Project Buggy–I, conducted on March 12, 1968, on the Nevada Test Site, marked a very significant step in the excavation program. Buggy–I was this country's first nuclear row-charge cratering experiment and involved the simultaneous detonation of five 1.1-kiloton nuclear explosives, spaced 150 feet apart at a depth of 135 feet, in hard rock. The explosion produced a smooth-sided ditch about 65 feet deep, 250 feet wide, and 860 feet long. Radioactivity levels beyond the crater and throwout area were very low.

Plowshare designed scientific experiments round out Plowshare's field program for fiscal year 1969 and $500,000 is requested for this purpose. These experiments—done in conjunction with nuclear detonations conducted for other purposes—are designed to study the mechanism of producing new transplutonium isotopes, and possibly new, very heavy elements, or to allow for neutron physics measurements of materials of interest to power reactor designers and research scientists. It is believed that this level of effort will return significant technical information.

Capital equipment authorization requested to support the Plowshare program in 1969 is estimated at $0.5 million and includes initial funds for a specially designed, stream-lined and simplified operational equipment system to conduct those Plowshare projects located off the Nevada test site. No new construction projects are included for this program.

COMMUNITY

The operating cost request of $6.9 million for the community program consisted of $4.3 million at Los Alamos, N. Mex., for assistance payments estimated at $3.2 million and for support of other municipal activities estimated at $1.1 million, and $2.6 million for assistance payments to the former AEC communities at Oak Ridge, Tenn., and Richland, Wash. The Authorization Act reduced our request by $150,000.

PROGRAM DIRECTION AND ADMINISTRATION

This program covers the costs associated with the technical direction and management of AEC operations and the discharge of regulatory functions of the Commission.

The operating costs for this program in fiscal year 1969 were estimated at $102.9 million and provided for salaries, travel, and other costs of Federal employees at the Washington headquarters and the field offices. The Authorization Act reduced operating costs by $500,000 to about $102.4 million.

Employment at the end of fiscal year 1969 is projected at 5,952, an increase of 140 employees above the strength of 5,812 planned for the end of fiscal year 1968. The increase of 140 positions is to provide primarily for needs in the weapons, reactor, and regulatory programs. In making this request to increase employment, careful consideration has been given to the Commission's activities and the relative priorities of each. To the extent practicable, increased manpower requirements will be met through internal adjustments of staffing.

The increase of 140 positions represents those needs which cannot be met through such redeployment.

Plant and equipment obligations of $2,052,000 include $1,812,000 for capital equipment and $240,000 for modifications and alterations to the existing facilities at the headquarters.

CONCLUSION

This concludes my opening statement. I will be pleased to answer any questions the committee may have. My fellow commissioners, the general manager and other members of the staff are also available to answer any questions you may have and to discuss our programs and budget estimates in further detail.

Mr. KIRWAN. That is a very interesting statement, Doctor, and very well prepared.

Dr. SEABORG. Thank you.

EFFECT OF STRETCHOUT

Mr. KIRWAN. You mentioned the reductions and deferrals made in the current year program under Public Law 90–218 totaling $269.6 million.

How serious has been the effect of this action on the AEC program?

Dr. SEABORG. I would say rather serious. It has made it necessary for us to postpone a number of very worthwhile programs, and also to cut back in operating expenses, of course, for programs which are not recoverable.

However, as I indicated in my prepared statement, these are deferrals that we can live with. We certainly recognize the importance of such deferrals and the budget stringency which led to them.

UNBUDGETED ITEMS ADDED IN AUTHORIZATION BILL

Mr. KIRWAN. The authorization legislation includes provision for some unbudgeted items including the $8.5 million for the development of the attack submarine reactor.

Do you plan to request the submission of budget amendments to cover any of these add-on items in the authorization bill?

Dr. SEABORG. No, the Commission does not propose to submit budget amendments to fund these items. As we view the Joint Committee action, even with the additional items provided in their report, sufficient reductions were made in other portions of the AEC budget submission to more than offset the increased funds required by the added items and, technically, budget amendments are not necessary to fund these items.

However, it is clear that before we can proceed with the additions made by the Joint Committee it will be necessary for the Appropriations Committees of the Congress to provide the funds in our appropriation.

1969 REQUEST FOR WEAPONS TESTING

Mr. KIRWAN. One of the large items in the budget request is $320.1 million for weapons testing, an increase of $71.8 million over the current year.

I would appreciate your elaborating somewhat on why such a large amount is essential in fiscal year 1969.

Dr. SEABORG. Yes. This requirement is due chiefly to our need to develop the nuclear warhead for the ABM missile and the more versatile warhead for the Poseidon, and to some extent warheads for the Minuteman and other missiles, in consonance with national policy and at the request of the Department of Defense.

I can give you a breakdown of that $320.1 million. It breaks down to $156,900,000 for on-continent testing; $104,300,000 for the supplemental test sites, Alaska and central Nevada; $20 million for the off-continent test readiness program; $33,400,000 for the expenses of the participation of the laboratories in these programs, and $5.5 million for test detection activities.

Mr. KIRWAN. I think it would be helpful if we insert in the record at this point a summary of the fiscal year 1969 AEC budget, which also reflects the changes made in the authorization bill by the Joint Committee on Atomic Energy.

(The information follows:)

SUMMARY OF FY 1969 AEC BUDGET
(In Thousands)

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Operating Expenses:					
Raw Materials Program	$ 127,733	$ -15,263	$ 112,470	$ -	$ 112,470
Special Nuclear Materials Program	340,670	-6,367	334,303	-	334,303
Weapons Program	722,450	118,340	840,790	-100 1/	840,690
Reactor Development Program	482,103	27,417	509,520	-7,350 1/	502,170
Physical Research Program	265,000	15,000	280,000	-3,100 1/	276,900
Biology and Medicine Program	88,450	3,601	92,051	-2,571 1/	89,480
Training, Education and Information Program	16,422	587	17,009	-637 1/	16,372
Isotopes Development Program	7,375	-190	7,185	800	7,985
Civilian Applications of Nuclear Explosives Program	17,965	-3,465	14,500	2,450 1/	16,950
Communities	6,771	171	6,942	-150	6,792
Program Direction and Administration	95,313	7,572	102,885	-580 1/	102,305
Security Investigations	6,795	-207	6,588	-	6,588
Cost of Work for Others	11,219	3,314	14,533	14,505	29,038
Total Program Costs, Funded	2,188,266	150,510	2,338,776	3,267	2,342,043
Change in Selected Resources	7,561	48,118	55,679	-20,625	35,054
Gross Obligations	2,195,827	198,628	2,394,455	-17,358	2,377,097
Revenues Applied	-66,464	-32,652	-99,116	-23,692	-122,808
Net Obligations	2,129,363	165,976	2,295,339	-41,050	2,254,289
Unobligated balance, start of year	-59,110	-10,629	-69,739	-10,000	-79,739
Unobligated balance, end of year	69,739	-69,739	-	-	-
Transferred to General Services Administration	8	-8	-	-	-
Appropriation - Operating Expenses	$ 2,140,000	$ 85,600	$ 2,225,600	$ -51,050	$ 2,174,550
Plant and Capital Equipment:					
Construction			352,960	-23,249	329,711
Capital Equipment Not Related to Construction			176,040	-1,000	175,040
Total Appropriation - Plant and Equipment			$ 529,000	$ -24,249	$ 504,751
Grand Total			$ 2,754,600	$ -75,299	$ 2,679,301

1/ Includes $500 thousand JCAE reduction in foreign travel applied to programs by AEC.

SUMMARY OF FY 1969 AEC BUDGET

Operating Expenses
(In Thousands)

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Accrued Costs:					
Raw Materials Program					
Concentrate Procurement					
United States	$ 127,378	$ -15,508	$ 111,870	$ -	$ 111,870
Resource Investigations	355	245	600	-	600
Total Raw Materials	127,733	-15,263	112,470	-	112,470
Special Nuclear Materials Program					
Feed Materials	24,196	5,608	29,804	-	29,804
Production of Enriched Uranium (U-235)	133,152	-13,260	119,892	-	119,892
Procurement of Reactor Products	553	2,897	3,450	-	3,450
Safeguards & Other Special Activities	2,140	1,198	3,338	-	3,338
Process Development	23,313	3,186	26,499	-	26,499
Other	157,316	-5,996	151,320	-	151,320
Total Special Nuclear Materials	340,670	-6,367	334,303	-	334,303
Weapons Program					
Production, Storage and Surveillance	244,800	25,890	270,690	-	270,690
Research and Development	229,370	20,630	250,000	-100	249,900
Testing of Atomic Weapons					
Continental Tests	128,800	28,100	156,900	-	156,900
Supplemental Test Sites	64,300	40,000	104,300	-	104,300
Off Continent Test Readiness	19,340	660	20,000	-	20,000
Laboratory Participation - Common	30,290	3,110	33,400	-	33,400
Total Testing	242,730	71,870	314,600	-	314,600
Special Test Detection Activities	5,550	-50	5,500	-	5,500
Total Weapons	722,450	118,340	840,790	-100 1/	840,690

1/ Adjustment for reduction in foreign travel applied by AEC.

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Reactor Development Program					
Civilian Power Reactors					
Converter Reactors					
Water Reactors					
Shippingport Atomic Power Station	$ 6,400	$ -1,460	$ 4,940	$ -	$ 4,940
Operation Analysis - Private Reactor	100	-	100	-	100
Total Water Reactors	6,500	-1,460	5,040	-	5,040
Superheat Reactors - BONUS	1,375	385	1,760	-	1,760
Plutonium Utilization					
Plutonium Utilization	4,865	-915	3,950	-	3,950
Experimental Boiling Water	135	-85	50	-	50
Total Plutonium Utilization .	5,000	-1,000	4,000	-	4,000
Total Converter Reactors...	12,875	-2,075	10,800	-	10,800
Advanced Converter and Low Gain Breeder Reactors					
Water Reactors - Light Water Breeder Reactor (LWBR).....	14,700	800	15,500	-2,000	13,500
Heavy Water Moderated Reactors					
Heavy Water Organic Cooled Reactor	2,700	-2,700	-	-	-
Operations Analysis - Piqua ...	350	-350	-	-	-
Canadian Cooperative Program ..	1,000	-	1,000	-	1,000
Heavy Water Reactor General ...	1,550	450	2,000	-450	1,550
Total Heavy Water Moderated Reactors	5,600	-2,600	3,000	-450	2,550
High Temperature Gas Reactors ...	6,700	-700	6,000	-	6,000
Thorium Utilization	1,400	-300	1,100	-	1,100
Total Advanced Converter and Low Gain Breeder Reactors ...	28,400	-2,800	25,600	-2,450	23,150

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Reactor Development Program (Continued)					
High Gain Breeder Reactors					
Liquid Metal Fast Breeder Reactors					
Fuel Development - FBR	$ 12,300	$ 2,550	$ 14,850	$ -	$ 14,850
Physics Development - FBR	14,402	3,098	17,500	-	17,500
Component Development - FBR ...	12,300	5,840	18,140	-	18,140
Systems and Plant Development - FBR	5,118	-1,358	3,760	-	3,760
Experimental Breeder Reactor II	10,380	3,320	13,700	-	13,700
Fast Flux Test Facility	11,120	2,880	14,000	-	14,000
Sodium Reactor Experiment	430	-380	50	-	50
Total Liquid Metal Fast Breeder Reactors	66,050	15,950	82,000	-	82,000
Other Fast Breeder Reactor Systems	1,000	900	1,900	1,100	3,000
Molten Salt Breeder Reactor	4,200	2,500	6,700	-	6,700
Total High Gain Breeder Reactors	71,250	19,350	90,600	1,100	91,700
Desalting and Other Process Applications	2,650	-150	2,500	-	2,500
General Research and Development ..	3,300	-800	2,500	-	2,500
Total Civilian Power Reactor Program	118,475	13,525	132,000	-1,350	130,650
Cooperative Power Reactor Demonstration Program					
Converter Reactors	8,264	-2,506	5,758	-	5,758
Advanced Converters and Low Gain Breeders					
Public Service Co. of Colorado ...	14,808	-1,808	13,000	-	13,000
Carolinas - Virginia Nuclear Power Plant	100	-100	-	-	-
Philadelphia Elec. (Peach Bottom)	250	-	250	-	250
City of Piqua	1,505	1,145	2,650	-	2,650
Desalting (MWD)	2,256	3,744	6,000	-	6,000
Total Cooperative Power Reactor Demonstration Program	27,183	475	27,658	-	27,658

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Reactor Development Program (Continued)					
Euratom	$ 2,440	$ 60	$ 2,500	$ -	$ 2,500
Merchant Ship Reactors	100	-	100	-	100
Naval Propulsion Reactors					
Submarine Advanced Reactor	10,440	3,080	13,520	-	13,520
Small Submarine Reactor	2,590	-120	2,470	-	2,470
Attack Submarine Reactor	8,175	35	8,210	8,500	16,710
Natural Circulation Reactor	7,790	1,070	8,860	-	8,860
Deep Submergence Research Vehicle Reactor	1,320	-800	520	-	520
Large Ship Reactor	12,470	1,710	14,180	-	14,180
Destroyer Type Dual Reactor	16,090	3,110	19,200	-	19,200
Aircraft Carrier Type Dual Reactor	36,305	155	36,460	-	36,460
SIW Reactor Facility	3,750	10	3,760	-	3,760
Expended Core Facility	4,470	50	4,520	-	4,520
High Temperature Test Facility	1,500	300	1,800	-	1,800
Naval Reactor Design Studies	1,800		1,800	-	1,800
Total Naval Propulsion Reactors .	106,700	8,600	115,300	8,500	123,800
Space Propulsion Systems					
Reactor Propulsion (Rover)					
NERVA	35,480	3,520	39,000		
Advanced Rocket Reactor Technology					
Graphite Reactors (Phoebus) ...	25,100	-2,600	22,500		
Supporting Graphite Technology	520	-20	500		
Nuclear Rocket Development Station Operations	9,400	600	10,000		
Total Space Propulsion Systems ...	70,500	1,500	72,000	-3,000	69,000

Reactor Development Program (Continued)	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Space Electric Power Development					
Radioisotope Power Development					
Pu-238 Space Generator Development	$ 9,950	$ -3,450	$ 6,500	$ -2,500	$ 4,000
Po-210 Space Generator Development	6,700	-700	6,000	-	6,000
Large Heat Source (KW) Generator	900	2,100	3,000	-500	2,500
Thermionic Space Generator Development	-	750	750	-	750
Supporting Technology - Radioisotope Power	2,340	160	2,500	-	2,500
Total Radioisotope Power Development	19,890	-1,140	18,750	-3,000	15,750
Reactor Power Development					
Zirconium-hydride Reactor Technology	6,018	-18	6,000	500	6,500
Advanced Reactor Technology	11,525	-3,525	8,000	-2,500	5,500
Supporting Technology-Reactor Power	692	8	700	-	700
Total Reactor Power Development	18,235	-3,535	14,700	-2,000	12,700
Power Conversion Development	3,720	1,180	4,900	-	4,900
Space Nuclear Safety	4,011	189	4,200	-	4,200
Isotopes Fuel Development and Heat Source Fabrication	9,684	416	10,100	-	10,100
Total Space Electric Power Development	55,540	-2,890	52,650	-5,000	47,650
Terrestrial Electric Power Development					
Radioisotopes Power Development ...	5,925	875	6,800	-	6,800
Terrestrial Low Power Reactor	1,400	-1,370	30	-	30
Total Terrestrial Electric Power Development	7,325	-495	6,830	-	6,830
General Reactor Technology	49,000	1,000	50,000	-2,000	48,000

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Reactor Development Program (Continued)					
Advanced Systems Research and Development					
Ultra High Temperature Reactor Experiment	$ 2,000	$ -	$ 2,000	$ -	$ 2,000
Advanced Plutonium Fuel Technology Program	2,790	440	3,230	-	3,230
Research Reactors Research and Development	2,213	-513	1,700	-1,000	700
Test Reactors Research and Development	355	-205	150	-	150
Other Advanced Systems Research and Development	1,177	-277	900	-	900
Total Advanced Systems Research and Development	8,535	-555	7,980	-1,000	6,980
Nuclear Safety					
Nuclear Safety Research and Development	9,654	2,646	12,300		
Effluent Control Research and Development	4,459	141	4,600		
Engineering Field Tests	8,430	1,570	10,000		
Reactor Safety Analysis and Evaluation	1,792	708	2,500		
Engineered Safety Features	8,970	2,030	11,000		
Total Nuclear Safety	33,305	7,095	40,400	-3,400	37,000
Operational Services	3,000	-898	2,102	-100 1/	2,002
Total Reactor Development Program	482,103	27,417	509,520	-7,350	502,170

1/ Adjustment for reduction in foreign travel applied by AEC.

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Physical Research Program					
High Energy Physics	$ 113,400	$ 7,000	$ 120,400	$ -1,042	$ 119,358
Medium Energy Physics	11,100	500	11,600	-5	11,595
Low Energy Physics	28,820	1,280	30,100	-10	30,090
Mathematics and Computer Research	5,720	180	5,900	-3	5,897
Chemistry Research	54,000	2,300	56,300	-1,320	54,980
Metallurgy and Materials Research	27,060	1,240	28,300	-310	27,990
Controlled Thermonuclear Research	24,900	2,500	27,400	-410	26,990
Total Physical Research Program	265,000	15,000	280,000	-3,100 1/	276,900
Biology and Medicine Program					
Somatic Effects of Radiation	26,050	1,320	27,370		
Radiation Genetics	7,330	320	7,650		
Combating Detrimental Effects of Radiation	1,950	50	2,000		
Molecular and Cellular Level Studies	16,300	560	16,860		
Environmental Radiation Studies	18,340	690	19,030		
Radiological and Health Physics and Instrumentation	7,240	260	7,500		
Chemical Toxicity	600	31	631		
Nuclear Energy Weapons Effects Studies	1,100	20	1,120		
Cancer Research	5,800	220	6,020		
Selected Beneficial Applications	3,300	120	3,420		
Radiation Preservation of Foods	440	10	450		
Total Biology and Medicine Program	88,450	3,601	92,051	-2,571 1/	89,480
Training, Education and Information Program					
Training and Education in the Physical and Life Sciences and Engineering	9,500	150	9,650	-150	9,500
Technical Information Services	6,352	442	6,794	-487	6,307
Other	570	-5	565	-	565
Total Training, Education and Information Program	16,422	587	17,009	-637 1/	16,372

1/ Includes adjustment for reduction in foreign travel applied by AEC.

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Isotopes Development Program					
Radioisotope Production and Materials Development	$ 2,500	$ -175	$ 2,325	$ -	$ 2,325
Thermal Applications Development	650	250	900	800	1,700
Radioisotope Applications Development	1,375	-25	1,350	-	1,350
Radiation Processing Applications Development	1,415	10	1,425	-	1,425
Radiation Preservation of Foods	1,435	-250	1,185	-	1,185
Total Isotopes Development Program	7,375	-190	7,185	800	7,985
Civilian Applications of Nuclear Explosives Program					
Research and Development	6,415	-915	5,500		
Excavation Experiments	8,421	-1,421	7,000		
Scientific Experiments	350	150	500		
Underground Engineering Experiments	2,779	-1,279	1,500		
Total Civilian Applications of Nuclear Explosives (Plowshare) Program	17,965	-3,465	14,500	2,450 1/	16,950
Communities	6,771	171	6,942	-150	6,792
Program Direction and Administration	95,313	7,572	102,885	-580 1/	102,305
Security Investigations	6,795	-207	6,588	-	6,588
Cost of Work for Others	11,219	3,314	14,533	14,505	29,038
Total Program Costs, Funded	2,188,266	150,510	2,338,776	3,267	2,342,043
Change in Selected Resources	7,561	48,118	55,679	-20,625	35,054
Gross Obligations	2,195,827	198,628	2,394,455	-17,358	2,377,097
Revenues Applied	-66,464	-32,652	-99,116	-23,692	-122,808
Net Obligations	2,129,363	165,976	2,295,339	-41,050	2,254,289

1/ Includes adjustment for reduction in foreign travel applied by AEC.

	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Isotopes Development Program					
Radioisotope Production and Materials Development	$ 2,500	$ -175	$ 2,325	$ -	$ 2,325
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	FY 1968 Column	(+ or -)	FY 1969 Request	Change by JCAE (+ or -)	JCAE Markup
Net Obligations	$ 2,129,363	$ 165,976	$ 2,295,339	$ -41,050	$ 2,254,289
Unobligated balance, start of year	-59,110	-10,629	-69,739	-10,000	-79,739
Unobligated balance, end of year	69,739	-69,739	-	-	-
Transferred to General Services Administration	8	-8	-	-	-
Appropriation	$ 2,140,000	$ 85,600	$ 2,225,600	$ -51,050	$ 2,174,550

Atomic Energy Commission
Plant and Capital Equipment

Construction Projects:		FY 1969 Budget Request	Change by JCAE (+ or -)	JCAE Markup
69-1-a	Powder metallurgy facility, Savannah River, South Carolina	$ 700,000	$ -	$ 700,000
69-1-b	Waste storage tanks, Savannah River, South Carolina	3,500,000	-	3,500,000
--	Equipment test facility, Oak Ridge, Tennessee	3,925,000	-3,925,000	-
69-2-a	Calcined solids storage facility additions, National Reactor Testing Station, Idaho	2,100,000	-	2,100,000
69-3-a	Rehabilitation of plutonium processing site, Los Alamos Scientific Laboratory, New Mexico	3,500,000	-	3,500,000
69-3-b	Weapons production, development, and test installations	10,000,000	-	10,000,000
69-4-a	Hot fuel examination facility, National Reactor Testing Station, Idaho	10,000,000	-	10,000,000
69-4-b	Modifications to EBR-II and related facilities, National Reactor Testing Station, Idaho	2,000,000	-	2,000,000
69-4-c	Research and development test plants, Project Rover, Los Alamos Scientific Laboratory, New Mexico, and Nevada Test Site, Nevada	1,000,000	-	1,000,000
69-4-d	Modifications to reactors	1,000,000	-	1,000,000

Construction Projects:		FY 1969 Budget Request	Change by JCAE (+ or -)	JCAE Markup
--	Conversion of heating plant to natural gas, Argonne National Laboratory, Illinois	$ 525,000	$ -525,000	$ -
69-5-a	Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York	600,000	-	600,000
69-5-b	Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois	875,000	-	875,000
69-5-c	Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California	750,000	-	750,000
69-5-d	Accelerator improvements, Cambridge and Princeton accelerators	145,000	-	145,000
69-5-e	Accelerator improvements, Stanford Linear Accelerator Center, California	630,000	-	630,000
69-5-f	Omnitron accelerator, Lawrence Radiation Laboratory, Berkeley, California (AE only)	-	1,000	1,000
--	Conversion of steam plant to natural gas, Brookhaven National Laboratory, New York	800,000	-800,000	-
69-6	General plant projects	37,010,000	-	37,010,000
68-2-a	New weapons production capabilities, various locations	184,500,000	-	184,500,000
68-4-f	200 Bev accelerator, Du Page and Kane Counties near Chicago, Illinois	25,000,000	-	25,000,000

94-075 O-68-pt. 3—3

Plant and Capital Equipment - continued

Construction Projects:		FY 1969 Budget Request	Change by JCAE (+ or -)	JCAE Markup
67-3-a	Fast flux test facility	$ 35,000,000	$ -	$ 35,000,000
66-2-d	Environmental test facility, Lawrence Radiation Laboratory, Livermore, California	3,200,000	-	3,200,000
66-5-h	Meson physics facility, Los Alamos Scientific Laboratory, New Mexico	26,200,000	-	26,200,000
65-5-a	Argonne advanced research reactor, Argonne National Laboratory, Illinois	-	-18,000,000	-18,000,000
	Subtotal Construction	352,960,000	-23,249,000	329,711,000
	Capital Equipment Not Related to Construction	176,040,000	-1,000,000	175,040,000
	Total Appropriation Request for Plant & Capital Equipment	$ 529,000,000	$ -24,249,000	$ 504,751,000

Mr. KIRWAN. Are there any questions, gentlemen?

Mr. EVINS. Chairman Seaborg, I want to commend you for your detailed and precise statement of your budget. It is well presented.

I note in general that you state that about 80 percent of your budget increase is for weapons production.

Dr. SEABORG. Yes; 80 percent of the increase.

PORTION OF 1969 REQUEST FOR NONWEAPONS ACTIVITIES

Mr. EVINS. How much of the increase is for nonweapons or civilian activities of the Atomic Energy Commission?

Dr. SEABORG. Well, the balance, broadly speaking, is for nonweapons activities which you can refer to as the civilian activities including the reactors and the research portions especially. I think that accounts for the remaining, rather modest increase.

Mr. EVINS. How does this percentage increase relate to previous year's budgets for civilian activities?

Dr. SEABORG. It is less. It is less, for example, in the research area.

COMMISSION'S VIEWS ON EMPHASIS BETWEEN PROGRAMS

Mr. EVINS. What is the combined Commission view with respect to the emphasis that should be placed on the various AEC programs and activities? Should we continue on an increasing scale weapons research and production, or should we proceed more in the area of civilian application of nuclear energy and its resultant benefits?

Dr. SEABORG. I do not believe we have any real choice in the weapons area. We do have to keep abreast there.

I would answer the question by saying I would hope we could also increase in the civilian applications area, because the promise there is so great it is almost unlimited. In fact I have referred to it on many occasions as the proliferation of the peaceful uses of atomic energy.

There are so many potentially beneficial uses here, beneficial to mankind in general, that we find it difficult even to make a choice among them as to which areas we should emphasize.

Mr. EVINS. The times in which we live necessitate the Commission's devoting a great effort to the military weapons program, whereas from your previous speeches and statements you have emphasized the desirability of the expansion of the peaceful uses of nuclear energy.

Dr. SEABORG. That is right.

Mr. EVINS. We are not able to do this to the extent that the Commission feels it desirable. Would that be a fair statement?

Dr. SEABORG. Yes; I would say that is a fair statement.

SENTINEL AND POSEIDON PROGRAM

Mr. RHODES. In developing the warhead for Sentinel, Minuteman, and Poseidon you have a new concept. Can you give us any unclassified information as to just what your development and production problem is so far as the Merv concept is concerned?

Dr. SEABORG. Perhaps it would be better to furnish that. It is a touchy and delicate area.

Dr. TAPE. Perhaps we can try it both ways. If we look at it carefully perhaps we can give you some unclassified information.

Mr. RHODES. It would be interesting for the general public to know what you are up against.

Dr. SEABORG. I am confident we can give you something in an unclassified way, because we do that in our annual report. However, it is something we work over very carefully before we submit it.

Mr. ABBADESSA. The Director of the Division of Military Application will be testifying tomorrow morning and we will prepare a special statement tonight. We can cover it.

Also we can cover anything of a classified nature that the committee wants and then we can sanitize the record.

(The following information was provided for the record:)

SENTINEL AND POSEIDON PROGRAMS—UNCLASSIFIED STATEMENT ON RESEARCH AND DEVELOPMENT AND PRODUCTION DIFFICULTIES

As with other large-scale developments which use new concepts and ideas, reduction of the Sentinel and Poseidon concepts and ideas to practice pose many difficulties. Increased development and engineering effort is required to assure our ability to penetrate enemy defenses and to assure our ability to protect against enemy threats. The uniqueness of the designs being pursued for those systems which create the most difficult engineering tasks involve highly classified components. In these programs there are no known difficulties to which engineering effort will not provide an adequate solution. Similarly, the translations of design solutions to quantity and quality production requires production engineering solutions. There are no known production engineering difficulties for which the planned effort cannot provide satisfactory solutions. To accomplish production of these complex weapons requires new facilities. For example, large numerical controlled machine tools, of watchmaker precision, require considerable effort to achieve the unusually exacting tolerances needed for attaining performance goals.

RELATION OF OPERATING EXPENSES TO OTHER REQUIREMENTS

Mr. EVINS (presiding). You testified about the reductions by the authorizing joint committee. You indicated a total of $75 million in reductions including $51 million in operating expenses. What is the relationship of the operating budget to the plant and capital equipment appropriation?

Dr. SEABORG. Well, if we take the entire budget for fiscal 1969, for which, as I indicated earlier, 80 percent of the increase was due to military requirements, there is an increase in both the operating expenses and in the plant and capital equipment; an $85.6 million increase in the operating expenses and $160 million in the plant and capital equipment.

Mr. EVINS. I understand your testimony that there were certain areas where the authorizing committee did not authorize your budget request but did authorize some unbudgeted items. Could you highlight these?

Dr. SEABORG. They added a number of items—something in the fast submarine, a little bit in the fast breeders, the zirconium-hydride reactor, the artificial heart project, and the plowshare excavation program. This comes to a total of $13,400,000. However, they reduced to an extent of $88,700,000, so what I indicated was that we felt since the reductions much more than offset the additions, we would be able to go ahead with it.

NAVAL PROPULSION REACTORS

Mr. EVINS. Concerning the naval propulsion reactors, the authorizing committee added $8,500,000 to enable the Commission to proceed with the design and development of a new nuclear propulsion plant for the "attack submarine reactor project."

Dr. SEABORG. Yes, sir.

Mr. EVINS. How many nuclear submarines do we have?

Dr. SEABORG. Seventy-six nuclear-powered submarines are operational, including all 41 Polaris missile-launching type. Four nuclear-powered surface ships are also operational.

Mr. ABBADESSA. Admiral Rickover will be here tomorrow at 2 o'clock and he will give you a report card.

Mr. EVINS. We are proud of our fleet.

Dr. TAPE. Total authorized is 107.

Dr. SEABORG. The number operating is 76, including 41 Polaris missile-launching type.

EFFECT OF STRETCHOUT

Mr. EVINS. What effect did Public Law 90–218 have on the Atomic Energy Commission? What was the result of this ceiling?

Dr. SEABORG. It resulted in our having a cutback.

Mr. EVINS. Further cutback?

Dr. SEABORG. Yes, a further cutback of about $70 million in operating expenses, and $200 million was deferred in the form of equipment and construction.

Mr. EVINS. Can you tell us at this time how much, if any, funds you will have by way of carryover?

Dr. SEABORG. $79,739,000 after the JCAE revisions.

NEW DEVELOPMENTS IN URANIUM EXTRACTION AND DISCOVERY

Mr. EVINS. I was interested in your uranium extraction techniques and new developments. We have been buying and purchasing and having delivered uranium ore for many years and we are still discovering new methods of extracting it.

Dr. SEABORG. Yes, although the main emphasis is on discovery of new deposits.

Mr. EVINS. Not in extraction?

Dr. SEABORG. Not so much, although we are also doing some work on the recovery from the standpoint of trying to learn how to recover it from low-grade ores and allowing economical development from low-grade ores. These are the studies going on.

The civilian nuclear power industry in the United States, and throughout the world for that matter, will require augmented sources of uranium in the future in order to support the requirements.

REACTOR DEVELOPMENT PROGRAM

Mr. EVINS. The committee notes the authorizing committee reduced your reactor development program by $7.3 million. What is the current status of the program?

Dr. SEABORG. Our program now emphasizes the advanced reactors, which use the uranium fuel more efficiently and which possibly will

begin to use the thorium fuel. We have a program for what we call advanced converters, which would use the fuel several times more efficiently, and breeders, which would use it 50 times more efficiently.

USE OF REACTORS BY PRIVATE CONCERNS

Mr. EVINS. How many private utilities have adopted reactors developed by the Commission?

Dr. SEABORG. These would be utilities throughout the country. I can tell you that there are about 100, considering the number of reactors in operation, under construction, or announced by utilities. I saw the total 99 just a day or two ago.

Mr. EVINS. I have a press release issued by AEC on April 10, 1968, which gives a brief status report on the program.

Dr. SEABORG. That corresponds. The output from these reactors corresponds to a total capacity of about 70 million kilowatts, which is a very impressive record, indeed.

(The referred to press release follows:)

U.S. ATOMIC ENERGY COMMISSION

(For immediate release, Wednesday, Apr. 10, 1968)

Note to Editors and Correspondents

Following is a brief status report on the U.S. civilian nuclear power program.

During the first quarter of this year, electric utilities made known plans for 11 nuclear powerplants with a total capacity of 9,525,000 kilowatts. Reactor suppliers have been selected for six of these plants.

During the first quarter of 1967, utilities made known plans for 11 nuclear powerplants with a total capacity of 8,350,800 kilowatts. Reactor suppliers have been selected for eight of these plants.

Status of nuclear powerplants, as of Mar. 31, 1968

	Kilowatts
15 in operation	2,798,700
23 under construction	16,890,300
44 planned (reactors ordered)	35,041,800
17 planned (reactors not ordered)	14,760,000
Total	69,490,800

RELATION OF NUCLEAR PRODUCTION OF POWER TO OTHER MEANS OF GENERATION

Mr. ROBISON. Will you try to relate that figure for nuclear production of kilowatts to the production of kilowatts by other methods of generation, be it waterpower or steamplants?

Dr. SEABORG. Yes. When these reactors are built it will correspond to a percentage of about 10 or 15 percent of the total. It continues to rise rather dramatically in percentage, so that by 1980 we expect the combined nuclear capacity to be about 150 million kilowatts and the percentage of the total to be 25 to 30 percent, and then continues to rise to about 50 percent of the total by the year 2000. It is something on that order.

I do want to make this point, though, and it is very important—while nuclear power is growing at this rate the use of coal and other fossil fuels—but coal particularly—will continue to grow and not diminish. While nuclear power is therefore growing from the small percentage that it represents today, 1 percent or so, to 25 or 30 percent by 1980, the use of coal to generate electricity will be almost doubling at the same time. This is a consequence of the high and increasing requirement we have for electricity. That is an important point.

USE OF NUCLEAR REACTORS FOR ELECTRIC POWER

Mr. RHODES. Do you have any projections to indicate the extent to which we can expand our nuclear reactors for the production of electric power, bearing in mind the supply of uranium presently available, and considering probable new discoveries in the future? Do we not come to a point some time in the future where we cannot maintain the number of reactors we need?

Dr. SEABORG. That is the purpose of our advanced converters and breeders. If we are successful in developing the breeders that will utilize the uranium more efficiently and that will utilize thorium, then we do not see any time limit. We can project an adequate supply of uranium and thorium economically for periods of hundreds or maybe thousands of years. That is why it is so important to develop the breeder reactor.

The breeder reactor has two recommended advantages. It uses the fuel perhaps 50 times more efficiently than the present reactors which correspond to that 70 million kilowatts we just mentioned, and in so doing enables the reactor operator to use fuel at such a low cost, because it is using it so efficiently, that it becomes feasible to economically utilize uranium which could be mined at greater cost, that is a lower grade, and there is so much in that category that we can therefore project the almost unlimited time frame for the future.

Mr. RHODES. We do this every year but I think, Mr. Chairman, at this point in the record it might be well to include a statement from Dr. Seaborg as to what a breeder reactor is and what it accomplishes.

Dr. SEABORG. Yes. A breeder reactor is a reactor which converts the nonfissionable part of the uranium, the uranium-238, into fissionable plutonium, and it does this at a rate whereby it produces more plutonium, while it is producing electricity, than is consumed in the reactor in the process; so therefore you produce more plutonium than you consume, and the net result is, if you think about it, you are indirectly burning the nonfissionable uranium-238. That is basically what it is.

The same type of cycle operates with thorium. Nonfissionable thorium can be converted into fissionable uranium-233. This is a different isotope and not the uranium-235. Then you operate a breeder reactor on the uranium-233 with a thorium blanket, converting the thorium to uranium-233 at a higher rate than you burn up the uranium-233 in the core, producing electricity at the same time. The net result then is that you indirectly burn the nonfissionable thorium.

PLUTONIUM REACTOR

Mr. RHODES. One of the problems you have now is to perfect the plutonium reactor?

Dr. SEABORG. Yes.

Mr. RHODES. To take advantage of this?

Dr. SEABORG. Yes. That is our first-priority reactor, as I indicated in my testimony, and we refer to that as the fast breeder because in the case of the uranium-plutonium breeder cycle it is more efficient if you use fast neutrons.

In the case of the thorium-uranium 233 breeder cycle, it is more efficient if you use the thermal neutrons, so we refer to the thorium system, and that includes Admiral Rickover's LWBR and the molten salt reactor being developed at Oak Ridge, as thermal breeders, and we refer to the first-priority, uranium-plutonium cycle, as fast breeders.

It is in order to develop our first priority program that we are building the fast flux test facility (FFTF).

Mr. EVINS. This relates to my earlier question. This is your highest priority civilian program and you want to develop competitive uses of it.

INDUSTRY USE OF FAST BREEDER

To what extent is industry cooperating in the development of the fast breeder?

Dr. SEABORG. Industry is involving itself in the development of the fast breeder. We intend to carry on our development with a strong industrial involvement, just as we did in the development of the water-cooled reactors.

COOPERATIVE POWER REACTOR PROGRAM

Mr. EVINS. You indicated earlier that one of your cooperative power reactor programs was being discontinued.

How long have we been engaged in this cooperative power reactor demonstrations program and what results have we achieved to date?

Dr. SEABORG. This particular one or all of them?

Mr. EVINS. All of them generally.

Dr. SEABORG. Generally they began soon after the passage of the Atomic Energy Act of 1954, which made is possible to have industrial participation. We have had a number of different kinds of arrangements, varying from those in which we owned the reactor—and Piqua is an example of that, usually with small utilities involved—to arrangements where the utility owned the reactor with a certain amount of financial participation on the part of the AEC, of which the Connecticut Yankee reactor is a prime example. In the advanced converter field the Public Service Co. of Colorado's high temperature gas-cooled reactor is a prime example.

SPACE PROPULSION SYSTEMS

Mr. EVINS. In view of the stringent budgetary situation, many people feel that the space program should be delayed or reduced. Which one of your programs related to space would you place in the category of highest priority?

Dr. SEABORG. I suppose we would place the nuclear rocket, the Rover program, highest. There is no doubt about that being the highest priority.

Mr. RHODES. That is interesting. Would you care to elaborate on that and tell us why you would put such a high priority on this nuclear rocket?

Dr. SEABORG. Because of the great potential that it has for future missions of all kinds and because of the large amount of effort which has already gone into it. We are right at the payoff point. We just have the reactor engine tests to make in order to make it feasible to complete the engine development. It has been a very successful program, exceedingly successful. The reactors have performed almost beyond our fondest dreams, and it is clear now that this is a feasible means for propulsion. We think there are a lot of missions short of a manned mission to a planet, missions involving orbiting around the earth and trips to the moon and back, for which the nuclear rocket is going to be the least expensive of ways——

Mr. EVINS. Other fuels are expendable in short times, whereas nuclear power has long life and possibility for extended stays.

Dr. SEABORG. Exactly.

POWER GENERATION BY NUCLEAR ROCKET

Mr. RHODES. In your statement I believe you said that this nuclear rocket would generate 1,500 megawatts of power? Was that correct? I wondered if you had too many zeros on there. That is an awful lot of power.

Dr. SEABORG. That is an awful lot of power. It is more than the power of Hoover Dam, I believe.

Mr. RHODES. It is. It is almost twice as much power as Hoover generates.

Dr. SEABORG. This is the right figure. This is what we mean.

Mr. RHODES. That is a higher output than most of your nuclear powerplants.

Dr. SEABORG. Yes, it is.

Mr. RHODES. You usually have 1,000 megawatts.

Dr. SEABORG. That is right. This is thermal, by the way, so it is not more than the nuclear powerplants being built now, but it is comparable to the largest one that is now operating.

We should also distinguish rocket propulsion, which runs for a few minutes on the hydrogen propellant at this very high power rate, from the auxiliary space electrical systems, which can run for long periods of time.

Mr. RHODES. You are speaking now of those operated with radioisotopes?

Dr. SEABORG. And reactors. There are two types in the SNAP systems—the compact reactors and the isotope, both of which run for a long time.

GENERAL REACTOR TECHNOLOGY

Mr. EVINS. You requested $50 million for general reactor technology and the authorizing committee reduced it to $48 million, a reduction of $2 million. The committee also reduced the request for nuclear

safety by $3.4 million. Would you desire to comment on the need for this work. The authorization does allow an increase to $37 million.

Dr. SEABORG. We want to assure the safety of all categories of reactors. We have a number of reactors coming on line, as I indicated to you earlier, and we want to learn all that we can about their future safe operation, and we have in mind a number of engineered safety features that we can introduce and standards that we could put into effect which we believe require further development.

We also have the advanced converter reactors, and the breeder reactors of the future for which we would like to assure as completely as possible safe operation.

RADIOISOTOPE HEAT ENGINE FOR HEART PUMP

Mr. EVINS. The authorizing committee added the item for the development of an engine for the heart pump. You indicate 100,000 heart cases could have been helped if certain support were made available. Could you elaborate on this for the committee, as it holds great interest to everyone.

Dr. SEABORG. I regard this as one of the most promising peaceful uses of nuclear energy that there is. I think I have made this statement publicly many times.

The concept of a circulatory support system pump, going all the way to a pump that might completely replace the human heart, is a definite possibility for the future. It is a serious possibility.

I have talked to eminent heart surgeons like Dr. DeBakey, of Houston, and they feel definitely that such devices are feasible, and can be and will be developed in the future. There is good reason to believe that one of the best sources of energy and of power for this will be the radioisotope source.

I am personally very excited about the possible development of such a device and rather expect that we will see them within, say, 10 years or something of that order in actual operation in humans.

I do want to emphasize we are working closely with the National Heart Institute in this development. They are also investigating other sources of power. We, of course, emphasize the radioisotope source, which I personally believe will probably be the most versatile and the most feasible.

ATOMIC BOMB CASUALTY COMMISSION

Mr. EVINS. You mentioned the expenses of the Atomic Bomb Casualty Commission. I was wondering what steps the Commission can take to help the balance-of-payments situation.

Most agencies say their program is very small and it would have no effect, but if everyone takes that attitude we will not resolve the problem. If each makes a contribution, however small, it may be successful.

Dr. SEABORG. We are making a contribution.

Mr. ABBADESSA. Mr. Chairman, we are one of the few agencies that has a positive balance of payments coming into the country. You will see an increase in our revenues projected for next year of $33 million

of which $27 million is from toll enrichment. We estimate that $20 million of this increase in revenues will come from foreign sources.

Mr. EVINS. That has been improved over the past several years?

Mr. ABBADESSA. Yes, and it is projected to improve dramatically in the future.

PLOWSHARE PROGRAM

Mr. EVINS. Would you provide for the record a brief summary of the Plowshare program as there is a great deal of public interest and concern regarding the various projects you intend to undertake.

Dr. SEABORG. We will be glad to furnish it.

(Information requested follows:)

STATUS OF THE PLOWSHARE PROGRAM

During the past year significant progress was made in the Plowshare program with the conduct of Project Gasbuggy—the first Government-industry cooperative experiment—which is investigating the use of nuclear explosions to stimulate low-producing gas fields, with the execution of Project Cabriolet a 2.5 kiloton nuclear cratering experiment in hard rock, and with the execution of Buggy-I, the first nuclear row-charge detonation.

EXCAVATION PROGRAM

The Commission has planned a series of nuclear cratering experiments designed to provide the Atlantic-Pacific Interoceanic Canal Study Commission with sufficient technical information on which to base a determination, as required by Public Law 88–609, concerning the feasibility, cost, and other factors involved in the nuclear excavation of a sea-level canal across the American Isthmus.

Cabriolet and Buggy-I

On January 26, 1968, Project Cabriolet, a 2.5 kiloton nuclear cratering experiment in hard rock, was conducted on the Nevada test site (NTS) as the first of these experiments. The explosion created a crater 360 feet wide and 120 feet deep, the depth being somewhat greater than the 57- to 117-foot depth predicted.

Cabriolet was followed by Project Buggy-I, the first nuclear row-charge experiment, conducted on March 12, on the NTS. Buggy-I, involved the simultaneous detonation of five 1.1 kiloton nuclear explosives, spaced 150 feet apart at a depth of 135 feet. A ditch about 250 feet wide, 860 feet long and 65 feet deep was created.

The amount of radioactivity released in both Cabriolet and Buggy-I was very low, even less than had been predicted.

Future excavation experiments

The fiscal year 1969 request for $3,700,000 will be used to conduct a point charge cratering experiment in hard rock in the hundred kiloton range, and to begin preparations for a second row charge experiment. The additional $2.5 million authorized by the Joint Committee on Atomic Energy would be used to conduct a slope-stability experiment.

Development of explosives and emplacement techniques

Progress was also made this calendar year with the Marvel event which provided data on emplacement methods, and Switch, an explosive development test. Both experiments were aimed at reducing the amount of radioactivity released in future cratering experiments. Two to three explosive development or emplacement techniques tests are planned for fiscal year 1969.

UNDERGROUND ENGINEERING

Fiscal year 1968 marked a turning point in the development of the underground engineering technology. Heretofore, the program's efforts have been aimed at developing the basic knowledge and understanding of the phenomenology of completely contained nuclear explosions. With the execution of Project Gasbuggy, the first step has been taken to apply this knowledge to a practical application, in this case the stimulation of low-producing natural gas field.

Project Gasbuggy

Project Gasbuggy is jointly sponsored by the El Paso Natural Gas Co., the Department of Interior, and the AEC. Technical direction is provided by the Lawrence Radiation Laboratory at Livermore, Calif. Successfully detonated on December 10, 1967, the Gasbuggy explosion of approximately 26 kiloton, created a chimney of broken rock estimated to be 333 feet high with a fracture radius of about 440 feet.

Drillback operations to reach the chimney were begun on December 13, 1967, and completed January 10, 1968, when a void was reached at a depth of 3,907 feet. At that time a number of preliminary, short-term gas-flow tests were run. Data obtained, however, are not conclusive and cannot be considered definitive, relative to either reservoir evaluation or chimney volume determinations. The reentry hole was subsequently capped pending the beginning of gas-flow production tests to be conducted at a later date.

Initial evaluations of a few gas samples collected early in the reentry phase reveal that the concentrations of radioactivity measured were lower than anticipated. Detailed analyses of gas samples taken at the bottom of the hole are currently underway.

Future work is being designed to investigate the connection of the reentry hole with the chimney, the nature of the chimney itself, the extent and the nature of the fracture area, and more detailed analyses of a larger number and variety of gas samples.

Future gas stimulation experiments

Two gas stimulation experiments to extend data obtained from Gasbuggy have been proposed and several others have been suggested.

Project Dragon Trail

Project Dragon Trail, a gas stimulation experiment proposed by the Continental Oil Co. (CONOCO) of Houston, Tex., and CER Geonuclear Corp. (CER) of Las Vegas, Nev., would extend information gained from Gasbuggy to a geologically different gas formation. Current plans call for the detonation of a 26 kiloton nuclear explosive, 2,700 feet beneath the earth's surface at a site in Rio Blanco County, Colo. Agreement is close on a detailed technical plan for the experiment, and we anticipate that formal negotiations with CONOCO and CER could begin in the relatively near future.

Project Rulison

The Commission is also considering Project Rulison, a gas stimulation experiment proposed by Autral Oil Co. of Houston, Tex. and CER Geonuclear Corp. Technical direction for this project has recently been reassigned from the Lawrence Radiation Laboratory-Livermore, to the Los Alamos Scientific Laboratory.

The current concept calls for the detonation of a 50-kiloton explosive at a depth of about 8,000 feet. By comparison, Gasbuggy was detonated at a depth of 4,240 feet. This depth poses a number of engineering problems, both in the actual drilling of the emplacement hole and in adapting an explosive to withstand the high pressures and temperatures which exist at these depths. Once the final technical concept of the experiment is developed, the Commission will be in a position to begin formal negotiations with Austral and CER.

Other gas stimulation experiments

Two additional nuclear gas stimulation experiments have also been suggested for the Pinedale area of Wyoming, one by the El Paso Natural Gas Co. of El Paso, Tex.—the industrial partner in Project Gasbuggy—and the other by a group of companies headed by the Wolf Exploration Co. of Denver, Colo.

Other industrial applications

Three cooperative industry-Government feasibility studies which investigated other potential industrial applications were also completed in fiscal year 1968; namely, the Bronco study, the Sloop study, and the Ketch study. All three studies resulted in formal proposals to the AEC by the participating companies for joint industry-Government experiments.

Project Bronco

The Bronco experiment would involve the use of a nuclear explosion to create a deep underground chimney of broken oil shale which subsequently would be treated by an in-place retorting technique to recover the oil. It was formally

proposed to the Department of the Interior and the Commission by CER Geonuclear Corp., on behalf of more than 15 oil companies. Negotiations are now in progress between the Government and CER.

Project Sloop

Project Sloop, proposed by Kennecott Copper Corp. of New York City, is being designed to investigate whether a nuclear explosion will fracture a low-grade copper ore body located near Safford, Ariz., in such a manner as to permit the recovery of the copper from the fractured ore by an in-place leaching process. The Los Alamos Scientific Laboratory was recently assigned technical direction for this project and development of a detailed technical program is currently underway. Once the technical plan is developed, contract negotiations can begin.

Project Ketch

The Commission is also considering Project Ketch, proposed by the Columbia Gas System Service Corp. of New York City. As now planned, Ketch will involve the detonation of a 24-kiloton nuclear explosion in a deep (about 3,300 feet), relatively impermeable rock formation. It will investigate the feasibility of using the void space in the chimney, created by the explosion, to store natural gas. The final technical plans for Project Ketch are still in the process of development. In addition, initiation of the safety evaluation studies of the proposed site in Clinton County, Pa., are awaiting completion of leasing arrangements with the Commonwealth of Pennsylvania as the proposed site is located in a State forest reserve. Once the detailed technical plan and the site evaluations are completed, formal negotiations with Columbia Gas would begin.

SCIENTIFIC RESEARCH

In the area of scientific research, the Plowshare program supported a number of cross section measurements, made in conjunction with the Pommard test conducted this spring. These measurements, pertinent both to basic physics research and reactor design needs, are designed to study the interaction of neutrons of various energies with isotopes of interest. Some of the funds requested in this category for fiscal year 1969 are planned to be used to support additional studies in this area.

Effort is also continuing on the use of the intense neutron flux generated during a nuclear explosion to create heavy isotopes, and possibly new elements. Design of a heavy element experiment was carried out in fiscal year 1968, and tentative plans are being made for a test of this design in fiscal year 1969 in conjunction with a nuclear experiment being conducted for other purposes.

RESEARCH AND DEVELOPMENT

Progress was made in fiscal year 1968 at the Lawrence Radiation Laboratory, in developing and refining a theory of nuclear explosion effects in a variety of environments; in developing a predictive capability for ground motion, air blast, and radiological safety; and in designing and developing nuclear explosives which are more economical and have other special features desirable for peaceful applications. In addition, the Sandia Laboratory, Albuquerque, N. Mex., continued cratering and nuclear explosive studies. The fiscal year 1969 request includes funds to continue both of these efforts as well as research work being done by several other organizations. In addition, the fiscal year 1969 request includes funds to permit the program to respond to new proposals from industry to develop various applications through the preliminary feasibility study stage, including, if appropriate, the initiation of engineering and site evaluation effort.

PROJECT BUGGY–I

Mr. EVINS. The report on project Buggy–I indicates you have produced a ditch of 65 feet deep, 250 feet wide, and 860 feet long. What other results were obtained from this experiment?

Dr. SEABORG. The other results are quite interesting. One of the most interesting aspects was that the amount of radioactivity released was lower than expected and, for all practical purposes, was confined to the site. That shows we can conduct these tests within the requirements of the limited test ban treaty.

Mr. EVINS. Questions, Mr. Morris?

Mr. MORRIS. I have no questions at the present time, Mr. Chairman.

I want to commend Chairman Seaborg and the other Commissioners for their very fine presentation.

200 BEV ACCELERATOR—LINAC PROTOTYPE

There is one thing I want to be sure is perfectly clear, and that concerns the 200 Bev accelerator. I do not have any idea, Mr. Chairman, what will take place, but I want to be absolutely sure that we have a clear understanding for the record that when you talk about the $1 million which you alluded to in your general statement you are talking about a prototype of low intensity of the 200 Bev and not the actual construction. This is something that will enable the designers to have a better design. Is that correct?

Dr. SEABORG. That is correct. It is a prototype in connection with the injector.

Mr. MORRIS. This does not start construction?

Dr. SEABORG. That is right. This is something we ordinarily would do under the AE authorization.

Dr. TAPE. As long as we are being very careful in our statements, I know those fellows at the National Accelerator Laboratory well enough to know that if they have in that prototype a part which would eventually fit into the final construction they will salvage it. I think you understand this is still a prototype and not directed toward the construction. We will use whatever we can salvage from it.

Mr. MORRIS. Of course, and that is only good judgment and good technical sense.

What I am trying to do is to be sure that we on the committee and you on the Commission understand what the record says, and very clearly.

Thank you, Mr. Chairman.

Mr. EVINS. Mr. Rhodes, do you have any further questions?

PROJECT GASBUGGY RESULTS

Mr. RHODES. Can you give us some idea as to the production of natural gas from Gasbuggy?

Dr. SEABORG. Yes. Preliminary results based on penetration into the chimney and the withdrawal of gas samples indicate two very encouraging things, first, the level of radioactivity was lower than we had predicted, which is very favorable; and second, the gas pressure in the chimney is building up to the level which had been predicted, at about the rate predicted. So there is nothing to indicate, up until now, that Gasbuggy is not a complete success.

It will take some time, of course before we can fully evaluate the results of the experiment. The project participants—the AEC, El Paso Natural Gas Co., and the Department of the Interior's Bureau of Mines—will have to run extensive gas production tests later on to see whether the gas continues to flow into the chimney to yield the large quantities that we hope for. This will take perhaps a year or so to determine.

Mr. MORRIS. In other words, so far your practical results from the experiment have confirmed your theoretical results and calculations made prior to the detonation?

Dr. SEABORG. That is right. They have confirmed or exceeded them insofar as the low level of radioactivity is concerned.

Mr. MORRIS. And so far as gas pressure and volume are concerned?

Dr. SEABORG. Yes. The apparent volume of the chimney produced agrees very well with the theoretical predictions, and the rate of buildup of gas pressure is also in agreement with the theoretical prediction.

Dr. TAPE. The question of pump down and recovery of gas is still in the works so that the effects on the production have not been confirmed yet.

Dr. SEABORG. This is not the final answer. We have to be able to extract gas at a useful rate and one also where it is continually replenished in order to have a successful application of this method to recover natural gas from low producing fields.

PROJECT SLOOP

Mr. RHODES. In your statement, also, you mention rather briefly the proposal to fracture low grade copper ore bodies and to recover copper by a leaching process. Could you expand on that?

Dr. SEABORG. That is the Sloop experiment. It would be carried out in Arizona in cooperation with the Kennecott Copper Corp., and the Department of the Interior's Bureau of Mines. The idea here is to bury a nuclear explosive deep underground in the low-grade deposit and then set it off, to fracture the deposit. A chemical solution would be pumped into the chimney perhaps through drilling a vertical hole nearby, going over laterally to the chimney to dissolve out the copper. The copper bearing solution would then be pumped to the surface.

This would have the advantage not only of recovering the copper without having to move the ore to the surface, but also the waste material would remain underground rather than accumulating in large piles on the surface. This may have application to other ores as well as copper. Copper, however, seems to be the one with the most promise at this time which is why we are considering it first.

WATER CONSERVATION

Mr. RHODES. My friend and colleague from California, Mr. Hosmer, the ranking Republican on the Joint Committee on Atomic Energy, and I have often discussed the possibility of increasing water production by some such technique as this. It would entail fracturing certain underground strata to facilitate the entry of water from rains into the underground either for storage or for recharge of aquifers.

Dr. SEABORG. Yes, and such a project is being considered for Arizona, as you may know.

Dr. TAPE. A local effort in Arizona is looking at this very seriously.

Mr. RHODES. All of us feel we can do a better job of salvaging what rainfall we have than has been done. We hope this has promise.

Dr. SEABORG. Apparently there is enough water if you diminish its rate of loss by evaporation by creating a cavity underground to hold it there until you need it.

WEAPONS DEVELOPMENT TEST

Mr. RHODES. I have in my hand here a news story which concerns the explosion which will be set off in Nevada of about 1 million tons of TNT, about 1 megaton, and further down in the article it deals with protests by a delegation called Women's Strike for Peace and some other group of people who for some reason or another do not want this explosion to go off.

Would you care to tell us what this is all about?

Dr. SEABORG. They expressed concern about the possibility of seismic damage, the release of radioactivity, and perhaps even the triggering of earthquakes.

We feel that we have given all of these possibilities very serious consideration. None of these deep hole shots have vented radioactivity. There has not been any damage from the shots so far. This shot is only a little larger than those of the past. On the basis of studies by seismic experts it is considered to be essentially impossible that it could bring about an earthquake.

PROGRAM DIRECTION AND ADMINISTRATION

Mr. RHODES. Turning to your budget, I notice one particular item which we on the Appropriations Committee always notice—program direction and administration. This was $95,313,000 in fiscal 1968 and in 1969 the request is $102,885,000, an increase of some $7,572,000 for Program Direction and Administration.

Could you elaborate for us to the necessity for this increase, which which is about 8 percent?

Dr. SEABORG. I think I should begin by reminding you that we operate perhaps somewhat differently from a number of other departments and agencies. We operate through contractors and it is the need for people to help us have an efficient supervision of these contractor efforts that leads to this requirement. This is an increase of 140 people.

This is a rather "bare bones" and minimal increase which would be required to carry out our responsibilities. Eighty-seven positions are in the regulatory area. We have the responsibility to regulate, that is, to issue the construction and operating licenses, as well as other licenses, such as for radioactive materials for this whole burgeoning nuclear industry. This is a growing responsibility, as you can imagine, on the basis of the number of nuclear power reactors which we mentioned earlier. In addition, we have the requirement for about 17 of these people to help supervise our growing responsibility in the weapons area which I mentioned earlier, the building of the Sentinel and Poseidon systems. We need about 25 people to increase our technical capability in such areas as reactor development which I mentioned, breeder reactors, and naval reactors. Only nine out of the total of 140 are in the program support area.

This, Mr. Rhodes, is what it is. In some ways perhaps it is almost the most important part of our budget because we feel that with a few people here we can save the Government millions of dollars through more efficient operation.

Mr. RHODES. Does part of the money go for pay increases?

Dr. SEABORG. Yes.

Mr. RHODES. Statutory increases?
Dr. SEABORG. Yes.

METROPOLITAN WATER DISTRICT REACTOR

Mr. RHODES. Can you give us some idea now as to how the rather large desalting project to be constructed as a cooperative effort between the Atomic Energy Commission and the Metropolitan Water District of Southern California is going and what the future of it is?

Dr. SEABORG. This is period of decision. I think that is the best way for me to describe it. The Government involvement, the AEC involvement, is not very large, some $15 million. The bulk of the cost is being borne by the utilities involved and by the Metropolitan Water District.

However, there has been an increase in the estimated cost, due in no small way to the general escalation and inflation which has occurred during the several years that this has been under consideration.

Because of this increase in cost, the participants are evaluating any possible effects that this might have on their desire to go ahead with it.

I very much hope that they do decide to go ahead with it because this is a trail-blazing venture, one which I think will open the way to many such dual purpose plants in the future, and perhaps open the way to these agro-industrial complexes that a number of us, including particularly Dr. Weinberg at Oak Ridge, have talked about recently.

The Government's share in this is fixed at about $60 million. That does not escalate. The other participants are faced with this escalation in cost.

The decision as to whether the project proceeds or not resides essentially with them. The Government is exceedingly anxious to pursue this project.

Mr. RHODES. I share your hope. I hope they will be able to go ahead and do it. It is a very hopeful thing for the future.

CONTROLLED THERMONUCLEAR RESEARCH PROGRAM

Can you give us some report on the status of your controlled thermonuclear research effort? Are we making any progress toward fusing that bottle?

Dr. TAPE. I would say yes.

Mr. RHODES. You just never have found a cork.

Dr. SEABORG. That is a good way of putting the question.

Dr. TAPE. Since I talked to you last year, the work has been going forward in the several laboratories, and in answer to whether we have been able to get the bottle closed a little bit more, the answer is definitely yes. It does not mean we have the answer to the final solution. As we have said on many occasions, at each step we have found some more problems and more answers to the previous problems, but the net effect has been progress. Although we have some major problems still before us, the future still looks pretty good.

The Commission, through its staff in the controlled thermonuclear branch of our Research Division, has been doing very extensive analysis of each of the concepts and each step in the future design of experiments which will contribute significantly to the problems you

are talking about. This has been a very successful endeavor. It has been a very worthwhile analysis.

There has been some slowup, though. Earlier, we were talking about deferrals. The CTR-Scyllac project we had authorized last year and approved last year, did get caught in one of these deferrals so that is sliding it out in time more than we anticipted a year ago.

Mr. RHODES. Do you feel the time has about arrived when you should begin to concentrate your effort as to location? I know you have certain parts of it in various laboratories, and I have often wondered if this is really wise.

Dr. TAPE. This is a question which comes up periodically, and it is one we ourselves have looked at. We did a rather extensive study about a year ago, perhaps a little longer than a year ago, on just this subject. Our joint determination was that we would look at each of these approaches and move forward in the areas where we saw promise, but we did not see that it was a wise step to just take one and cut it out completely at this stage.

We have also been concentrating on trying to involve the university community somewhat more, especially in the rather basic understanding of the problem.

SUBMISSION OF LIST OF PRIORITIES

Mr. RHODES. The last question, and this is the most expensive question—as you know, I do not have to tell you the budgetary situation in the Congress today. If it becomes necessary for Congress to make very massive cuts in this budget, would you be prepared to reconsider your budget and give us a list of priorities, just where the cuts would be made? All of us would understand ahead of time that this would be the most painful task you ever had in your life because you would have to cut into things which you feel are absolutely essential and on which we perhaps would agree with you.

However, with the budgetary situation as it is, we may have to do something like this. Can you do it?

Dr. SEABORG. We certainly would feel we should be responsive to Congress; yes, sir.

Mr. RHODES. Thank you.

Mr. EVINS. Mr. Robison?

Mr. ROBISON. Mr. Rhodes stole my first question from me with the last question he put to you.

However, in view of the President's recent emphasis on the need for what he calls austerity, and the need for Congress to make cuts now in the budget which he sent us in January, cuts which he has in effect "pleaded" with Congress to make, and which he indicates he is most willing to accept though not so far to initiate, in view of all this, has the Commission reviewed or begun yet to review and reorder its own priorities, either on its own or at the direction of the President or the Bureau of the Budget?

Dr. SEABORG. We have not done it in this budget. We have gone through what we thought was a wringer in coming up with this budget and had to go through an ordering of priorities in order to do that.

Then we have accepted the cuts which have been made by the Joint Committee in the President's budget. We have not gone beyond that.

The items which are left where increases have been made from last year are very small in number, as you noted in reviewing the presentation, and these are less than cost-of-living increases, really.

The answer is no, we have not gone further than that yet.

Mr. ROBISON. Looking at the overall budgetary situation, just to summarize, your overall request is $245 million more than the amount appropriated for fiscal 1968, although this request has now been affected by the Authorization Act which, as you say, brought about a net reduction of about $75 million. Is that right?

Dr. SEABORG. That is right.

Mr. ROBISON. At the same time the authorizing committee made a number of add-ons to your original request, the largest of which was $8.5 million for an advanced submarine nuclear plant.

Dr. SEABORG. But in the defense area.

EFFECT OF STRETCHOUT

Mr. ROBISON. Yes. What you said a moment ago with respect to priorities in reply to my first question to you was with reference to the review of your program which you conducted a few months ago in response to Public Law 90–218, the so-called Economy Act of 1968, as a result of which effort on your part you did reduce your operating costs by almost $70 million. Is that right?

Dr. SEABORG. Yes, we reduced $70 million in operating expenses and deferred about $200 million in construction and equipment.

Mr. ROBISON. Are both the $70 million and the $200 million in deferrals part of your 1969 request?

Dr. SEABORG. The 1969 operating request has been reduced by the $70 million.

Mr. ABBADESSA. The difference is that the $70 million was clearly lost to the AEC. We are carrying that forward and reducing our 1969 request by $70 million.

The $200 million is not being obligated in 1968. It is being carried forward but we are not reducing our request. We still need that money. It is not effectively lost to the program.

Mr. ROBISON. So the $200 million was a deferral but the $70 million is a continuing "savings"?

Dr. SEABORG. That is right, it was a reduction. That is lost to the program.

Mr. ROBISON. "Lost" in the sense that, but for that, the budget request would be $70 million more, even though we have to weigh that against the fact that the overall request is $245 million more?

Dr. SEABORG. Yes, that is right, but that $245 million was reduced somewhat in the authorization process and was essentially in the weapons area.

Mr. ROBISON. I understand. I want it clear in my own mind that we make "a savings," but the savings is washed out for other reasons.

RAW MATERIALS PROGRAM

I notice on page 4 of your prepared statement you say that procurement of raw materials now will be exclusively from domestic sources. This is good and it is responsive to an attitude the Subcommittee has had for some time.

Now, is the $600,000 which is in the new budget for funding selected research and development contracts in uranium geology, geophysics, and so on, a new program or requirement?

Dr. SEABORG. It is increased. It is not a new line item. It shows $355,000 for the present fiscal year.

PRODUCTION AND SURVEILLANCE ACTIVITIES

Mr. ROBISON. On page 7 you refer to increases in weapons programs and operating costs. You lump together the increase of $25.9 million for "production" and also for "surveillance activities." Can you divide these for us?

You can supply it for the record if you wish.

Mr. CORSO. It becomes classified if we do that.

Mr. ROBISON. I can wait on this, for the moment, then.

NUCLEAR WEAPONS SUPERIORITY

On the same page in the same general area would you comment on whether or not we do still have in the United States a nuclear weapons superiority?

Dr. SEABORG. That is a broad question because it has to do with the sophistication of our weapons as well as the numbers.

Mr. ROBISON. I recognize the difficulty involved.

Dr. SEABORG. I would answer it in the positive. I just wanted to emphasize the complexity of it. In my mind the question of whether we have a superiority involves the sophistication of the weapons, the number of the weapons, the means for the delivery of the weapons, and our plans for the future.

I think if we take all of that into account we do have a superiority.

PRIORITY OF CIVILIAN POWER REACTOR PROGRAM

Mr. ROBISON. You made reference to the civilian power reactor program. Here, for one of the few times throughout your prepared statement, I see a reference to priorities because you say on page 9 that your estimate for this program indicates the "high priority" the Commission has assigned to this program.

I do not want to be unkind in pursuing this but it relates back to my first question to you. I think you have a responsibility to do the very best you can, and I am quite sure you have tried to do the best you can, but you have a special responsibility to present us with priorities, as you view them, in this complex and complicated field where our technical knowledge of this subject matter is very limited. I think that you have a heavier share of responsibility here than would most other Federal departments and agencies. This adds urgency, I believe, to what Mr. Rhodes proposed to you. If we find a necessity to review the budget and your portion of the request in view of the overall fiscal problem you should be of great help to us in that respect, unhappy as you might be in that role.

LOWEST PRIORITY PROGRAM

Finally, getting into the space field, Mr. Evins produced from you your comment that the Rover program was of the highest priority.

I might be playing the devil's advocate but would you have any suggestion as to what, here, might be of lowest priority to the AEC, or don't you want to go into that?

Dr. SEABORG. I would not be able to respond offhand to that; no.

Mr. ROBISON. We will be hearing from somebody later on?

Dr. TAPE. We might note that in the authorization legislation there already has been taken one of the space reactor programs so that that has been canceled.

Whether we agree with that priority or not, let us face the facts—it has been taken out. What was an almost $5 million program in fiscal 1968 will be phased out to zero in fiscal 1969.

Mr. ROBISON. Talking about last year's authorization?

Dr. TAPE. This year's authorization.

I am referring to the AEC portion.

This is an auxiliary space power project. In terms of priorities we have had one selection made for us already.

200 BEV ACCELERATOR—FISCAL YEAR 1969 FUNDING

Mr. ROBISON. Mr. Morris discussed with you the 200 Bev accelerator. You had a discussion with him about a prototype for this facility costing about $1 million.

But, then, if I read the statement right, the budget does include a request for $25 million to go forward with construction on the facility itself. Is that correct?

Dr. SEABORG. That is right.

Mr. ROBISON. You say on page 23 of your prepared statement that you have reached the point where "construction should go forward."

What is the overall estimated cost of this accelerator?

Dr. SEABORG. $250 million.

Mr. ROBISON. $25 million would represent a small start.

Dr. SEABORG. That is right. I might make a point with respect to the $1 million for the prototype to which I referred. That would be something which we would do immediately during the fiscal 1968 period.

Mr. ROBISON. I was seeking the actual need for going forward even with such a small amount on construction in fiscal 1969, when generally speaking Federal construction projects are being deferred or delayed otherwise.

Dr. SEABORG. Yes; I could respond to that and perhaps Commissioner Tape will amplify what I have to say.

This, we believe, is just about the minimum that can keep the project viable. We have assembled a very good group, including an exceptionally able director. I frankly believe that if we went below this we would get to the point where there would be nothing for them to do and the laboratory would fall apart and we might probably even lose the director and have to start over again in the future, putting us well behind in this important field.

Dr. TAPE. I might remind Mr. Robison that the director is the man we took from Cornell.

Mr. ROBISON. I know that very well.

Dr. SEABORG. I don't have to amplify his ability.

Dr. TAPE. Before he left Cornell he produced an excellent machine and he has an excellent staff.

I might comment further that we looked at just this question before we set the $25 million figure for the coming year. Working with Dr. Wilson and his staff, we evaluated the most effective and fastest schedule which we thought would be prudent for this machine. To do that would have taken something like an authorization of over $70 million for the coming year.

This did not look feasible to us. We went back and worked with him in terms of laying out just a minimum schedule necessary to keep this on a reasonable time scale and yet not lose the momentum and lose the staff that Dr. Seaborg referred to.

This comes out to $25 million.

Mr. ROBISON. Suppose you got the $25 million from this committee and the Congress. Would that, or some portion of it, actually go into construction or would it go toward the final A–E work on the facility?

Dr. TAPE. Portions would go into actual construction. Site work would proceed.

Mr. ROBISON. And later on, I suppose, somebody else will tell us specifically which is which here?

Dr. TAPE. That is right.

One of the things that Dr. Wilson has done to bring this fiscal year 1969 request down is this—instead of going forward immediately with what you might call the administrative and service type structures, he will utilize the housing which happens to be on the site which would be left over from the Weston community. Many of these houses are in Government ownership due to default, and so on; and he would use these as temporary site housing and then provide permanent facilities later in the schedule. He has been imaginative to keep the cost down.

Mr. ROBISON. Of the $800,000 add-on recommended and approved by the authorizing committee for further work on the heart-pump engine, will you need an actual appropriation for some portion or all of that?

Dr. SEABORG. All of it.

Mr. ROBISON. This has a high priority?

Dr. SEABORG. Yes. This would allow us to proceed with perhaps two out of the four approaches that we would otherwise like to have developed.

Mr. ROBISON. In other areas you have said since the reductions exceeded the additions you did not need to submit a modified budget request or something of that sort.

Dr. SEABORG. Amendment.

Mr. ROBISON. Why is this different?

Mr. ABBADESSA. With respect to the total amount that the President sent forth to the Congress, the authorization committee has reduced $80 million-plus, and has added only $13 million. Therefore, even with these additions, we are substantially below the President's request to the Congress.

Dr. SEABORG. Provided we get congressional approval.

Mr. ABBADESSA. It is clear we cannot go forward unless this committee approves each of those amounts. It is a kind of technical answer.

Dr. TAPE. You are getting a technical response to when an amendment is necessary.

MOLTEN SALT BREEDER REACTOR

Mr. EVINS. With regard to the Molten Salt Breeder reactor, you had $4,200,000 for this project last year and $6,700,000 is requested for 1969. Can you tell us what your budget request was?

Dr. SEABORG. $10 million.

Mr. EVINS. Do you feel this is a project of high priority and that additional funds could be used effectively if made available?

Dr. SEABORG. I would like to put it this way: This is a project which I feel has a lot of promise and one which will open the possibility of using thorium—not only that, but in a very low cost fuel cycle. Therefore it has the potential for providing nuclear power very inexpensively.

I think in trying to answer your question explicitly, I would like to see more money in that program; yes.

Mr. RHODES. What kind of salt is it?

Dr. SEABORG. Uranium fluoride salt. This concept is different from others in that the fuel itself flows through the reactor in molten salt form so that the undesirable neutron-absorbing fission products can be removed more or less continuously; and, hence, you get a longer fuel life and greater fuel utilization before you have to take it away somewhere and do some chemical processing. You do the processing right on site and more or less continuously.

Dr. TAPE. There is a small experiment now at Oak Ridge where they are gaining experience and it has been very successful to date.

Mr. EVINS. Dr. Weinberg is greatly interested in this program and the Commission also expresses interest.

If there are no further questions, I am reminded of the statement of one of our former colleagues. He used to have a habit of making a little speech and he would say on some of these matters—"Mr. Speaker, we just must trust somebody in this great Government of ours with all the programs and the large budgets. And, Mr. Speaker, I trust our President."

I want to say we trust the Chairman and the members of the Atomic Energy Commission.

Dr. SEABORG. Thank you.

Mr. EVINS. We thank you for your appearance and want to wish good luck to you.

We shall adjourn until 10 o'clock tomorrow morning.

WEDNESDAY, APRIL 24, 1968.

Mr. MORRIS. The committee will be in order. We will insert pages GS–1 through GS–19, the summary portion of the justification.

(Pages referred to follow:)

SUMMARY JUSTIFICATIONS

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates

GENERAL STATEMENT FOR OPERATING EXPENSES

Estimate of Appropriation

The budget estimates for Operating Expenses for fiscal year 1969 provide for total obligations of $2,394,455,000 to be funded by (1) a new appropriation of $2,225,600,000, (2) the utilization of an unobligated balance of $69,739,000 estimated to be available at the end of fiscal year 1968, and (3) an estimated $99,116,000 to be received as revenues from non-Federal sources during the fiscal year.

Estimates of Costs and Obligations

The budget estimates for this appropriation are stated in terms of accrued costs for each of the AEC's operating programs. "Accrued costs" denotes the actual application of labor, materials and services to the program during the year, but excludes depreciation of facilities used in the operations. The AEC does, however, maintain accounts for depreciation for the purpose of determining total costs of production and for use in establishing prices for services rendered or products sold to others.

The costs of operation are reconciled to the total obligations to be incurred during the year by estimating the build-up or decrease during the year of the resources that are to be applied to future years' operations. These estimates are included in the section titled, "Increase or Decrease in Selected Resources" and include inventories and undelivered orders.

From total obligations are deducted the revenues estimated to be obtained from non-Federal sources in order to arrive at the amount of appropriations required. These revenues are obtained from AEC-owned community and housing operations, from the sale of products, from services performed for others, and from other miscellaneous sources. These revenues are identified and summarized under the tab "Revenues Applied".

The following table summarizes the accrued costs for each program, and the total obligations for 1967, 1968, and 1969. The detailed justifications present the programs in the same order as they appear on this summary table.

SUMMARY OF ACCRUED OPERATING COSTS
BY PROGRAM RECONCILED TO NET OBLIGATIONS

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Accrued Costs by Program:			
Raw Materials	$ 161,893,637	$ 127,733,000	$ 112,470,000
Special Nuclear Materials	349,302,531	340,670,000	334,303,000
Weapons	661,132,729	722,450,000	840,790,000
Reactor Development	455,019,468	482,103,000	509,520,000
Physical Research	253,398,920	265,000,000	280,000,000
Biology and Medicine	85,747,442	88,450,000	92,051,000
Training, Education and Information	15,947,747	16,422,000	17,009,000
Isotopes Development	6,880,565	7,375,000	7,185,000
Civilian Applications of Nuclear Explosives	12,852,846	17,965,000	14,500,000
Community	9,347,955	6,771,000	6,942,000
Program Direction and Administration	87,512,110	95,313,000	102,885,000
Security Investigations	6,250,088	6,795,000	6,588,000
Cost of Work for Others	24,448,390	11,219,000	14,533,000
Adjustment to Prior Year Costs	-1,936,310	-	-
Total Accrued Program Costs	2,127,798,118	2,188,266,000	2,338,776,000
Increase or Decrease in Selected Resources	3,231,100	7,561,232	55,679,000
Total Obligations for Operating Expenses	2,131,029,218	2,195,827,232	2,394,455,000
Less: Revenues Applied	-97,088,745	-66,464,000	-99,116,000
Net Obligations (Financed by Appropriated Funds)	$2,033,940,473	$2,129,363,232	$2,295,339,000

Financing of Obligations

The financing of the estimated total obligations of $2,394,455,000 proposed in the budget estimates for 1969, together with comparable data for 1967 and 1968, is summarized in the following table:

SUMMARY OF FINANCING

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Funds available for obligations:			
Unobligated balance, beginning of year	$ 170,217,438	$ 59,110,507	$ 69,739,000
Appropriation	1,923,000,000	2,140,000,000	2,225,600,000
Transfer to other accounts	-166,458	-8,275	-
Revenues received from non-Federal sources	97,088,745	66,464,000	99,116,000
Total funds available for obligation	2,190,139,725	2,265,566,232	2,394,455,000
Less: Unobligated balance, end of year	59,110,507	69,739,000	-
Total obligations incurred	$2,131,029,218	$2,195,827,232	$2,394,455,000

Expenditures for Operating Expenses

Expenditures from the "Operating Expenses" appropriation for 1969 are estimated at $2,136,000,000. The estimated amounts available for expenditure in 1967, 1968, and 1969, the expenditures for each year, and the remaining unexpended balances are shown in the following table:

EXPENDITURE ANALYSIS

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Funds available for expenditure:			
Unexpended balance, beginning of year:			
Obligated	$ 932,989,643	$ 963,520,569	$1,070,883,801
Unobligated balance	170,217,438	59,110,507	69,739,000
New appropriation	1,923,000,000	2,140,000,000	2,225,600,000
Transfer to other accounts	-166,458	-8,275	-
Total funds available for expenditure	3,026,040,623	3,162,622,801	3,366,222,801
Less: Expenditures	2,003,409,547	2,022,000,000	2,136,000,000
Unexpended balance, end of year:			
Obligated	963,520,569	1,070,883,801	1,230,222,801
Unobligated balance	59,110,507	69,739,000	-
Unexpended balance, end of year	$1,022,631,076	$1,140,622,801	$1,230,222,801

HIGHLIGHTS OF OPERATING PROGRAMS

There follows a brief description of each of the programs set forth in the summary on page GS-2.

1. Raw Materials Program - Operating costs for the raw materials program are estimated at $112.5 million in 1969, compared with 1968 estimated costs of $127.7 million and 1967 actual costs of $161.9 million. The 1969 program estimates provide for the continued procurement of uranium concentrates and activities related to resource investigations. The deliveries of uranium concentrates are from domestic sources and reflect the completion of deliveries deferred during the CY 1963-1966 period. Deliveries during the last half of the fiscal year are from the additional material which the AEC agreed to purchase in CY 1969-1970 pursuant to the domestic stretchout program announced in 1962.

2. Special Nuclear Materials Program - Operating costs for the special nuclear materials program are estimated at $334.3 million in 1969, compared with 1968 estimated costs of $340.7 million and 1967 actual costs of $349.3 million. Special nuclear materials are produced to meet weapons production schedules and requirements for other programs. Uranium concentrates are processed into feed materials from which plutonium and other products are produced in the reactors at Richland, Washington, and Savannah River, South Carolina, and the isotope uranium-235 is extracted in plants at Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio. The 1969 estimates provide for the enrichment of feed supplied from the private sector pursuant to Sec. 161v of the Atomic Energy Act of 1954, as amended, and for which revenues resulting from charges for separative work are budgeted under the Revenues Applied Program. The 1969 estimates also reflect full year savings of $16.5 million related to the shutdown, in February 1968, of a production reactor at Richland and one at Savannah River. Work will continue on process improvements to assure continuity and safety of operations, more economical methods of production, and more timely development of new production processes with increased emphasis in 1969 on the production of enriched uranium.

3. Weapons Program - Operating costs for the weapons program are estimated at $840.8 million in 1969, compared with 1968 estimated costs of $722.4 million and 1967 actual costs of $661.1 million. The weapons program encompasses the production of atomic weapons; the maintenance of stockpiled weapons in a state of constant readiness; the design, development and underground testing of new weapons types; maintenance of a readiness capability to resume atmospheric testing; and participation with the Department of Defense in the development of test detection methods. The 1969 estimates include increases for the production of new weapons systems and increased emphasis on the development and testing of new weapons types.

4. Reactor Development Program - Operating costs for the reactor development program are estimated at $509.5 million in 1969 compared with 1968 estimated costs of $482.1 million and 1967 actual costs of

$455.0 million. Emphasis will continue to be placed on advancing power reactor technology in order to achieve large scale generation of economic electrical energy and conservation of natural resources from atomic reactors. In particular, the development program on liquid metal cooled fast breeder reactors will increase substantially to support the plan leading to an economic fast breeder nuclear power plant. Special attention will be given also to the timely development and use of nuclear energy for desalting sea water, including support of the large dual-purpose nuclear power desalting plant to be constructed by the Metropolitan Water District of Southern California. Cooperative endeavors will be continued between the Commission and industrial groups, as well as with the European Atomic Energy Community (EURATOM) and Canada.

The estimates provide for research and development in advanced systems and technology, and in nuclear safety with particular emphasis directed toward engineered safety features.

Development of nuclear reactors for propulsion of naval vessels will be continued. The NERVA technology program test activities will be completed and the definition and design of a NERVA engine will be underway, including component fabrication and testing; development of advanced fuels and graphite reactor concepts will also continue. Radioisotope power sources and reactors are also being developed to meet power requirements for remote areas, and to provide electric power and heat for satellites.

Operation of test facilities and experimental reactors will be continued at the National Reactor Testing Station in Idaho, and at other locations.

5. Physical Research Program - Operating costs for the physical research program are estimated at $280.0 million in 1969 compared with 1968 estimated costs of $265.0 million and 1967 actual costs of $253.4 million. The physical research program consists of theoretical and experimental investigations required to support the Commission's immediate and long-range research objectives. The phenomena dealt with are at the forward boundaries of scientific knowledge. Unusual materials are employed and their nuclear, as well as their chemical and physical properties, must be determined. The temperatures and radiation densities at which these materials are used are outside the range of previous experience in industrial technology. Advances achieved in the past can be traced back to similar laboratory investigations. The Commission serves as the executive agent for the nation's high energy physics program. Also included in the estimates for this program are funds for the Ernest O. Lawrence awards, $25,000.

6. Biology and Medicine Program - Operating costs for the biology and medicine program are estimated at $92.1 million for 1969, compared with estimated costs of $88.5 million in 1968 and actual costs of $85.7 million in 1967. Emphasis will continue to be placed on research directed toward the protection of the health and safety of atomic energy plant workers, uranium miners, and the general populace from the hazards of atomic energy operations. The upper-air sampling program and research on chemical toxicity will be continued at approximately the current level of effort. There will be a continuing research effort in beneficial applications of radiation and radioisotopes in medicine, agriculture, and in cancer research. Close liaison will continue to be maintained with other agencies performing functions interrelated with AEC biomedical interests. Research is carried on by AEC laboratories, universities and other independent institutions.

7. Training, Education and Information Program - Operating costs for the training, education and information program are estimated at $17.0 million in 1969 compared to 1968 estimated costs of $16.4 million and 1967 actual costs of $15.9 million. Primary program emphasis will be placed on broadening the base of nuclear technology. Program efforts are directed toward provision of assistance to colleges and universities in establishing nuclear curricula; provision of assistance to states for training in radiation control; operation of the Puerto Rico Nuclear Center; conduct of specialized courses; administration of cooperative programs between universities and AEC laboratories; offering of graduate fellowships in the nuclear energy field, including a traineeship program; presenting nuclear science demonstrations and exhibits; and development and dissemination of information.

8. Isotopes Development Program - Operating costs for the isotopes development program are estimated at $7.2 million in 1969 compared to 1968 estimated costs of $7.4 million and 1967 actual costs of $6.9 million. The program consists of research and development activities required to accelerate realization of the potentially vast uses of radioisotopes and radiation technology. Primary emphasis will be placed on development of fuels for a circulatory support system, technology development and radiation

processing applications, and on research and development related to environmental pollution. Work will continue on radiation preservation of foods and radioisotope production and materials development. Much of this work is carried out in cooperation with industry and other Government agencies.

9. Civilian Applications of Nuclear Explosives Program - Operating costs for the civilian applications of nuclear explosives program (Plowshare) are estimated at $14.5 million for 1969 compared to estimated costs of $18.0 million in 1968 and actual costs of $12.9 million in 1967. The program provides for the investigation and development of peaceful uses for nuclear explosives. The 1969 estimates provide for research and development aimed at a fundamental understanding of nuclear explosive design and explosion phenomenology and the development and testing of cleaner devices for use in nuclear excavation projects; a cratering experiment to extend the development of excavation technology; work on special nuclear explosives for producing transuranium elements; and development of nuclear technology capable of being used in the recovery of natural resources.

10. Community Program - Operating costs for the community program are estimated at $6.9 million in 1969, as compared with estimated costs in 1968 of $6.8 million and 1967 actual costs of $9.3 million. The 1969 estimate provides $5.8 million for assistance payments to the former AEC communities of Oak Ridge, Tennessee, Richland, Washington, and Los Alamos, New Mexico, in accordance with the Atomic Energy Community Act of 1955, as amended. The estimate also provides for $1.1 million in costs at Los Alamos principally for community administration, fire protection and continued maintenance and operation of certain real estate properties which have not been sold. Operating revenues for Los Alamos related to these real estate properties and budgeted under the revenues applied program are estimated at $0.5 million in 1969.

11. Program Direction and Administration - Operating costs for program direction and administration are estimated at $102.9 million in 1969 compared to 1968 estimated costs of $95.3 million and 1967 actual costs of $87.5 million. An increase in staff of 140 employees is budgeted for 1969 under this program. Estimates for program direction and administration cover the salary costs and other expenses of Commission personnel engaged in general management, executive direction, and technical supervision of program operations; the negotiation and administration of contracts; other related administrative activities; and the discharge of safeguards and regulatory functions.

12. Security Investigations - Cost of investigations performed by the Civil Service Commission and the Federal Bureau of Investigation, at the request of the Commission, of persons to be employed on work involving access to restricted data, under the provisions of the Atomic Energy Act of 1954, as amended, in 1969 are estimated at $6.6 million compared with 1968 estimated costs of $6.8 million and 1967 actual costs of $6.3 million.

13. Cost of Work for Others Program - Cost of work for others is estimated to be $14.5 million in 1969, compared to 1968 estimated costs of $11.2 million and actual costs of $24.5 million in 1967. This program includes costs incurred by the Commission in furnishing materials and services to industrial organizations and other private parties apart from those which it provides normally for its own basic program. The costs are incurred only upon the request of others. Charges are made for these materials and services and the revenues derived are included under "Revenues Applied."

14. Increase or Decrease in Selected Resources - This program covers change in inventory stocks held by AEC and its contractors, collateral funds, and goods and services on order under contract. The appropriation requirements for these items are based on the changes in balances from the previous fiscal year. Balances at the end of 1969 are estimated at $957.5 million, as compared with $901.9 million at the end of 1968, or an increase of $55.6 million in 1969. Balances at the end of 1967 were $894.3 million.

15. Revenues Applied - This program includes income from sale and lease of products and from services rendered, revenues from communities, and other miscellaneous income items. These revenues are applied against Atomic Energy Commission appropriation requirements. Revenues are estimated at $99.1 million for 1969, compared to an estimate of $66.5 million for 1968 and actual revenues in 1967 of $97.1 million. The FY 1969 estimate includes an amount of $27.0 million related to charges for separative work in providing uranium enrichment services to the private sector pursuant to Sec. 161v of the Atomic Energy Act of 1954, as amended.

U. S. ATOMIC ENERGY COMMISSION

EXPLANATION OF PROPOSED LANGUAGE CHANGES - OPERATING EXPENSES

The proposed change in language is indicated as follows: language enclosed in brackets [ ] indicates proposed deletion; language underscored _____ indicates proposed insertion.

1. "[$2,140,000,000] $2,225,600,000 and any moneys (except sums received from disposal of property under the Atomic Energy Community Act of 1955, as amended (42 U.S.C. 2301)) received by the Commission, notwithstanding the provisions of section 3617 of the Revised Statutes (31 U.S.C. 484), to remain available until expended:"

This change reflects the FY 1969 appropriation amount.

EXPLANATION OF PROPOSED LANGUAGE CHANGES - GENERAL PROVISIONS

The proposed changes in the language for the administrative provisions are described below. Language enclosed in brackets [ ] indicates proposed deletions; language underscored _____ indicates proposed insertions.

1. [Any appropriation available to the Atomic Energy Commission may initially be used subject to limitations in this Act during the current fiscal year to finance the procurement of materials, services, or other costs which are a part of work or activities for which funds have been provided in any other appropriation available to the Commission: Provided, That appropriate transfers or adjustments between such appropriations shall subsequently be made for such costs on the basis of actual application determined in accordance with generally accepted accounting principles.]

This paragraph is deleted as the passage of P. L. 89-473 approved June 29, 1966 makes this provision no longer necessary.

94-075 O-68-pt. 3—5

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates

GENERAL STATEMENT FOR PLANT AND CAPITAL EQUIPMENT

Summarization of estimated 1969 obligations by program follows:

SECTION 1 - SUMMARY OF FY 1969 OBLIGATIONS FROM NEW APPROPRIATIONS

	Funding for Projects Authorized in Prior Years	Funding for Projects Included in the 1969 Authorization Request	Capital Equipment Not Related to Construction	Total Obligations from New Appropriation
Raw Materials	$ -	$ 120,000	$ 510,000	$ 630,000
Special Nuclear Materials	-	16,875,000	17,950,000	34,825,000
Weapons	-	215,400,000 a/	79,270,000	294,670,000
Reactor Development	35,000,000	25,925,000	38,550,000	99,475,000
Physical Research	26,200,000	32,025,000 b/	30,850,000	89,075,000
Biology and Medicine	-	950,000	5,000,000	5,950,000
Training, Education and Information	-	225,000	595,000	820,000
Isotopes Development	-	-	1,000,000	1,000,000
Civilian Applications of Nuclear Explosives	-	-	500,000	500,000
Community	-	-	3,000	3,000
Administrative	-	240,000	1,812,000	2,052,000
Total Obligations from New Appropriations	$ 61,200,000	$ 291,760,000	$ 176,040,000	$ 529,000,000

a/ Includes $184,500,000 for a FY 1968 project, and $3,200,000 for a FY 1966 project for which additional authorization is being requested in FY 1969.

b/ Includes $25,000,000 for a FY 1968 project for which additional authorization is being requested in FY 1969.

SECTION 2 - SUMMARY OF FY 1969 OBLIGATIONS DEFERRED FROM FY 1968

	Construction Projects	Capital Equipment Not Related to Construction	Total Obligations Deferred From FY 1968
Raw Materials	$ -	$ 20,000	$ 20,000
Special Nuclear Materials	4,170,000	2,558,000	6,728,000
Weapons	10,728,000	5,792,000	16,520,000
Reactor Development	71,114,000	14,450,000	85,564,000
Physical Research	69,559,000	11,171,000	80,730,000
Biology and Medicine	4,789,000	1,700,000	6,489,000
Training, Education and Information	475,000	140,000	615,000
Isotopes Development	-	410,000	410,000
Civilian Applications of Nuclear Explosives	-	250,000	250,000
Administrative	-	77,000	77,000
Construction Planning and Design	2,448,000	-	2,448,000
Total Obligations Deferred from FY 1968	$ 163,283,000	$ 36,568,000	199,851,000
Total Obligations			$ 728,851,000

Summary of Obligations

The following table summarizes the total obligations for each of the programs for 1967, 1968 and 1969 with the latter year including $199,851,000 of obligations deferred from FY 1968.

SUMMARY OF OBLIGATIONS BY PROGRAM

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Raw Materials	$ 88,015	$ 205,000	$ 650,000
Special Nuclear Materials	31,620,804	22,319,000	41,553,000
Weapons	92,146,800	178,286,000	311,190,000
Reactor Development	57,296,916	46,863,643	185,039,000
Physical Research	93,456,258	61,487,000	169,805,000
Biology and Medicine	11,620,912	5,377,000	12,439,000
Training, Education and Information	710,497	1,811,000	1,435,000
Isotopes Development	1,361,443	990,000	1,410,000
Civilian Applications of Nuclear Explosives	497,102	100,000	750,000
Community	1,031,608	5,000	3,000
Administrative	1,992,864	1,254,000	2,129,000
Construction Planning and Design	745,419	1,561,000	2,448,000
Total Obligations	$ 292,568,638	$ 320,258,643	$ 728,851,000

Financing of Obligations

The financing of the estimated total obligations of $728,851,000 proposed in the budget estimates for 1969, together with comparable data for 1967 and 1968, is summarized in the following table:

SUMMARY OF FINANCING

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Funds Available:			
Unobligated balance at beginning of year	$ 161,783,414	$ 150,098,643	$ 199,851,000
Recovery of prior year obligations	4,853,867	878,000	-
Appropriation	276,030,000	369,133,000	529,000,000
Net Amount Available for Obligation	442,667,281	520,109,643	728,851,000
Unobligated Balance at End of Year	150,098,643	199,851,000	-
Total Obligations	$ 292,568,638	$ 320,258,643	$ 728,851,000

Expenditures for Plant and Capital Equipment

Expenditures from the "Plant and Capital Equipment" appropriation for 1969 are estimated to be $410,000,000. The estimated amounts available for expenditure in 1967, 1968, and 1969, the expenditures for each year, and the remaining unexpended balances are shown in the following table:

EXPENDITURE ANALYSIS

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Funds available for expenditure:			
Unexpended balance, beginning of year	$ 483,885,932	$ 477,350,599	$ 535,483,599
Appropriation	276,030,000	369,133,000	529,000,000
Total Funds Available for Expenditure	759,915,932	846,483,599	1,064,483,599
Less: Expenditures	282,565,333	311,000,000	410,000,000
Unexpended balance, end of year	$ 477,350,599	$ 535,483,599	$ 654,483,599

HIGHLIGHTS OF PLANT AND CAPITAL EQUIPMENT

There follows a brief statement related to the proposed obligations for each of the programs set forth in Section 1 of the summary on page GS-12.

1. Raw Materials - Obligations for raw materials plant and capital equipment in 1969 are estimated at $630 thousand. This includes $120 thousand for minor modifications and improvements to existing plant or installations, and $510 thousand for capital equipment not related to construction. Included in these figures are approximately $310 thousand for procurement of a computer and $95 thousand in plant for modifications to a building to house this computer.

2. Special Nuclear Materials - Obligations for special nuclear materials plant and capital equipment in 1969 are estimated at $34.8 million of which $16.9 million is necessary to provide for new construction projects proposed for authorization and $17.9 million is estimated for capital equipment not related to construction. The $16.9 million proposed for new construction projects includes $3.5 million for waste storage tanks at Savannah River, South Carolina; $0.7 million for a powder metallurgy facility, Savannah River, South Carolina; $3.9 million for an equipment test facility at Oak Ridge, Tennessee; $2.1 million for calcined solids storage facility additions, National Reactor Testing Station, Idaho; and $6.7 million for general plant projects.

3. Weapons - Obligations for weapons plant and capital equipment in 1969 are estimated at $294.7 million of which $215.4 million is necessary to provide for new construction projects proposed for authorization, and $79.3 million is estimated for capital equipment not related to construction. The new construction projects include $3.5 million for the rehabilitation of plutonium processing site, Los Alamos Scientific Laboratory, New Mexico; $10.0 million for additional production, development, and test installations; $14.2 million for general plant projects. Also included are $184.5 million in obligations for new weapons production capabilities, various locations; and $3.2 million in obligations for an environmental test facility, Lawrence Radiation Laboratory, Livermore, California. These projects were originally authorized in 1968 and 1966, respectively.

4. Reactor Development - Obligations for reactor development plant and capital equipment in 1969 are estimated at $99.5 million of which $25.9 million will provide for new construction projects proposed for authorization, $35.0 million for funding on a project the construction of which was authorized in FY 1968, and $38.6 million for capital equipment not related to construction. The new construction projects include $10.0 million for a hot fuel examination facility and $2.0 million for modifications to EBR-II and related facilities at the National Reactor Testing Station, Idaho; $0.5 million for conversion of the heating plant to natural gas at Argonne National Laboratory, Illinois; $1.0 million for a support project for modifications to reactors; $1.0 million for a support project for Project Rover; and $11.4 million for general plant projects. Additional obligations of $35.0 million for the fast flux test facility are included for annual funding of this project, the construction of which was authorized in FY 1968.

5. Physical Research - Obligations for physical research plant and capital equipment in 1969 are estimated at $89.1 million of which $32.0 million is for new construction projects requiring authorization, $26.2 million for funding on a project the construction of which was authorized in FY 1968, and $30.9 million is for capital equipment not related to construction. The new construction projects include $25.0 million for partial funding of the 200 Bev accelerator project for which full authorization at $250.0 million is requested; $0.8 million for conversion of the steam plant to natural gas at Brookhaven National Laboratory, New York; $3.0 million for accelerator improvements at various sites; and $3.2 million for general plant projects. Additional obligations of $26.2 million for the meson physics facility, Los Alamos Scientific Laboratory, New Mexico, are included for annual funding of this project, the construction of which was authorized in FY 1968.

6. Biology and Medicine - Obligations for biology and medicine plant and capital equipment in 1969 are estimated at $6.0 million of which $1.0 million is for new general plant projects requiring authorization and $5.0 million is for capital equipment not related to construction.

7. Training, Education and Information - Obligations for training, education and information plant and capital equipment in 1969 are estimated at $0.8 million. This includes $0.2 million for general plant projects at the Puerto Rico Nuclear Center; and $0.6 million for capital equipment not related to construction.

8. Isotopes Development - Obligations for isotopes development are estimated at $1.0 million all of which is for capital equipment not related to construction.

9. Civilian Applications of Nuclear Explosives - Obligations for civilian applications of nuclear explosives are estimated at $0.5 million for capital equipment not related to construction.

10. Community - Obligations for community are estimated at $3 thousand for capital equipment not related to construction.

11. Administrative - Obligations for improvements and modifications of administrative facilities at the Commission Headquarters in Germantown, Maryland, and for procurement of capital equipment to support the operating program in 1969 are estimated at $2.0 million. This includes $240 thousand for general plant projects and $1.8 million for capital equipment not related to construction.

U. S. ATOMIC ENERGY COMMISSION

EXPLANATION OF PROPOSED LANGUAGE CHANGES - PLANT AND CAPITAL EQUIPMENT

Proposed changes in language are indicated as follows: language enclosed in brackets [ ] indicates proposed deletions, and underscoring _____ indicates proposed insertion of new language.

1. "purchase of not to exceed [four hundred,] five hundred and eighty-nine (including five hundred and fifty-three for replacement [only] only), of which [seven] eleven for police-type use may exceed by $300 each the general purchase price limitation for the current fiscal year, and hire of passenger motor vehicles; and hire of aircraft;"

This change provides for authorization to procure 589 passenger vehicles in FY 1969 of which 553 are for replacement of older vehicles and 36 would be additions to the fleet.

All vehicles to be replaced will meet or exceed the GSA replacement standards. The additional vehicles requested include 25 automobiles, 8 station wagons, 1 ambulance and 2 buses. Of this increase, 25 automobiles and 7 station wagons will be required by Chicago in connection with the 200 BEV Accelerator project, 1 ambulance is needed by the Ames Laboratory for remote locations at the Reactor and Synchrotron sites, one station wagon is needed to replace a panel truck for use on the exhibits program in South America and 2 buses are required at the National Reactor Testing Station for transportation of employees.

The 11 sedans at not to exceed $1,800 each are for use in police patrol activities within plant areas, including the enforcement of state motor vehicle laws and the execution of security duties. Contractors are assigned passenger motor vehicles as Government-furnished equipment and operate them in carrying out the Commission's program. The estimated passenger vehicle fleet at the end of FY 1969 will number 2,517 or 36 more than the number estimated at the end of FY 1968.

2. "[$369,133,000] $529,000,000, to remain available until expended."

This change provides for deletion of the amount appropriated in FY 1968 and insertion of the amount of the FY 1969 appropriation request.

Operating Expenses

OBJECT CLASSIFICATION (IN THOUSANDS OF DOLLARS)

		1967 actual	1968 estimate	1969 estimate
	ATOMIC ENERGY COMMISSION			
	Personnel compensation:			
11.1	Permanent positions	79,442	84,260	88,996
11.3	Positions other than permanent	1,557	1,503	1,560
11.5	Other personnel compensation	1,464	1,322	1,485
11.8	Special personal service payments	82	58	69
	Total personnel compensation	82,545	87,143	92,110
12.0	Personnel benefits	6,503	6,847	7,471
13.0	Benefits for former personnel	106	103	110
21.0	Travel and transportation of persons	3,725	4,300	4,607
22.0	Transportation of things	3,044	3,714	4,171
23.0	Rent, communications, and utilities	124,095	117,372	98,333
24.0	Printing and reproduction	566	665	688
25.1	Other services	1,669,609	1,760,297	1,932,359
25.2	Services of other agencies	63,505	64,708	69,120
26.0	Supplies and materials	167,397	137,028	123,236
41.0	Grants, subsidies, and contributions	6,580	5,926	6,408
42.0	Insurance claims and indemnities	66	63	63
91.0	Unvouchered		100	100
	Total cost, Atomic Energy Commission	2,127,741	2,188,266	2,338,776
94.0	Change in selected resources	3,231	7,561	55,679
	Total obligations, Atomic Energy Commission	2,130,972	2,195,827	2,394,455
	ALLOCATION ACCOUNTS			
25.1	Other services	57		
	Total obligations, allocation accounts	57		
99.0	Total obligations	2,131,029	2,195,827	2,394,455
	Obligations are distributed as follows:			
	Atomic Energy Commission	2,130,972	2,195,827	2,394,455
	Interior, Saline Water	262		
	Commerce, Maritime Administration	−205		

PERSONNEL SUMMARY

Total number of permanent positions	7,221	7,391	7,536
Full-time equivalent of other positions	267	223	233
Average number of all employees	7,244	7,275	7,447
Average grade, grades established by Atomic Energy Commission	9.7	9.8	9.9
Average salary, salaries established by Atomic Energy Commission	$11,368	$12,126	$12,368

PROGRAM AND FINANCING (IN THOUSANDS OF DOLLARS)

	1967 actual	1968 estimate	1969 estimate
Program by activities:			
1. Raw materials	161,894	127,733	112,470
2. Special nuclear materials	349,302	340,670	334,303
3. Weapons	661,133	722,450	840,790
4. Reactor development	455,019	482,103	509,520
5. Physical research	253,399	265,000	280,000
6. Biology and medicine	85,747	88,450	92,051
7. Training, education, and information	15,948	16,422	17,009
8. Isotopes development	6,881	7,375	7,185
9. Civilian applications of nuclear explosives	12,853	17,965	14,500
10. Communities	9,348	6,771	6,942
11. Program direction and administration	87,512	95,313	102,885
12. Security investigations	6,250	6,795	6,588
13. Cost of work for others	24,448	11,219	14,533
14. Adjustment to prior year costs	−1,936		
Total program costs, funded	2,127,798	2,188,266	2,338,776
Change in selected resources [1]	3,231	7,561	55,679
10 Total obligations	2,131,029	2,195,827	2,394,455
Financing:			
Receipt and reimbursements from:			
13 Trust funds	−4,583	−2,060	−1,188
14 Non-Federal sources (81 Stat. 480)	−92,506	−64,404	−97,928
21 Unobligated balance available, start of year	−170,217	−59,110	−69,739
24 Unobligated balance available, end of year	59,110	69,739	
New obligational authority	1,922,833	2,139,992	2,225,600
New obligational authority:			
40 Appropriation	1,923,000	2,140,000	2,225,600
41 Transferred to other accounts	−167	−8	
43 Appropriation (adjusted)	1,922,833	2,139,992	2,225,600
Relation of obligations to expenditures:			
10 Total obligations	2,131,029	2,195,827	2,394,455
70 Receipts and other offsets (items 11–17)	−97,089	−66,464	−99,116
71 Obligations affecting expenditures	2,033,940	2,129,363	2,295,339
72 Obligated balance, start of year	932,990	963,521	1,070,884
74 Obligated balance, end of year	−963,521	−1,070,884	−1,230,223
90 Expenditures	2,003,409	2,022,000	2,136,000
Expenditures are distributed as follows:			
01 Out of current authorizations	1,070,419	999,369	995,377
02 Out of prior authorizations	932,990	1,022,631	1,140,623

[1] Selected resources as of June 30 are as follows:

	1966	1967	1968	1969
Inventories and items on order:				
Inventories	193,748	188,323	192,732	193,192
Unpaid undelivered orders	674,126	686,524	689,803	745,149
Advances	9,768	6,436	6,309	6,182
Collateral funds and other deposits (insurance collateral, employee benefit and annuity funds merchandise deposits with vendors and miscellaneous deposits)	13,389	12,979	12,979	12,979
Total selected resources	891,031	894,262	901,823	957,502

Plant and Capital Equipment

OBJECT CLASSIFICATION (IN THOUSANDS OF DOLLARS)

		1967 actual	1968 estimate	1969 estimate
	ATOMIC ENERGY COMMISSION			
25.1	Other services	657	1,372	4,000
25.2	Services of other agencies	2,738	4,097	5,025
26.0	Supplies and materials	163	320	640
31.0	Equipment	152,206	138,541	171,159
32.0	Lands and structures	132,684	175,184	261,504
	Total costs funded, Atomic Energy Commission	288,448	319,514	442,328
94.0	Change in selected resources	4,307	733	286,523
	Total obligations, Atomic Energy Commission	292,755	320,247	728,851
	ALLOCATION ACCOUNTS			
25.1	Other services	−186	12	
99.0	Total obligations	292,569	320,259	728,851
	Obligations are distributed as follows:			
	Atomic Energy Commission	292,755	320,247	728,851
	Commerce, Maritime Administration	−214		
	Defense—Military, Army	28	12	

ALLOCATIONS RECEIVED FROM OTHER ACCOUNTS

Note: Obligations incurred under allocations from other accounts are included in the schedules of the parent appropriations as follows:

Defense—Military: Navy, "Shipbuilding and conversion."
Housing and Urban Development: "Community disposal operations."
National Aeronautics and Space Administration: "Construction of facilities."

PROGRAM AND FINANCING (IN THOUSANDS OF DOLLARS)

		1967 actual	1968 estimate	1969 estimate
	Program by activities:			
	Facilities and equipment for—			
	1. Raw materials	88	205	650
	2. Special nuclear materials	31,621	22,319	41,553
	3. Weapons	92,147	178,286	311,190
	4. Reactor development	57,297	46,864	185,039
	5. Physical research	93,456	61,487	169,805
	6. Biology and medicine	11,621	5,377	12,439
	7. Training, education, and information	711	1,811	1,435
	8 Isotopes development	1,361	990	1,410
	9. Civilian applications of nuclear explosives	497	100	750
	10. Communities	1,032	5	3
	11. Administrative	1,993	1,254	2,129
	12. Construction planning and design	745	1,561	2,448
	Total obligations	292,569	320,259	728,851
	Financing:			
17	Recovery of prior year obligations	−4,854	−878	
21	Unobligated balance available, start of year	−161,784	−150,099	−199,851
24	Unobligated balance available, end of year	150,099	199,851	
40	New obligational authority (appropriation)	276,030	369,133	529,000
	Relation of obligations to expenditures:			
10	Total obligations	292,569	320,259	728,851
70	Receipts and other offsets (items 11–17)	−4,854	−878	
71	Obligations affecting expenditures	287,715	319,381	728,851
72	Obligated balance, start of year	322,102	327,252	335,633
74	Obligated balance, end of year	−327,252	−335,633	−654,484
90	Expenditures	282,565	311,000	410,000
	Expenditures are distributed as follows:			
01	Out of current authorizations	87,600	99,330	123,300
02	Out of prior authorizations	194,965	211,670	286,700

PROGRAM BY ACTIVITIES

[In thousands of dollars]

	Costs to this appropriation			Analysis of 1969 financing			
	1967 actual	1968 estimate	1969 estimate	Deduct selected resources and unobligated balance, start of year	Add selected resources, end of year	Appropriation required for 1969	Appropriation required to complete
Raw materials	83	219	640	26	16	630	
Special nuclear materials	33,303	27,868	27,583	36,320	43,562	34,825	
Weapons	91,105	135,918	231,793	143,688	206,565	294,670	
Reactor development	57,738	68,484	87,722	151,136	162,889	99,475	24,000
Physical research	84,185	72,995	81,899	157,199	164,375	89,075	229,662
Biology and medicine	9,243	6,831	7,028	12,036	10,958	5,950	
Training, education and information	651	1,426	1,830	1,604	594	820	
Isotopes development	1,334	1,105	1,250	1,467	1,217	1,000	
Civilian applications of nulcear explosives	588	100	400	453	553	500	
Communities	3,563	345	3			3	
Administrative	601	2,417	1,500	780	1,332	2,052	
Construction planning and design	1,014	940	680	3,630	2,950		
Total program costs, funded	283,408	318,648	442,328	508,339	595,011	529,000	253,662
Change in selected resources [1]	4,307	733	286,523				
Recovery of prior year obligations	4,854	878					
Total obligations	292,569	320,259	728,851				

[1] Selected resources as of June 30 are as follows: 1966, $303,448,000; 1967, $307,755,000; 1968, $308,488,000; 1969, $595,011,000.

Raw Materials Program

Mr. Morris. We will hear first this morning from the Raw Materials Division. Have you a prepared statement?

Mr. Faulkner. Not a prepared statement, sir, but an oral statement.

Mr. Morris. You may proceed.

BUDGET REQUEST

Mr. Faulkner. Mr. Chairman, our operating expense budget request this year is $112.5 million, a decrease of $15.3 million from last year. The procurement this year is roughly the same as last, at 7,960 tons of U_3O_8, all from domestic sources, but the price during the first half of the year will be at $8 a pound of U_3O_8, and at $5.90 during the second half.

In the operating budget we have also included $600,000 for research and development work on the scientific aspects of uranium deposition which may help find hidden deposits; those which are not easily found and have no surface expression. Most of this work is done in our universities and colleges and private research foundations.

In the end, we hope that this work will help to develop better tools, better techniques, and better methods of finding uranium.

We endeavor to avoid duplication in this effort with any work being done by the industry. If industry will do it, we will not.

Secondly, we have close contacts with the U.S. Geological Survey to determine to the extent possible that there is no duplication in this area.

Our procurement program is to run 2½ years from the beginning of fiscal year 1969 to the end of calendar year 1970, which will phase out Government procurement.

The last 2 years of the purchases, calendar years 1969 and 1970, will be at the lower price of about $6 a pound U_3O_8. Our current estimate is $5.90.

We have an equipment request of $510,000, mostly to cover the purchase of a small computer which will be used in making reserve and resource estimates as well as for administrative work at the Grand Junction office.

Our general plant projects request is $120,000, including $95,000 for the modification of an existing building to house the computer, and the balance is for general improvements at the Grand Junction office complex.

Unless you wish to further discuss the budget at this time, I have a few slides and a general program statement to show the balance between requirements and supplies as now seen.

Mr. MORRIS. If there is no objection, we will dispense with the slides, unless they have some direct bearing on the budget, because of our tight schedule.

Mr. FAULKNER. The bearing they do have is that there is a very large requirement developing, which in turn has a bearing on the R. & D. work.

Mr. MORRIS. Developing for what?

Mr. FAULKNER. For uranium for industrial purposes.

Mr. MORRIS. I think the committee and the country realize that in the interest of time, I believe we should proceed with our questioning.

Mr. FAULKNER. We shall be glad to defer to your wishes.

Mr. MORRIS. We will insert pages RM–1 through RM–7, covering the request of $112,470,000 for operating costs and $650,000 for plant and capital equipment for the raw materials program.

(The pages follow:)

U.S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

RAW MATERIALS PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$112,470,000
Estimate FY 1968	127,733,000
Decrease.	$-15,263,000

The Raw Materials Program estimated operating costs for FY 1969 total $112.5 million, a decrease of $15.3 million from the estimated level for FY 1968. The budget estimate includes $111,870,000 for the purchase of uranium concentrates under existing contracts with domestic producers and associated operating costs and $600,000 for research and development related to the resource investigations program.

Total procurement in FY 1969 is estimated at 7,960 tons of U_3O_8. Approximately one-half of this quantity will be purchased during the first six months of the fiscal year at a price of $8.00 per pound U_3O_8. The purchase price for deliveries during the last half of the fiscal year is estimated at approximately $5.90 per pound U_3O_8.

The budget estimate includes $600,000 for research and development projects supporting resource investigations. AEC's effort is not directed toward the discovery or delineation of ore deposits but is limited to appropriate geologic investigations and development of improved geologic, geophysical and other exploration concepts and tools. This effort will be carried out through contracts with educational and non-profit institutions and private research facilities.

RAW MATERIALS PROGRAM - continued

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category/Activity	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
RM-3	1. Procurement of Uranium Concentrates and Oxides:			
	United States	$146,429,669	$127,378,000	$111,870,000
	Canada	5,098,259	0	0
	Overseas	13,365,086	0	0
	Subtotal, U_3O_8 Procurement	$164,893,014	$127,378,000	$111,870,000
	Canadian Refining Costs	183,425	0	0
	Uranium Ore Sales (credit)	-3,427,305	0	0
	Subtotal, Procurement of Uranium Concentrates and Oxides	$161,649,134	$127,378,000	$111,870,000
RM-4	2. Resource Investigations	244,503	355,000	600,000
	Total Raw Materials Program	$161,893,637	$127,733,000	$112,470,000

94-075 O-68-pt. 3—6

SUMMARY OF PROCUREMENT OF URANIUM CONCENTRATES AND OXIDES

Source	Actual FY 1967			Estimate FY 1968			Estimate FY 1969		
	Tons U_3O_8	Cost Per Lb.	Cost in Thousands	Tons U_3O_8	Cost Per Lb.	Cost in Thousands	Tons U_3O_8	Cost Per Lb.	Cost in Thousands
United States	9,097	$ 8.05	$146,430	7,890	$8.07	$127,378	7,960	$7.03	$111,870
Canada . . .	258	9.88	5,098	0	0	0	0	0	0
Overseas . .	624	10.71	13,365	0	0	0	0	0	0
Totals . . .	9,979	$ 8.26	$164,893	7,890	$8.07	$127,378	7,960	$7.03	$111,870

JUSTIFICATION OF CATEGORIES

1. Procurement of Uranium Concentrates and Oxides $111,870,000

Total procurement in FY 1969 is estimated at 7,960 tons of U_3O_8 with an average cost of $7.03 per pound. Approximately one-half of this quantity, or 3,993 tons, will be delivered during the first six months of the fiscal year; this will complete the delivery of the U_3O_8 deferred from the CY 1963-1966 period into CY 1967-1968 at the purchase price of $8.00 per pound U_3O_8.

Deliveries during the last half of the fiscal year are estimated at 3,967 tons of U_3O_8. These purchases represent the additional material which the AEC agreed to purchase in CY 1969-1970 pursuant to the domestic stretchout program announced in 1962. The price per pound of this additional material is to be determined by the application of the formula, $1.60 plus 85% of the CY 1963-1968 allowable production costs, with a maximum price of $6.70. Prices are expected to differ with each producer, and the average purchase price for CY 1969-1970 is currently estimated at approximately $5.90 pending determination of actual production costs for the previous six-year period. Included in these quantities for the last half of the fiscal year are the purchases of U_3O_8 under the announced program for small mining properties estimated at 237 tons of U_3O_8 at a price of $6.70 per pound.

RAW MATERIALS PROGRAM - continued

2. Resource Investigations $600,000

Many of the deposits having surface expression have already been found by extensive prospecting. Therefore, an adequate long-range supply of uranium for nuclear power may depend on the discovery of hidden deposits through the successful development of improved geologic concepts, techniques and tools. Because of the need for substantial progress in these areas, the AEC plans to complement private industry activities with research which industry appears unlikely to undertake. Some effort may also be placed on the development of uranium extraction processes applicable to new types and/or low-grade ores which, if successful, would have the effect of increasing available resources. This program will be carried out through the negotiation of research and development contracts with educational and non-profit institutions and private research companies with the information developed disseminated to the mining and milling industry.

U.S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

RAW MATERIALS - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$650,000
A Construction Projects	
A-1 Obligations for new projects.	($120,000)
A-2 Obligations for prior year projects	($ 0)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($510,000)
B-2 Obligations from prior year appropriations. . . .	($ 20,000)
Estimated Obligations FY 1968	$205,000
Actual Obligations FY 1967.	$ 88,015

Obligations for the Raw Materials Program for FY 1969 are estimated at $650,000, of which:

a. $120,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $510,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

c. $20,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION A-1

The projects comprising Section A-1, which are requested for authorization in FY 1969.

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-8	General plant projects	$120,000	$ 0	$120,000	$ 0
	Total	$120,000	$ 0	$120,000	$ 0

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-8 General plant projects $120,000

The major portion (approximately $95,000) of this estimate is required for alterations and modifications to an existing building at the Grand Junction, Colorado, Office to make the structure suitable for the installation of automatic data processing equipment. In addition to the structural changes, the space to be occupied will require changes in existing fire protection and air conditioning equipment. The remainder of this project consists of minor capital improvements, alterations, additions, engineering, retirements, and minor new construction required to provide continuity of operation and reduce operating and maintenance costs of the Grand Junction Office facilities.

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Raw Materials Equipment Not Related to Construction	$510,000

JUSTIFICATION

Raw Materials Equipment	$510,000

The major portion (approximately $310,000) of the estimate is for the purchase of a computer at the Grand Junction Office. The workload associated with evaluating, processing, storing, and distribution of the large volume of information currently being generated by AEC and private industry on uranium supplies, reserves and requirements, and the large increase in number of complicated drill hole log evaluations and ore reserve computations resulting from the rapidly expanding private exploration activity justify the use of a full-time on-site computer at a central location.

The remainder of the estimate is to provide for the purchase of specialized electronic equipment for fabricating borehole logging units and laboratory models and assemblies to provide analytical support to field activities and to replace and/or update obsolete field and laboratory equipment. No part of the funds requested for equipment relates to the off-site research and development contracts budgeted under this program's request for operating funds.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Raw Materials Equipment Not Related to Construction	$ 20,000

U_3O_8 PROCUREMENT

Mr. MORRIS. What is the Federal Government's commitment for the purchase of uranium concentrates planned for fiscal year 1969 at a cost of $111.9 million?

Mr. FAULKNER. It is 7,960 tons of U_3O_8 in concentrates, and the costs incident to their purchase and operation of the Grand Junction complex.

Mr. MORRIS. All of these are going contracts which have been in effect for several years?

Mr. FAULKNER. That is correct, sir.

Mr. MORRIS. How much is included in the request for resource investigations?

Mr. ABBADESSA. $600,000 is for the resource investigation program.

Mr. MORRIS. Thank you.

U_3O_8 INVENTORY

What is the present stockpile of uranium concentrates owned by this Government.

Mr. QUINN. I can respond to that, Mr. Morris.

As of January 1 of this year, our inventory of U_3O_8 was about ——. This is material that has accumulated since 1964 when the first cutbacks were made in the production of plutonium and U^{235}.

Mr. MORRIS. What is your estimate of the value of it?

Mr. QUINN. At $8 a pound, with about ——.

Mr. MORRIS. That is a pretty good bank account.

Mr. QUINN. Yes, sir.

Mr. MORRIS. Could we count that as an asset of the Federal Government, considering our huge debt?

Mr. QUINN. We certainly consider it an asset. We expect it will be used very beneficially, either for Government or for private purposes.

RESEARCH AND DEVELOPMENT

Mr. MORRIS. The $600,000 budgeted for uranium resource investigation is an increase of $245,000, or more than 200 percent. Why is this increase essential, considering that the U.S. uranium mining industry set an alltime high for surface exploration and development drilling in 1967?

Mr. FAULKNER. The work that we are planning, sir, is not the work being done by the industry. There is no physical exploration involved in our program.

What we are looking at is the long-term picture and the large requirement expected to show up down the road. While industry is mounting a tremendous program and we think this program will even increase this year, over the long pull a very large amount of uranium will be required, and some better means of finding it is necessary.

ROLE OF U.S. GEOLOGICAL SURVEY

Mr. MORRIS. You get right back to who is to do what. Is that mission not the responsibility of the U.S. Geological Survey?

Mr. FAULKNER. We are not competing with them in this area. They are budgeting roughly a million dollars each year for mapping and work of this kind, and also some projects in uranium. The work we are doing is not the same work.

Mr. MORRIS. As you know, last year the committee stated in its report that the discovery and development of new uranium reserves should be the responsibility of the U.S. Geological Survey, and that appropriate provisions for this purpose should be reflected in its future budget proposals.

What action has your Division taken in this regard?

Mr. FAULKNER. To clarify the record a bit, Mr. Chairman, neither the Survey nor the AEC is involved in search for uranium per se.

Mr. MORRIS. We understand that. We know that you are not actively engaged in drilling for uranium or the search for uranium. You are asking for these funds for geologic investigations of improved exploration concepts and tools. The committee understands that.

My question was—do you want me to repeat it?

Mr. FAULKNER. No, sir. I understand the question.

Mr. MORRIS. All right.

Mr. FAULKNER. To continue, we have written to the U.S. Geological Survey requesting them to step up their program, in topographic and geologic mapping particularly, and other areas of interest in the uranium field.

We have been informed by the Survey that its budget in 1969 is at approximately the same level as in prior years, and that they are unable to see their way clear to fund an increase in the size of the program.

Mr. MORRIS. In other words, the budget request of the U.S. Geological Survey does not consider this item important enough to expand the effort?

Mr. FAULKNER. I think it starts back at the internal level of the Department of the Interior. Since the Survey's budget is only a part of the entire budget for the Interior Department the amount of the USGS total request may be determined by priorities within the Department.

Mr. MORRIS. Do you not think these factors face all of us?

Mr. FAULKNER. Yes, I think this is right.

On the other hand, we are the people who have the information on the growth of the industry and are in a position to justify this particular program.

Mr. ABBADESSA. Mr. Chairman, in answer to your question as to what we did as a consequence of this subcommittee's report, last year we asked the committee for money to transfer to the Department of the Interior. As a result of the committee report, this year's request does not contain any money for purposes of transfer to have them do work.

We think we have been completely responsive to the committee's guidance in this respect.

Mr. MORRIS. Would you mind repeating that?

Mr. ABBADESSA. We were going to transfer funds and have the Interior Department do some work for us. The committee said "No," and their report indicated this was the Interior Department's responsibility and they should fund it.

We did not use the money for that purpose. We have not requested money this year for this purpose. We have discussed this with the Bureau of the Budget, and we believe we have been completely responsive to the committee's guidance.

Mr. MORRIS. I ask unanimous consent that at this point to insert the following from the budget document which seems to me clearly to delineate the U.S. Geological Survey's responsibilities are for long-range development of techniques and concepts of mining.

"Geologic and mineral resource surveys and mapping—the continuing national program of geologic research and investigations produces (a) new or improved methods and instruments for mineral exploration, et cetera."

COMPUTER

Mr. MORRIS. On page RM–6, $120,000 is budgeted for alterations to a building for installation of automatic data processing equipment. Why is this item so urgent in fiscal year 1969? I understand this involves installation of a computer.

Mr. FAULKNER. It is the building alterations for installation of the computer that requires the bulk of this $120,000, Mr. Morris. We are at the point where the computer arrangement we have is no longer satisfactory. The existing capability is being used up and we are having trouble getting adequate time for reserve and resource computations and other matters of this kind.

Mr. MORRIS. Have you contacted GSA about computers?

Mr. FAULKNER. We have been exploring every possible avenue. I think the Controller might wish to make some comment on that.

Mr. ABBADESSA. We watch this carefully, Mr. Chairman. First, we have been using the Sandia computer capability, but this involves shipment back and forth of the data. We work with GSA on sharing computers. We are even large enough that we do some within the AEC.

Grand Junction is a remote site. This is a relatively small undertaking, and the computer is for the purpose of accumulating statistics and for administrative application. While it appears to be a good computer application, we are still looking at the feasibility of it.

Mr. MORRIS. You are still studying the feasibility of this plan?

Mr. ABBADESSA. That is correct, sir.

Mr. MORRIS. Thank you.

Mr. Davis?

Mr. DAVIS. Not at this point, Mr. Chairman.

Mr. MORRIS. Mr. Robison of New York?

INDUSTRY ACTIVITY

Mr. ROBISON. One or two questions, Mr. Chairman.

Can you, sir, put a "ball park" dollar figure on the amounts being invested by industry in resource investigation and/or collateral research on an annual basis?

Mr. FAULKNER. No, I do not think we have a ball park figure for that. The work that the industry does by itself has been related to the areas which they are specifically studying. In other words, their research and investigation efforts are directed toward property they have acquired or are trying to acquire for exploration. We have no specific figures on this.

Mr. ABBADESSA. You can get some feel, though, that industry is stepping forward and making a fairly substantial investment, from the amount of drilling that has been done. The previous high point, to our knowledge, was in 1957 when it was 9.2 million feet. This dropped down in 1965 to 2 million feet. In 1966, it went up to 4.2 million; and in 1967, it went up to 10.7 million.

This is the largest amount of drilling that we have statistics on, and represents a very substantially increased effort on the part of industry.

Mr. ROBISON. There would not be any doubt in anybody's mind here, would there, that the $600,000 that the Commission is asking for resource investigation is a very small part of the industrial investment?

Mr. FAULKNER. There is no question about that.

Along the same lines, we are trying to look at some of the broader aspects of uranium deposition, without application to a particular company.

Mr. ROBISON. Is your program more in the area of research?

Mr. FAULKNER. Yes.

Mr. ROBISON. Low-grade ores, new type ores, and so forth?

Mr. FAULKNER. Most of our program is oriented toward geochemical and geophysical research—in other words, to develop the kind of information which might serve as a guide to the location of ore deposits.

Mr. ROBISON. But industry is not doing this sufficiently, in your view?

Mr. FAULKNER. They are doing a great deal of drilling, but we are looking for this work to assist industry in the long run to better plan their work and locate their drill holes.

RESEARCH AND DEVELOPMENT

Mr. ROBISON. How much money did you apply to this program, or will you apply in the current fiscal year?

Mr. FAULKNER. $355,000.

Mr. ROBISON. Can you give us now some rough information with respect to what has been done with it? You say you have negotiated contracts with private institutions and private research companies. Is this one or two or three contracts for the current year?

Mr. FAULKNER. No, sir; there are several contracts. In 1968 we had contracts with Rice University on the natural radioisotope measurements and geochemistry of uranium, thorium, and potassium as geologic and exploration tools, $35,000. With the University of California we are doing studies on rock alterations in uranium deposits. With Penn State, for example, we are doing some mathematics models for exploration strategy and mathematical studies to see what sort of statistical approaches might be useful.

Mr. ROBISON. That is enough as a sample. You might amplify your answer for the record.

Mr. FAULKNER. The kind of work we are planning would be broadly applicable, but not necessarily the kind that a company would do. We try to stay away from the work which companies would do for themselves.

(The information follows:)

U.S. ATOMIC ENERGY COMMISSION

DIVISION OF RAW MATERIALS

RESEARCH AND DEVELOPMENT PROGRAM

INTRODUCTION

In recent years, there has been a growing awareness that the rapid development of new uranium resources is essential to supply the increasing uranium requirements projected for the expanding nuclear power program. According to present estimates, total domestic uranium requirements through 1980 plus an eight year forward reserve will exceed presently known domestic uranium reserves exploitable at $8 per pound by about 500,000 tons.

From the standpoint of the mining industry, the increasing volume of commercial uranium sales and promise of a long-range market have been viewed with an optimism reflected by the resurgence of exploration activity by established firms as well as the influx of companies new to the uranium industry. The consensus of those concerned directly with uranium production is that the prospects for successful exploration are good. Although this optimism is justified, it is balanced by a very legitimate concern for the magnitude of the task ahead and points to the need for broadening the technical base for uranium exploration.

The magnitude of the exploration problem can perhaps best be appreciated by comparing the size of existing uranium producing regions with projected requirements. In order to satisfy expected requirements for nuclear fuel through 1980 and provide a reserve at that time sufficient to meet requirements

for the following eight years an average of about 35,000 tons of uranium will have to be discovered each year for the next 13 years. Only six of the ten major producing districts in the United States exceed 30,000 tons and only one, Ambrosia Lake, exceeds 40,000 tons. Thus reserves equal to one of our major producing districts will have to be discovered every year.

Although the goals are well defined, resolution of the problems inherent in future exploration dictates the need for a substantial increase in basic and applied research, by both government and industry, to reduce the risk that the uranium required will not be found on a timely basis. Moreover, as the producing deposits are exhausted and exploration of the more favorable areas is completed, the problems of discovery will increase in both number and complexity, emphasizing the need for a much improved understanding of geologic principles and concepts of uranium occurrence which can be applied to entirely new areas and geologic environments. These problems can become acute if advance planning and execution of appropriate research are not expeditiously carried out.

OBJECTIVES

The objectives of the Raw Materials research and development program are essentially two-fold. They are, first, to provide appropriate support to private exploration through development of new knowledge, concepts and techniques for achieving exploration objectives more quickly, efficiently, and more successfully in areas generally thought to be favorable on the basis of past experience. This will involve primarily development of geological, geochemical, and geophysical criteria that will indicate the

existence of ore where it can not be found directly by conventional surface and subsurface methods. Since a considerable part of the United States has been explored extensively for ore deposits evident from surface radioactivity, the consensus is that increasing dependence must be placed on the discovery of concealed deposits which are difficult to locate with methods currently at industry's disposal.

The second equally important objective is to advance our capability to evaluate the prospects for the existence and discovery of major uranium resources in areas of the United States that are virtually unexplored and about which nothing is now known concerning discovery possibilities. The deep regions of sedimentary basins of the United States are an example of such unexplored areas. Virtually all past discoveries have been in shallow basins and along the margins of deeper basins. This objective involves the particularly difficult task of developing an insight into completely new circumstances under which uranium deposits would form.

Development of basic information on the geology of uranium in presently unidentifiable source areas will improve substantially the prospects of discovery. Moreover, improvement in the capability to recognize favorable target areas in deep basins together with the resulting reductions in the risk and cost would make the prospects of drilling these basins more attractive to industry than at the present time. The basins of the United States are so vast it would be unfeasible to explore them by drilling without focusing on the most favorable target areas. The research effort should also provide additional insight to the magnitude of resources in unexplored segments of the United States.

The research and development effort foreseen will require integration of the resources of specialists skilled in various scientific disciplines and the knowledge of technical people who have a broad background and wide experience in the problem areas that will have to be resolved. Execution of such a program will require close coordination of research at various universities and government agencies contributing general geologic information as well as the results of current private exploration.

The extensive background of the AEC staff in uranium geology, geochemistry, geophysics and resource evaluation, its thorough familiarity with industry operations, and the AEC's critical interest and involvement in the development of the nation's nuclear economy make AEC a logical center for coordination and administration of such a program.

PROBLEM AREAS

In the major producing areas, uranium is confined to a particular type of sediment known as a "red-bed" sandstone which occupies basins or basin-like depressions in the earth's crust. The most significant feature of red beds that bears on uranium deposition is that they contain two diametric geochemical environments, one of which is chemically reducing, the other chemically oxidizing. In the reducing environment uranium is insoluble and is precipitated to form ore bodies. In the oxidizing environment it is soluble and readily moved in ground waters. The reducing environment is established by the presence of organic matter deposited in the red beds when they were first laid down, but it is readily destroyed by oxidation processes which accompany the

migration of oxygen in ground waters from the surface into the beds. The destruction process continues through geologic time and gradually encroaches basin-ward. Uranium ore deposits are formed at the reduction-oxidation boundary and their existence is, therefore, dependent on the chemical oxidation-reduction processes operative in the red-bed formations.

Recognition of whether a red bed is completely oxidized and, therefore, essentially devoid of uranium or incompletely oxidized and, therefore, likely to be productive is a challenging problem that has an important bearing on our ability to predict resources in this type of formation. The geologically older red beds appear to be more pervasively oxidized and generally give very little evidence of the presence of uranium. Because of this they have not been explored intensively by drilling. On the other hand, these older red beds are very extensive over large areas of the United States.

An important goal of the Raw Materials research and development program is to establish geologic, geochemical, and geophysical criteria that will indicate whether a red bed is or is not favorable and where within these beds reducing environments still may prevail and be productive. Several interesting approaches are under consideration and comprise a significant part of the proposed research effort.

Projects currently underway involve investigation of microbiological and organo-chemical processes which are instrumental in maintaining and possibly regenerating the reducing environment in red beds and may provide guides that can be followed into the deeper parts of the basins to the ore-producing reduction-oxidation boundaries. This research is

being conducted at the Denver Research Institute at Denver, Colorado. Various products of mineral alteration associated with uranium deposition are also being examined for clues to ore deposits by electron microprobe analysis at the University of California in Berkeley. Patterns of distribution of the common radioactive elements uranium, thorium, and potassium are being measured by geochemists at Rice University in Houston, Texas, to determine very low-level accretions of uranium which may reveal pathways along which oxygen-charged waters have gradually moved uranium into the basins. The statistical distribution of ore bodies is also being studied at Pennsylvania State University to determine optimum drill-hole spacings and drilling patterns for exploration and development of ore bodies.

A project is under consideration for measuring the extent of radiogenic helium and radon gas distribution in ground waters surrounding uranium ore deposits to determine whether ore is detectable by water sampling at considerable distances from the ore body. This will involve initially theoretical treatment and calculation of chemical rate-dependent processes governing the quantitative generation of helium and radon by a given size ore body under various conditions of host-rock permeability and at various assumed rates of ground-water flow which would affect the dispersion of the dissolved gas. Also proposed is a study of paleomagnetic and remnant magnetic properties of rocks to distinguish between products formed during the oxidation of an ore body and those not related to the uranium-ore forming process. Distribution of radiogenic lead, radiation-induced-thermoluminescence of minerals, and Eh and pH

sensitive components, as well as measurement of oxidation-reduction potentials and electrical properties of uranium ores and associated minerals are other research areas being considered for investigation.

Radiogenic lead is produced by uranium as it decays, and, because it is almost insoluble in ground water, remains behind after an ore body is destroyed by oxidation, thus producing a unique clue to the pathway along which uranium has moved through the rocks. Thermoluminescence conceivably may be used in the same manner inasmuch as the energy, which is imparted to common rock-forming minerals such as quartz by the decay of uranium, remains in the mineral throughout geologic time and can be measured to provide a clue to the pre-existence of uranium in an area now devoid of ore. Measurement of oxidation-reduction potentials in favorable rocks may provide a guide to the location of the reduction-oxidation boundary along which ore deposits may exist.

A study of the distribution and potential of favorable rock formations in the eastern United States is also contemplated. These older red-bed sediments are extensive and represent a possible source of ore in this region.

In addition to investigations related to the problem of exploring for uranium in red-bed type formations, research will also be undertaken to develop a capability to recognize possible ore deposits in other types of rocks and to determine the resource potential of these rocks. This will involve the application of chemical principles of behavior of uranium in the earth's crust to various types of geological environments to which they have not yet been applied, as well as the

94-075 O-68-pt. 3—7

development of new concepts of ore deposition. Problem areas such as the possible interaction and deposition of uranium at gas-water and water-oil interfaces occurring in deep marine sediments in the mid continent, Pacific, Gulf Coast and Appalachia regions of the United States will be investigated.

An effort to improve geophysical applications to uranium exploration is also needed to attempt to develop into workable techniques several approaches that are either novel, untried, or require field trials to demonstrate their usefulness. The chief objective of this effort in Fiscal Year 1969 will be to improve the capability of drill-hole instrumentation to obtain radiometric and other geophysical data from deep drill holes. One of the major problems with present-generation radiometric logging equipment is a critical attenuation of signal impulse between the probe in the drill hole and the surface recorder, particularly where spectral counting over long cable distances is involved. Preamplification of the signal in the drill hole would solve the problem, but development of an in-hole high-voltage source and preamplifier-probe assembly capable of fitting a small drill hole and operating under various in-hole conditions presents some significant design and operational problems which we hope to investigate through an appropriate contract.

Finally, some effort may be devoted toward improving the prospects for recovering uranium from low-grade ore deposits and solutions and to evaluate the problems of mining uranium under unusually difficult circumstances which preclude the use of conventional mining methods.

Particularly relevant is the development of information on improved and new reagents for solvent extraction of uranium from phosphate rock as replacement for conventional solvents which have given erratic performance. Also being considered is a study of practical alternatives to existing solvent extraction recovery methods and methods of recovering uranium from phosphate waste rock in possible by-product production of other metals such as aluminum and rare earths. A successful low-cost process could make available substantial additional quantities of uranium that would otherwise not be recovered.

The attached table outlines the scope of the research effort that is envisioned as needed at this time to meet the objectives described above. Probably about two-thirds of the projects listed can be started with the $600,000 budgeted for this work in Fiscal Year 1969. The importance and timing of the indicated requirements for nuclear fuel measured against the time it takes to produce useful information from basic research and development work make it clear that there should be no delay in implementing these studies.

U.S. ATOMIC ENERGY COMMISSION
RAW MATERIALS PROGRAM
RESEARCH & DEVELOPMENT CONTRACTS

Projects continuing from FY 1968

Geology	Contractor
1. Natural radioisotope measurements and geochemistry of uranium, thorium, and potassium as geologic and exploration tools	Rice University
Radiometric measurement of concentrations of the radioactive elements uranium, thorium, and potassium in uranium host rocks and in rocks from which uranium is derived by ground-water leaching to determine possible existence of patterns in the distribution of these radioelements that may serve as guides to ore.	
2. Rock alterations in uranium deposits	Univ. of Calif.
Analysis of sediments by electron microprobe and other techniques to determine mineral and chemical phase changes associated with rock alteration related to ore-emplacement processes.	
3. Mathematical models for exploration strategy	Penn. St. Univ.
Measurement and analysis of distribution patterns of ore bodies in basins to develop mathematical models useful in planning optimum exploration strategy.	
Geochemistry	
1. Relationship between organic matter and uranium deposits	Univ. of Denver
Determination of the organic materials that govern deposition and possible mobility of uranium in sediments and their geochemical stability to establish conditions of ore formation.	

Contractor

2. Relation of microbes to uranium deposits — Univ. of Denver

Investigation of natural microbial interactions in uranium ore deposits to identify the role of microflora in concentrating, transporting, and precipitating uranium as well as the effects on other mineral constituents that can be used as tracers to ore.

Geophysics

1. Remote pre-amplifier-High voltage circuits

Development of a probe-installed, down-hole, high voltage power supply and pre-amplifier matched to a bore-hole uranium logging system to improve spectral resolution and long-distance pulse transmission.

Projects proposed for FY 1969 and later years

Geology

4. Analysis of basin stratigraphy as a guide to uranium resource potential

Analysis of the sedimentological characteristics of major basins outside of the major producing region of the U.S., as an aid in appraising their potential for uranium ore deposits and in enhancing discovery prospects.

5. Sedimentological properties of potential uranium host rocks in New Mexico

Regional study of the as yet unproductive Dakota group, Tertiary, and Mesa Verde sandstones in New Mexico for sedimentation and mineralogical factors and trends to evaluate prospects for ore discovery.

6. Favorable uranium host rocks in the eastern U.S.

Investigation of the distribution of geologic environments suitable for uranium emplacement in unstudied and unevaluated sandstones of the eastern U.S.

7. Radiation-induced thermoluminescence of minerals as a guide to ore

Determination of the thermoluminescent properties of minerals associated with ore which behave like solid-state dosimeters by recording uranium emanations even long after the ore has been leached away.

8. Distribution patterns within uranium deposits

Development of mathematical techniques to analyze distributional patterns of existing ore deposits for prediction of ore trends in unexplored areas.

Geochemistry

3. Regional geochemistry of uranium-bearing red-bed sandstones and related sediments

Determination of the extent of interstratal variations in sandstone sediments with particular emphasis on minerals that are sensitive to processes and environmental changes accompanying uranium ore emplacement.

4. State of art on uranium geochemistry and low-temperature chemistry

Review of present concepts and information on chemical equilibria of uranium in aqueous solutions in deep sediments particularly relating to interactions at oil-water and gas-water interfaces.

5. Environment testing from drill holes

Measurement of reduction-oxidation potentials in sandstones to distinguish between oxidized ground that is barren and reduced ground that is uranium-bearing.

6. Lead isotopes in outcrops as an exploration tool

Measurement of the intensity of radiogenic lead concentration of outcrops of sandstones, especially where residual radioactivity is absent, as an indicator of ore at depth.

7. Sulfur chemistry in uranium-forming processes

Determination of the reaction chemistry and role of transitory ionic and mineral sulfur species involved in uranium migration and precipitation, with emphasis on oxidation-reduction effects of polythionates and other intermediate-valence compounds.

8. Isotopic fractionation by oxidative bacteria in uraniferous sediments

Determination of fractionation of isotopes of sulfur, carbon and oxygen by bacteria involved in uranium-ore-forming and ore-destroying processes to establish the influence of bacteria on the ore environment and on the isotopic composition of minerals which may be a criterion of mineralization.

Geophysics

2. Shallow surface electrical investigations

Application of electrical geophysical techniques such as induced polarization to exploration for uranium ores.

3. Helium-radon solubility and migration in ground water

Determination of the extend to which radon and helium gas diffuse in detectable concentrations in ground water around uranium deposits.

4. Paleomagnetism and remnant magnetic properties of uranium-bearing sandstone

Measurement of the residual magnetic properties of red-bed type uraniferous sandstones in order to establish magnetic criteria which may distinguish between syngenetically oxidized rock which is barren and post-mineralization oxidized rock which may contain ore deposits.

5. Development of portable radiation system

Development of an integrated portable system for making radiometric measurements in the field, with emphasis on modular design and spectral discrimination.

6. Remote-sensing investigations

Investigation of applications to uranium exploration of remote sensing systems involving gamma spectrometry, infrared and radar spectrometry and imagery and special photographic film and filter techniques.

Mining and Processing

1. Ground control in poorly consolidated sedimentary uranium host rocks

   Investigation of ground-control problems related to mining of uranium deposits and development of ground support procedures and techniques.

2. Recovery of uranium from large masses of fractured low-grade rocks

   Studies and in-situ tests of various chemical and bacteriological mechanisms of dissolving uranium from large masses of rock containing low-grade uranium.

3. Compendium of computer applications to mining and geological engineering problems

   Compilation of information on various computer data storage and retrieval systems applicable to mineral resource problems.

4. Phosphate waste and liquor processing for uranium

   Development of information on and testing of improved and new reagents for solvent extraction and alternative mechanism of uranium recovery from phosphate rock and waste.

Mr. ROBISON. Thank you, Mr. Chairman.

Mr. MORRIS. Unless there are further questions, that completes the questioning under the Raw Materials Program. Thank you, Mr. Faulkner.

Without objection, I would like to insert at this point a press release from the AEC, dated January 24, headed "Exploration and Development Drilling by U.S. Uranium Mining Industry Sets Record 10,764,000 Feet in 1967."

(The document follows:)

U.S. ATOMIC ENERGY COMMISSION, WASHINGTON, D.C.—EXPLORATION AND DEVELOPMENT DRILLING BY U.S. URANIUM MINING INDUSTRY SETS RECORD 10,764,000 FEET IN 1967

Surface exploration and development drilling by the U.S. uranium mining industry totaled 10,764,000 feet in 1967 and set an all-time high for the industry, according to a summary report made public today by the Grand Junction Office of the U.S. Atomic Energy Commission. The previous drilling high was a decade ago in 1957 when the industry drilled 9,200,000 feet.

According to information supplied to AEC by uranium companies active throughout the West, the surface drilling figures for 1967 were:

	Feet
1st Quarter	1,321,000
2d Quarter	2,444,000
3rd Quarter	3,410,000
4th Quarter	3,589,000
Total	10,764,000

From the previous high of 9,200,000 feet of drilling in 1957, the industry's exploration and development effort declined steadily to slightly over 2 million feet in 1965, the lowest year since 1952. Total surface drilling in 1966 was 4,200,000 feet.

The rapid acceleration in drilling since 1965 to increase uranium ore reserves was sparked by the fast-growing nuclear power industry and the forecast of rising needs for uranium as fuel. The rate of orders for nuclear plants continued to increase in 1966 and 1967, and the uranium industry moved into widely spread areas in the Western United States in search of additional ore reserves. The AEC's report shows that 2,577,000 feet, or nearly 25 percent of the drilling, was in areas more than 50 miles away from existing milling facilities.

Of the 10,764,000 feet of surface drilling in 1967, approximately 51 percent, or 5,435,000 feet, was exploratory drilling in the search for new deposits. The remaining 49 percent, or 5,329,000 feet, was development drilling which provides the information for mine layout. The industry's drilling by States was as follows:

State	Drilling	Percent of total
Colorado	752,000	7.0
New Mexico	2,520,000	23.4
Texas	620,000	5.8
Utah	606,000	5.6
Wyoming	5,888,000	54.8
Others (Arizona, California, Nevada, Oregon, South Dakota, Washington)	378,000	3.4
Total	10,764,000	100.0

The AEC reports that 1967 showed an increase in ore reserves of 7,000 tons of U_3O_8 after shipments to the mills of ore containing 10,700 tons of U_3O_8. This was the first year since 1959 in which there has been a net gain after production. Estimated ore reserves exploitable at $8 per pound of U_3O_8 stood at 148,000 tons of U_3O_8 at the end of the year.

During 1968, the AEC plans to continue to announce periodically the current status of exploration and development activity.

(Note to editors and correspondents: This information also is being issued by the Commission's Grand Junction Office, Grand Junction, Colo.)

Special Nuclear Materials Program

Mr Morris. We will now take up the Special Nuclear Materials program.

We will insert pages SNM–1 through SNM–15 and SNM–49 through SNM–60, covering the Special Nuclear Materials program.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

SPECIAL NUCLEAR MATERIALS PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$334,303,000
Estimate FY 1968	340,670,000
Decrease	$ 6,367,000

This program provides for the production and procurement of special nuclear and other materials required for military and peaceful uses.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.		Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
SNM-9	1.	Feed Materials	$ 24,329,000	$ 24,196,000	$ 29,804,000
SNM-9	2.	Production of Enriched Uranium (U-235)	1/	133,152,000	119,892,000
SNM-10	3.	Procurement of Reactor Products	20,951	553,000	3,450,000
SNM-10	4.	Reduction of Liquid Wastes to Solids	1,569,094	950,000	1,015,000
SNM-10	5.	Startup, Shutdown and Standby	6,670,347	8,586,000	4,237,000
SNM-11	6.	Transportation and Security Shipment	3,056,701	2,059,000	2,048,000
SNM-11	7.	Miscellaneous	10,552,707	6,814,000	4,047,000
SNM-12	8.	Special Activities	944,468	2,140,000	3,338,000
SNM-15	9.	Process Development	22,801,381	23,313,000	26,499,000
SNM-15	10.	Other Procurement and Production	279,357,882	138,907,000	139,973,000
		Total Special Nuclear Materials Program ...	$349,302,531	$340,670,000	$334,303,000

1/ Included in 10, Other Procurement and Production

These funds provide for the operation of a large complex of Government facilities for the production of special nuclear and other special materials required for use in weapons manufacture, research and development, and peaceful applications of atomic energy. The major units of the AEC production complex are gaseous diffusion plants for the enrichment of uranium; reactors and separations plants for the manufacture of plutonium and other reactor products; and a feed materials plant. Also included in this estimate are funds for the procurement of reactor products from domestic power reactor operators, commercial processing of spent reactor fuels, miscellaneous activities related to the production mission, and special activities related to safeguards and operational safety.

SPECIAL NUCLEAR MATERIALS PROGRAM

Summary of Production Sites, Major Facilities, Principal Functions and Contractors

Sites and major facilities	Principal functions	Contractors
Oak Ridge, Tennessee		
Gaseous diffusion plant (ORGDP)	Enrich UF_6 in the U-235 isotope.	Union Carbide Corp., Nuclear Div. (UCND)
Paducah, Kentucky		
Gaseous diffusion plant	Enrich UF_6 in the U-235 isotope.	Union Carbide Corp., Nuclear Div.
Feed Plant	Production of UF_6 feed for gaseous diffusion plants.	Union Carbide Corp., Nuclear Div.
Portsmouth, Ohio		
Gaseous diffusion plant	Enrich UF_6 in the U-235 isotope.	Goodyear Atomic Corporation (GAT)
Fernald, Ohio		
Feed material plant	All steps in manufacture of reactor fuel except extrusion.	National Lead Company of Ohio (NLO)
Ashtabula, Ohio		
Extrusion plant (Privately owned)	Extrusion of fuel and target elements for reactors.	Reactive Metals, Inc. (RMI)
Richland, Washington		
Fuel fabrication facilities	Fabrication of fuel and target elements for reactors.	Douglas United Nuclear Co. (DUN)
Production reactors	Manufacture of plutonium and other isotopes.	Douglas United Nuclear Co. (DUN)
Chemical separations plant	Chemical separations of irradiated fuel and target elements.	Atlantic Richfield Hanford Co. (ARHCO) (succeeded Isochem Inc. 9/4/67)
Supporting facilities	General support for operating contractors.	ITT Federal Support Services, Inc. (FSS)

SPECIAL NUCLEAR MATERIALS PROGRAM

Sites and major facilities	Principal functions	Contractors
Savannah River (near Aiken), South Carolina (SRP)		
Fuel fabrication facilities	Fabrication of fuel and target elements for reactors.	E. I. du Pont de Nemours & Co.
Production reactors	Manufacture of plutonium, tritium and other isotopes.	E. I. du Pont de Nemours & Co.
Chemical separations plants	Chemical separations of irradiated fuel and target elements.	E. I. du Pont de Nemours & Co.
Heavy water plant	Manufacture of heavy water.	E. I. du Pont de Nemours & Co.
Laboratory (SRL)	Process development	E. I. du Pont de Nemours & Co.
National Reactor Testing Station, Idaho		
Chemical processing plant (ICPP)	Chemical separations of irradiated fuel elements.	Idaho Nuclear Corp. (INC)
Waste calciner facility (WCF)	Reduction of liquid radioactive waste to solids.	Idaho Nuclear Corp. (INC)
West Valley, New York		
Chemical separations plant (Privately owned, privately operated)	Chemical separations of irradiated fuel elements.	Nuclear Fuel Services, Inc. (NFS)

Glossary of Isotopes and Chemical Compounds Referred to in the Budget

Americium (Am) -(Atomic number, 95).
A man-made element, americium occurs as an intermediate product in the production of curium-244.

Black Oxide
A trade term used for a uranium ore concentrate resulting from a uranium mill process employing salt fusion for final purification of the uranium cake. Black oxide is no longer produced.

Boron (B) - (Atomic number, 5; atomic weight, 10.82).
As found in nature, boron consists of B-10 (18.8%) and B-11 (81.2%). Because of the high neutron absorption cross section of B-10, boron is widely used for control of thermal reactors and for light-weight thermal neutron shielding. B-10 is also used for weapons. A complex of boron compounds is concentrated in the B-10 isotope at the AEC's plant at Model City, New York.

Californium-252 (Cf-252) - (Atomic number, 98).
An isotope of one of the new man-made elements resulting from reactor irradiation of curium. A high-activity alpha particle emitter with potential biomedical and analytical applications. Milligram quantities of this material have been made in the Savannah River reactors.

Cobalt-60 (Co-60) - (Atomic number, 27).
A radioactive isotope produced by reactor irradiation of Co-59. Because of its relatively short half-life and high activity, Co-60 is important as an energy source in isotopic power applications. Except for very high activity material which can only be produced in Savannah River reactors, all Co-60 is produced commercially.

Curium-244 (Cm-244) - (Atomic number, 96).
A radioactive isotope produced by successive reactor irradiations of plutonium-239 and americium. Cm-244 is a potential substitute for plutonium-238 in some isotopic power applications. Kilogram quantities of this material have been made in the Savannah River reactors.

Deuterium
A stable, naturally occurring hydrogen isotope (symbol, D, mass number, 2) having a natural abundance of 0.15% in the hydrogen element. In the form of "heavy water" (D_2O), which is concentrated at the Savannah River plant, it is the most effective material available for neutron moderation in reactors. Deuterium is combined with lithium at Oak Ridge, and the lithium deuteride is fabricated into parts for thermonuclear weapons.

Glossary - continued

Lithium (Li) - (Atomic number, 3; atomic weight 6.940).
A metallic element. As found in nature, lithium consists of Li-6 (7.5%) and Li-7 (92.5%). Li-6 is used in thermonuclear weapons, and facilities for concentrating Li-6 were operated at Oak Ridge through 1962. Lithium of various Li-6 concentrations is also irradiated in reactors to make tritium.

Neptunium (Np) - (Atomic number, 93).
A man-made element. Np-239 is an intermediate product in the transmutation of uranium-238 to plutonium-239. Np-237 targets are irradiated in thermal reactors to form plutonium-238.

Plutonium (Pu) - (Atomic number, 94).
A heavy, radioactive, highly toxic, metallic element. Although traces of plutonium occur naturally, plutonium is essentially a man-made element.

Isotopes

Pu-238 - An isotope of plutonium formed by the irradiation of Np-237, a by-product from the chemical separation of Pu-239 from irradiated uranium fuel elements. Pu-238 emits energetic alpha particles, has a high power density and does not require massive shielding. For these reasons, it is a valuable source of heat energy, which is converted into electrical power for space vehicle instruments, remote weather stations, and other applications where reliability and compactness compensate for the relatively high cost for the energy source. It also has promise as an energy source for pacemakers for heart attack patients.

Pu-239 - One of three primary fissionable materials (see also uranium-233 and uranium-235), it is formed by the irradiation of uranium-238 in reactors.

Pu-240 - An isotope of plutonium formed by neutron capture in Pu-239 in a thermal reactor. The amount of Pu-240 formation is directly proportional to the length of time uranium fuel is under irradiation in a thermal reactor.

Compounds

PuF_6 - Hexafluoride is the volatile form of plutonium.

$Pu(NO_3)_4$ - The nitrate is the usual chemical form of plutonium when shipped from plants where it has been chemically separated from uranium.

PuO_2 - Plutonium oxide is the ceramic form of Pu fuel to be used for the Fast Flux Test Facility (FFTF) and other plutonium-fueled reactors.

Glossary - continued

Polonium-210 (Po-210) - (Atomic number, 84).
A radioactive isotope produced by reactor irradiation of bismuth. Po-210 has a 138 day half-life, and is a commonly-used source of alpha activity. Kilogram quantities of this material have been produced in the Savannah River and Richland reactors.

Thorium (Th) - (Atomic number, 90; atomic weight, 232.12)
A heavy, slightly radioactive metallic element. As found in nature it consists almost entirely of the fertile isotope Th-232. Uranium-233 is produced by the irradiation of Th-232 in thermal reactors.

Tritium
A radioactive hydrogen isotope (symbol, T; mass number, 3) formed in thermal reactors by irradiation of Li_6. In addition to being a constituent of thermonuclear weapons, tritium is used in research and for thickness gauges.

Uranium (U) - (Atomic number, 92; atomic weight, 238.07).
A heavy, slightly radioactive metallic element. As found in nature, uranium is a mixture of three isotopes: U-234 (0.01%), U-235 (0.71%), and U-238 (99.28%).

Isotopes

U-233 - One of three primary fissionable materials. It is produced by the irradiation of Th-232. (See also U-235 and Pu-239).

U-234 - A naturally occurring isotope, of no practical importance.

U-235 - A naturally occurring isotope, it is one of three primary fissionable materials and the only one that occurs naturally (see also Pu-239 and U-233). UF_6 enriched in the U-235 isotope is produced in the gaseous diffusion plants.

U-236 - An isotope produced by irradiation of U-235, and a precursor to the production of Np-237 and Pu-238.

U-238 - A naturally occurring isotope. U-238 and Th-232 are the two fertile materials available for fissionable material production. U-238 is transmuted to the fissionable material Pu-239 by irradiation in thermal reactors.

94-075 O-68-pt. 3—8

Glossary - continued

Uranium (U) - continued

Compounds

UF_4 - "Green Salt" - An intermediate product in the conversion of UO_3 or other uranium compounds to UF_6 or to uranium metal.

$$UO_3 + H_2 \rightarrow UO_2 + H_2O$$

$$UO_2 + 4HF \rightarrow UF_4 + 2H_2O$$

$$UF_4 + F_2 \rightarrow UF_6$$

$$UF_4 + 2Mg \rightarrow U + 2MgF_2$$

UF_6 - Hexafluoride is the volatile form of uranium. It is the process gas in the gaseous diffusion process for enriching uranium in the U-235 isotope.

UO_2 - "Brown Oxide" - Commonly used as fuel for power reactors, and also an intermediate compound in the production of UF_6 or metal from UO_3.

$(UO_2)(NO_3)_2 \cdot 6H_2O$ - Uranyl nitrate hexahydrate (UNH) is an intermediate hydrate formed in the reproduction of a uranyl nitrate solution to UO_3.

UO_3 - The trade term "orange oxide" arises from the characteristic color of UO_3. UO_3 is the end product from refining unirradiated uranium concentrates at the Fernald refinery, and the chemical form of reactor tails as they are stored at Richland or Savannah River, or as they are shipped to other plants for further processing.

U_3O_8 - The assay unit generally used in the mining industry to express the uranium content of ores and concentrates. U_3O_8 arises from the naturally occurring equilibrium ratio of uranium oxide $2UO_3 \cdot UO_2$.

Glossary - continued

Yellow Cake

The trade term used for uranium ore concentrates, arising from the characteristic color of the dried filter cake. "Yellow cake", which assays from 75 to 85 percent U_3O_8, is a polyuranate salt, precipitated from an acid solution, generally by the addition of basic soda, magnesia or ammonia.

Zirconium (Zr) - (Atomic number, 40; atomic weight, 91.22).

A metallic element used as reactor fuel-element cladding or structural material. Reactor-grade zirconium, i.e., zirconium containing no more than 0.01% hafnium, has the lowest thermal neutron cross section of any metal of comparable mechanical strength or corrosion resistance.

JUSTIFICATION OF CATEGORIES

1. Feed Materials ..... FY 1967: $24,329,000 FY 1968: $24,196,000 FY 1969: $29,804,000

This category covers the manufacture of fuel elements, which are converted to Pu-239 and other reactor products in the Richland and Savannah River production reactors, and the preparation of UF_6 feed for the gaseous diffusion plants. Uranium compounds of below normal, normal, and slightly enriched U-235 assay are converted to fuel elements at the Fernald, Ohio feed material plant and the Ashtabula, Ohio extrusion plant. Uranium from the chemical separations plants at Richland and Savannah River is converted to UO_3. The UO_3 of below normal assay is shipped to Paducah for conversion to gaseous diffusion plant feed; that of above normal assay is shipped to Fernald, where it is used to make reactor fuel elements. The FY 1969 increase in this category is due principally to conversion of a significant quantity of UO_3 to UF_6 (none of which was converted in FY 1967 or FY 1968).

2. Production of Enriched Uranium (U-235)..... $119,892,000

	FY 1967:1/	FY 1968:	FY 1969:
Cascade power.....		$100,174,000	83,640,000
Plant test program		5,500,000	7,500,000
All other enriched UF_6 production		25,264,000	25,963,000
Other U-235 production		2,214,000	2,789,000
Totals		$133,152,000	$119,892,000

1/ Included in Category 10, Other Procurement and Production.

This category provides for operating the complex of gaseous diffusion plants at Oak Ridge, Paducah, and Portsmouth to produce UF_6 enriched in U-235, and for recovery of enriched uranium scrap. It also provides for a program of in-plant testing of potential improvements in gaseous diffusion technology. The increased level of effort for the plant test program in FY 1969 is required because the time when major improvements and new plant construction will be needed has been accelerated appreciably by the rapid growth of nuclear power. The lower cascade power cost in FY 1969 reflects previously scheduled reductions in cascade power procurement, with the level dropping to a three-plant total of 2,000 megawatts in January 1969.

3. Procurement of Reactor Products ..... FY 1969: $ 3,450,000

Plutonium	FY 1967:	$ 20,002	FY 1968:	$ 0	FY 1969:	$ 3,450,000
U-233		949		553,000		0
Totals.....		$ 20,951		$ 553,000		$ 3,450,000

This category provides for AEC's procurement of reactor products from domestic reactor operators. The FY 1968 estimate covers the purchase of U-233 from Consolidated Edison (Indian Point). The FY 1969 estimate provides for the purchase of 345 kilograms of plutonium at $10 per gram from the Dresden, Yankee, Humboldt Bay, Pathfinder and Big Rock Point reactor operators. The AEC is committed, until December 31, 1970, to purchase such plutonium when offered by power reactor operators.

4. Reduction of Liquid Wastes to Solids ..... FY 1967: $ 1,569,094 FY 1968: $ 950,000 FY 1969: $ 1,015,000

This category provides for the operation of the Idaho waste calciner facility which reduces to solids the radioactive liquid wastes generated by the Idaho chemical processing plant in the processing of irradiated fuel. The calciner is scheduled to operate approximately seven months a year in FY 1968 and FY 1969. FY 1969 construction project 69-2-a, calcined solids storage facility additions ($2,100,000), is related to this operating category. Costs associated with the nonoperating time of the calciner are included in Category 5.

5. Startup, Shutdown and Standby..... FY 1969: $ 4,237,000

Startup	FY 1967:	$ 694,689	FY 1968:	$ 401,000	FY 1969:	$ 264,000
Shutdown and Standby		5,975,658		8,185,000		3,973,000
Totals.....		$ 6,670,347		$ 8,586,000		$ 4,237,000

This category covers the startup of new and reactivated facilities, the shutdown of facilities whose operation is no longer required, and maintenance of shutdown facilities being kept in standby status for possible future use. The FY 1969 estimate includes funds for startup of the Paducah feed plant to convert UO_3 to UF_6 for the gaseous diffusion plants, as noted in 1., above. Shutdown and standby costs for FY 1969 are less than FY 1968 because the FY 1968 estimate includes costs to maintain the Weldon Spring, Missouri plant in standby until transfer to the Department of the Army January 1, 1968; shutdown costs associated with one Richland reactor that ceased operation in June 1967 and one Richland reactor and one Savannah River reactor scheduled for shutdown in February 1968.

6. Transportation and Security Shipment FY 1967: $ 3,056,701 FY 1968: $ 2,059,000 FY 1969: $ 2,048,000

This category covers the shipment of concentrates, fuel elements, intermediate products and finished products between AEC sites and between AEC sites and commercial processors. It also covers the cost of any security measures associated with the shipments. ~~Additional details are contained~~ in classified page SNM-25.

7. Miscellaneous ..... $ 4,047,000

This category provides funds for items not directly associated with any specific activity. A breakdown of costs by operations offices follows:

Oak Ridge	FY 1967: $ 3,193,545	FY 1968: $ 2,388,000	FY 1969: $ 2,426,000
Richland	6,249,678	3,465,000	685,000
Savannah River	1,109,484	961,000	936,000
Total Miscellaneous	$10,552,707	$ 6,814,000	$ 4,047,000

Oak Ridge - The FY 1969 costs cover analytical work at the New Brunswick Laboratory ($900,000), warehousing of residues ($362,000), maintenance of non-city roads, ground and property outside the plant areas ($88,000), salaries and expenses of the AEC combined operations planning (AECOP) staff at Oak Ridge ($841,000), and other miscellaneous items ($235,000). The increase in FY 1969 includes additional personnel for the AECOP staff, partially offset by a reduction in costs for special studies, all of which will be completed in FY 1968.

Richland - The FY 1969 estimate includes funds for warehousing of reactor depleted uranium oxide ($125,000), costs associated with the final closeout of the General Electric contract ($155,000), special studies ($200,000), and other miscellaneous items ($205,000). FY 1969 costs are below the FY 1968 level which includes higher levels of effort on special studies and GE closeout, and one-time costs associated with the takeover of separations activities by the Atlantic Richfield Hanford Company (ARCHO) from Isochem on September 4, 1967, and the non-productive costs incurred during the 15-week N reactor strike in the first half of FY 1968.

Savannah River - The FY 1969 estimate includes funds for warehousing of reactor depleted uranium oxide ($14,000), special studies ($359,000), land management[1/] ($476,000), and other miscellaneous items ($87,000). The decrease in FY 1969 costs below FY 1968 results from a lower level of special studies partially offset by an increase in the land management program to provide for reforestation of some areas.

1/ The value of the timber on the Savannah River plant site is currently estimated to increase approximately $2.0 million annually. Receipts from timber sales, which are included under the Revenues Applied Program, are as follows: FY 1967, $308,004; FY 1968, $305,000; FY 1969. $315,000.

8. Special Activities ..... $ 3,338,000

Safeguards and materials management...	FY 1967: $ 542,884	FY 1968: $ 1,640,000	FY 1969: $ 2,470,000
Filter testing and related activities.	401,584	500,000	868,000
Total Special Activities	$ 944,468	$ 2,140,000	$ 3,338,000

This category provides funds for programs under the direction of the newly established Office of Safeguards and Materials Management (SMM) and the Division of Operational Safety (OS). Prior to FY 1968 the costs of the SMM programs, which were conducted at a lower level under the direction of the Divisions of International Affairs and Nuclear Materials Management, and the OS programs were funded in the Miscellaneous category (No. 7).

Safeguards and materials management ..... $ 2,470,000

Systems studies	FY 1967: $ 185,000	FY 1968: $ 390,000	FY 1969: $ 530,000
Technical studies	357,884	1,250,000	1,940,000
Totals	$ 542,884	$ 1,640,000	$ 2,470,000

The increased distribution of special nuclear materials to both domestic private industry and to foreign countries requires an increasing emphasis on safeguards activities. Because of this increased emphasis the AEC has established the Office of Safeguards and Materials Management to coordinate and consolidate safeguards activities.

The FY 1969 estimates provide for an increased research and development effort on systems studies to evaluate current operations and private industrial plants and technical studies on scientific methods and techniques to assure that reliable quantitative data will be employed in the safeguards system to be used by private industry and the AEC.

First priority must be assigned to establishing regulations under which licensees are required to provide for safeguards control of special nuclear materials (SNM) in their possession. Basic to any such regulation are standards and criteria for evaluation of the licensees SNM safeguards control system. Therefore, first priority for safeguards research and development must be systems studies to evaluate current operations at private industrial plants to (1) determine present experience with respect to operational losses, inventory levels of unmeasured SNM bearing scrap, material unaccounted for, and shipper-receiver differences, and (2) establish numerical standards for these items with which industrial plants would be required to comply.

8. Special Activities - continued

Before regulations can be effective, there must be effective mechanisms to assure compliance on the part of the licensee. While AEC inspection and surveillance techniques have been employed for many years at AEC facilities, these techniques are not directly or completely applicable to the inspection and surveillance of private industrial facilities. More precise techniques of inventory verification, statistical control systems, and more comprehensive surveillance techniques must be developed to provide the AEC and the public adequate assurance that SNM in private plants has not been diverted to unauthorized uses. In addition, to simplify the AEC task of assuring adequate safeguards, recommended safeguards procedures for licensees should be developed so that the licensee will know what an adequate safeguards system is expected to include.

Data on which to base standards and criteria for licensed facilities must be obtained from detailed studies of such facilities and their operations. Generalizations cannot be made based on studies of some "typical" operations since the private nuclear industry has not become standardized and "typical" operations do not exist. Thus comprehensive studies of the many nuclear facilities currently in operation involve many man hours of technical personnel effort in the fields of engineering, physics, chemistry, reactor technology, and statistics.

While systems studies are noted as having first priority, the scientific methods and techniques which are employed in the safeguards systems either by the licensee or the AEC must be highly reliable to assure reliable quantitative knowledge of SNM. There are many types and forms of SNM currently in existence and soon to be encountered for which measurement methods are not sufficiently reliable. Basic studies are needed to develop new techniques on which to base SNM measurements. Developmental studies are needed to provide additional and more precise application of current basic techniques. Without reliable scientific methods and techniques to be applied in the safeguards systems, the data and information generated by the systems, and the standards and criteria developed from studies of such systems cannot be expected to be a valid basis for formulating safeguards regulations.

Fiscal year 1967 costs include $185,000 for system studies and $357,884 for technical studies. The systems studies included process and procedures studies of a general nature and not in sufficient detail to use as a basis for regulatory standards. With one exception, these studies were completed in FY 1967. The FY 1968 budget includes $390,000 to initiate detailed system studies needed for establishing safeguards and criteria, i.e., Nuclear Process Analyses, and to investigate improved surveillance and safeguards systems, i.e., Resident Inspection Test Program and Optimum System Studies. The FY 1969 budget includes $530,000 for continuation of these studies. Prior safeguards systems studies of a general procedural nature have cost in the order of $50,000 to $150,000 depending on the different types of facilities. In-depth, detailed studies are now required

8. Special Activities - continued

for specific individual facilities and processes, including the collection and evaluation of detailed process and control data. It is expected that a complete study of an individual facility will cost as little as $50,000 for a small conversion facility to as much as $300,000 for a complex conversion-fabrication scrap processing facility or a spent fuel reprocessing facility. To obtain sufficient data on which to base regulatory standards, many facilities of each type would have to be studied.

The majority of the technical studies in FY 1967 were continuations from the prior year. The FY 1968 budget for technical studies ($1,250,000) includes $716,000 for the continuation of prior years studies and $534,000 for the initiation of new studies. The FY 1969 technical studies proposed budget ($1,940,000) is an increase of $690,000 over the FY 1968 estimated budget. Of the total amount, $1,780,000 is for the continuation of prior studies and only $160,000 for initiation of new studies. While the current technical studies will provide technical support for the safeguards systems, there are many additional areas, such as heterogeneous scrap measurement, spent fuel measurement and scrap recovery processes, that will need investigation in succeeding years to maintain the scientific base of the safeguards system as it is applied to a rapidly developing nuclear industry. As the industry develops and special nuclear materials are utilized in increasingly more complex physical and chemical forms, the maintenance of this scientific base becomes more important to prevent the safeguards system from becoming technically outdated and thus ineffective.

Filter testing and related activities FY 1967: $ 401,584 FY 1968: $ 500,000 FY 1969: $ 868,000

The Division of Operational Safety conducts and provides technical liaison and coordination of this program for which a modest effort has been maintained since 1959 to assure that air and gases, exhausted from plants and laboratories of the atomic energy program, are free of radioactive contamination. This program has been devoted to quality assurance of commercial filtration devices delivered to the program and to applied research into new or better methods and techniques to overcome current deficiencies or provide economy. The predominant portion of the activity has been carried out at AEC operational sites, where the applications and deficiencies exist, with the remainder contracted to organizations that can supplement respective facets of air and gas cleaning with the specialized competence required.

For continuation of current elements of the activity, allocation of funds is essential to operate two facilities geographically located with instrumentation to verify the high order of efficiencies routinely required of commercial air filters delivered to the atomic energy program. These facilities likewise afford testing of gas mask canisters, instrument calibration, and complement applied research projects with which they are coordinated. Continued support also will be necessary to develop an air filtration medium resistant to air containing trace fluorine and hydrogen fluoride exhausted from a projected plutonium process. Work will be continued on projects to improve protection of glovebox operations, separations processes, activated carbon filters for iodine collection, and instrument improvement.

SPECIAL NUCLEAR MATERIALS PROGRAM - continued

8. Special Activities - continued

Additional effort includes studies on the characterization and capture of effluents from operating reactors for assessment of adequate protection, such as investigation of spontaneous ignition from collected fission products in carbon filters and determination of carbon filter design affording maximum fire safety, to update a 1951 AEC handbook on aerosols for operational use, and investigation of factors affecting the integrity of air filters as installed.

9. Process Development ..... FY 1967: $22,801,381 FY 1968: $23,313,000 FY 1969: $26,499,000

These funds provide for development effort, which varies at each site in accordance with production requirements and related needs, directed toward achieving program objectives in a safe, efficient and economical manner. They also provide for development work related to improvement of existing products and processes as well as for new materials of national importance for space, underwater and terrestrial uses and for other civilian-oriented programs. About $2.3 million of the increase in FY 1969 is for a higher level of gaseous diffusion development effort which is necessary because most of the new technology for improvements and power upratings in existing diffusion plants and for new plants must be completed before 1972-73 if requirements associated with the increased projections of nuclear power growth are to be met in a timely manner. This increase in gaseous diffusion development is related to the increase noted for the plant test program in 2., above.

10. Other Procurement and Production.FY 1967: $279,357,882 FY 1968: $138,907,000 FY 1969: $139,973,000

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

SPECIAL NUCLEAR MATERIALS - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$ 41,553,000
A Construction Projects	
A-1 Obligations for new projects	($ 16,875,000)
A-2 Obligations for prior year projects	($ 4,170,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 17,950,000)
B-2 Obligations from prior year appropriations ...	($ 2,558,000)
Estimated Obligations FY 1968	$ 22,319,000
Actual Obligations FY 1967	$ 31,620,804

Obligations for the Special Nuclear Materials Program for FY 1969 are estimated at $41,553,000 of which:

a. $16,875,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $4,170,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $17,950,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $2,558,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cutback."

SPECIAL NUCLEAR MATERIALS PROGRAM - continued

SECTION A-1

The projects comprising Section A-1, which are requested for authorization in FY 1969 are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-1-a	Powder metallurgy facility, Savannah River, South Carolina	$ 700,000	$ 0	$ 700,000	$ 0
69-1-b	Waste storage tanks, Savannah River, South Carolina	3,500,000	0	3,500,000	0
69-1-c	Equipment test facility, Oak Ridge, Tennessee	4,000,000			
	Construction Planning and Design Funds	-75,000			
	Net	3,925,000	0	3,925,000	0
69-2-a	Calcined solids storage facility additions, National Reactor Testing Station, Idaho	2,100,000	0	2,100,000	0
69-8	General plant projects	6,650,000	0	6,650,000	0
	Total	$16,875,000	$ 0	$16,875,000	$ 0

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-1-a Powder metallurgy facility, Savannah River, South Carolina ..... $ 700,000

This project would provide an improved facility to produce enriched uranium-aluminum alloy cores required to make billets for subsequent coextrusion into fuel tubes for Savannah River reactor loadings. It is needed to permit very high burnup of oralloy to produce a concentrated batch of uranium-236 in order to provide target material for the rapid production of neptunium-237 and plutonium-238. The powder metallurgy capability to be incorporated in the facility, which will be constructed as an extension to an existing building, will enable Savannah River to increase the uranium concentration in the enriched fuel elements beyond the capability of the existing casting process and to do so at less cost. The powder metallurgy process will minimize homogeneity problems that are experienced in the casting process. Other advantages of the powder metallurgy process include a reduction of scrap material that must be recycled; an adaptability to the production of target elements; an attractiveness when small quantities of scarce or expensive materials are involved; and a reduction in the total amounts of aluminum in the reactor which provides increased productivity and cost savings in the separations areas.

Details of Cost Estimate*	Item Cost	Total Cost
a. Engineering, design and inspection at approximately 15% of construction costs, Item b		$ 75,000
b. Construction costs:.....		510,000
(1) Addition to Bldg. 324-M Approximately 2000 sq. ft. @ about $30/sq. ft.	$ 60,000	
(2) Special facilities:		
(a) Melting and shot-forming equipment	110,000	
(b) Compact outgassing equipment	160,000	
(c) Material handling, instrumentation and quality control equipment	150,000	
(3) Utilities	30,000	
Subtotal		585,000
c. Contingency at approximately 20% of above costs		115,000
Total Project Cost.....		$ 700,000

* Based on partial conceptual design.

EXPLANATION OF PROJECTS IN SECTION A-1 - continued

2. Project 69-1-b Waste storage tanks, Savannah River, South Carolina $3,500,000

This project would provide four additional 1,300,000-gallon uncooled tanks for storage of aqueous radioactive waste in the waste storage tank farm serving the Savannah River separations plant in the F area. Each tank will be approximately 85 feet in diameter by 34 feet high and will have a primary self-supporting container (tank liner) of carbon steel. Because of the low heat generation rate in the wastes contemplated for these tanks, no supplementary cooling is required. The tanks are required because additional low level waste storage capacity must be available by the second quarter of FY 1972 to assure continued safe and economical management of the low level radioactive wastes resulting from fuel processing in the F area separations plant. Forecasts indicate three of the four existing uncooled tanks will be filled early in the second quarter of FY 1972,and the fourth must be available for use as a working tank for receiving and storing unconcentrated wastes, as well as for emergency use and for accommodation of changes in production schedules.

Details of Cost Estimate*	Item Cost	Total Cost
a. Engineering, design and inspection at approximately 10% of construction costs, Item b	$	$ 280,000
b. Construction costs		2,750,000
(1) Improvements to land	25,000	
(2) Four tanks (1,300,000 gallons each @ about $.52/gal) including piping and accessories	2,725,000	
Subtotal		3,030,000
c. Contingency at approximately 15% of above costs		470,000
Total Project Cost		$3,500,000

* Based on partial conceptual design.

EXPLANATION OF PROJECTS IN SECTION A-1 - continued

3. Project 69-1-c Equipment test facility, Oak Ridge, Tennessee $4,000,000

This facility will provide space, power supplies, instrumentation, and prototype equipment for the purpose of testing the performance of new types of production equipment in order to more accurately forecast the operating life of the equipment and thus determine the economics of using similar equipment in a production process. The facility will consist of a 16,000 square foot addition to an existing building at the Oak Ridge Gaseous Diffusion Plant.

Details of Cost Estimate*	Item Cost	Total Cost
a. Engineering, design and inspection costs at approximately 15% of construction costs, Item b		$ 415,000
b. Construction costs		2,770,000
(1) Building, approximately 16,000 sq. ft. @ about $35/sq. ft..	$ 560,000	
(2) Utilities, including water, gas, electricity (including emergency power), sewers, etc.	60,000	
(3) Special facilities, including		
(a) Power supply, piping and instrumentation	990,000	
(b) Prototype equipment	1,160,000	
Subtotal		3,185,000
c. Contingency at approximately 50% of prototype equipment costs and 12% of other costs		815,000
Total Project Cost		$4,000,000**

* Based on engineering performed under Construction Planning and Design authorization.

** Includes $75,000 Construction Planning and Design Funds.

EXPLANATION OF PROJECTS IN SECTION A-1 - continued

4. Project 69-2-a Calcined solids storage facility additions, National Reactor Testing Station, Idaho $2,100,000

This project provides for the design and construction of a 30,000 cubic foot underground calcined solids storage facility consisting of a concrete vault and two (2) small, separate, enclosed rooms, one for instrumentation and the other to house a cyclone and block valves in the transport air system. The facility is required because existing calcined solid waste storage facilities will be filled before the end of FY 1971 and additional storage space will be needed after that date if the waste calcining facility (WCF) is to continue operating. Coordination of the Idaho chemical processing plant (ICPP) which processes non-production highly enriched reactor fuels and the WCF activities by scheduling operations on an alternating basis permits use of the same operating staff. This coordinated and economical operation is dependent on availability of storage space for both the liquids generated by the ICPP and the solid wastes produced therefrom by the WCF. Construction of the additional storage facilities would avoid shutdown of the WCF in FY 1971 as well as later shutdown of the ICPP unless additional liquid waste tanks are constructed for the latter facility.

Details of Cost Estimate*	Total Cost
a. Engineering, design and inspection at about 15% of construction costs, Item b	$ 230,000
b. Construction costs including excavation, backfill, concrete vault, piping, instrumentation, cooling air system, off-gas system, solids removal, bins, etc.	1,520,000
Subtotal	1,750,000
c. Contingency at about 20% of above costs	350,000
Total Project Cost	$2,100,000

*Estimate is based on completed conceptual design for this storage facility addition, and upon the design of a previously constructed and similar storage facility at the NRTS.

EXPLANATION OF PROJECTS IN SECTION A-1 - continued

5. Project 69-8 General plant projects $6,650,000

This project provides for various items of new construction, additions, alterations, and retirements to the land, buildings and utility systems required in support of the Special Nuclear Materials Programs under the jurisdiction of the Oak Ridge, Richland and Savannah River Operations Offices. The project covers (a) general plant requirements of Oak Ridge production programs (this year, for the first time, general plant requirements for the Y-12 area at Oak Ridge are included in the Weapons Program general plant projects); projects for maintaining the electrical distribution system for the Oak Ridge plants, and projects for the Division of Technical Information Extension at Oak Ridge; (b) all general plant requirements at Savannah River; and (c) all general plant requirements at Richland except for the Pacific Northwest Laboratory (which are included in the Reactor Development Program general plant projects).

The FY 1969 level of $6.65 million is approximately 0.2% of the capital value of the Special Nuclear Materials production complex. Estimates of the FY 1969 obligations by location are as follows:

Savannah River	$1,650,000
Richland	1,650,000
Oak Ridge:	
Oak Ridge Gaseous Diffusion Plant	1,600,000
Paducah Gaseous Diffusion Plant	300,000
Portsmouth Gaseous Diffusion Plant	950,000
Fernald Feed Materials Production Center	200,000
All Other, Oak Ridge Operations	300,000
Subtotal, Oak Ridge	3,350,000
Total	$6,650,000

94-075 O-68-pt. 3—9

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-1-a	Hot laboratory, New Brunswick, New Jersey	$ 1,000,000	$ 124,000	$ 876,000	$ 0
68-1-b	Replacement waste storage tanks, Richland, Washington	3,125,000	1,900,000	1,225,000	0
68-6	General plant projects	7,000,000	6,200,000	800,000	0
67-7	General plant projects	6,584,000			
	Non-reimbursable excess utilized	-7,000			
	Net	6,577,000	6,502,000	75,000	0
66-1-a	Sludge removal and waste transfer facility, Richland, Washington	2,650,000			
	Non-reimbursable excess utilized	-13,000			
	Net	2,637,000	2,629,000	8,000	0
66-9	General plant projects	8,209,000			
	Non-reimbursable excess utilized	-49,000			
	Net	8,160,000	8,153,000	7,000	0
65-1-a	Radio-surgery facility, Richland, Washington	250,000	245,000	5,000	0
65-1-b	Isotopes production plant, Richland, Washington	882,000			
	Non-reimbursable excess utilized	-1,000			
	Net	881,000	844,000	37,000	0
59-a-5	Production reactor facility for special nuclear materials, convertible type, Hanford, Washington	199,350,000			
	Non-reimbursable excess utilized	-353,000			
	Net	198,997,000	197,860,000	1,137,000	0
	Total	$228,627,000	$224,457,000	$4,170,000	$ 0

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Feed Materials	$ 1,000,000
Production of Enriched Uranium (U-235)	2,950,000
Reactor Products	7,485,000
Separations of Irradiated Non-Production Reactor Fuels	250,000
Process Development	3,030,000
Other Capital Equipment	2,955,000
Special Activities	280,000
Total	$17,950,000

JUSTIFICATION

The capital equipment funds are required to provide and maintain an adequate, safe, efficient and economical production capability for production facilities representing an initial investment of over $4.0 billion. These facilities consist of feed materials facilities, gaseous diffusion plants, reactors, separations plants, a heavy water plant, laboratories and other supporting facilities, Equipment needs continue to increase as plants get older, equipment wears out or becomes obsolete or unsafe, new programs develop, and existing programs increase in level or scope.

Feed Materials ..... $ 1,000,000

This estimate would provide the Fernald plant with the equipment funds required for the purchase of a blanking route system ($300,000); a turning machine for tubular elements ($100,000); installation of infrared pyrometers to control temperatures ($120,000); and other items necessary to improve, replace and correct deficiencies.

Justification - Continued

Production of Enriched Uranium (U-235) ..... $ 2,950,000

These funds would provide for the equipment needs in the gaseous diffusion plants at Oak Ridge, Paducah, and Portsmouth. The equipment requirements included replacement of contaminated, deterioriated or obsolete plant equipment, additional equipment to improve plant operations, equipment in support of the expanded plant test program, and additional cylinders for storage of cascade tails of UF_6. Examples include an automatic mass spectrometer ($120,000); electron microscope ($75,000); an engine lathe ($85,000); equipment for the plant test program ($1,000,000); and storage cylinders ($538,000).

Reactor Products ..... $ 7,485,000

This activity covers the equipment needs of the fuel fabrication plants, reactors, separations plants, and waste management programs. Some of the major items at Richland are a flux monitoring system ($395,000); dose rate telemetering system ($395,000); drive turbine renovation ($275,000); a plutonium extraction type cycle ($170,000); and radioactive waste control improvements ($500,000). Savannah River items include a poison injection system ($600,000); replacement of slug buckets ($200,000); evaporator tube bundles ($165,000); reactor cavity ventilation ($150,000); Curium-Americium target fabrication facilities ($600,000); Californium-252 separation facilities ($600,000); Californium-252 source fabrication facilities ($600,000); and replacement of a precipitator cabinet sump ($150,000).

Separations of Irradiated
Non-Production Reactor Fuels ..... $ 250,000

The estimate provides for capital equipment additions and modifications to non-production fuel storage, handling and processing facilities at Savannah River and the Idaho Chemical Processing Plant. Included in the estimate is $100,000 for a second deionizer system at Savannah River and $60,000 for an electron microprobe at Idaho.

Justification - Continued

Process Development ..... $ 3,030,000

These equipment funds are needed in support of development and testing to determine the feasibility of the application of production processes to meet production requirements, maintain and/or improve health and safety standards and effect cost reductions. The estimate includes a number of miscellaneous equipment replacements and additions at all production sites. The major item at Savannah River is a developmental facility ($400,000) to be installed in the Isotopes process development laboratory. Oak Ridge requirements include numerous items in support of expanded U-235 development effort including improved test loops to test prototype modified diffusion plant equipment ($74,000); machinery for casting experimental compressor blades ($85,000); and a furnace to support barrier development projects ($60,000). Idaho requirements include high temperature demonstration equipment ($150,000). Some of the Richland items are samplers, welders, testers, hoods, and other special replacement equipment ($200,000).

Other Capital Equipment ..... $ 2,955,000

The estimate includes all the general purpose equipment requirements at all production sites. Included are replacement of rolling stock (automobiles, truck, railroad, etc.), heavy equipment, radiation monitoring, office telephone and radio, firefighting, machine shop, testing, plant protection, inspection, cafeteria, and laundry equipment. FY 1969 costs include $1.2 million for computers and related equipment as follows: Oak Ridge, $646,000; Richland, $360,000; Savannah River, $205,000.

Special Activities		$ 280,000
	Safeguards and Material Management	250,000
	Filter Testing and Related Activities	30,000

These funds are required to support the Safeguards and Operational Safety programs. All of the $250,000 for Safeguards in FY 1969 is for equipment requirements for the LASL project to investigate the delayed neutron response technique for detection and analyses of special nuclear material.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Feed Materials	$ 224,000
Production of Enriched Uranium (U-235)	182,000
Reactor Products	1,049,000
Separations of Irradiated Non-Production Reactor Fuels	140,000
Process Development	145,000
Other Capital Equipment	818,000
Special Activities	0
Total	$2,558,000

Mr. MORRIS. Mr. Baranowski, the committee is glad to have you. Do you have a written statement?

Mr. BARANOWSKI. I have some opening comments for the committee to assist it in going over the budget.

Mr. MORRIS. Proceed in the manner you desire.

Mr. BARANOWSKI. This is the 9th consecutive year in which the program operating costs have declined below that of the previous year. In the last 5 years the reduced operating dollar requirements were due primarily to the shutdown of the AEC-owned facilities throughout the production complex. The cost of producing enriched material in this budget to meet the nuclear power requirement will be offset in future years in the form of income to the Government. We estimate that beginning in fiscal year 1971, the Government will receive more revenue from uranium enrichment services than will be spent for the gaseous diffusion plant operations, process development, equipment, and general plant projects.

From the standpoint of balancing out on a cash-flow basis, we will be receiving more dollars in 1971 than we put out on the enriched uranium operation.

EFFECT OF CURTAILMENTS ON DIFFUSION PLANTS

The curtailment in production of enriched materials did not result in the shutdown of any of the three diffusion plants at Oak Ridge, Paducah, or Portsmouth. Instead, we lowered the power level in the facilities. The precutback combined electric power level for the three plants was 5,250 megawatts. As will be noted in the fiscal year 1969 budget before you, the total will reach its scheduled drop to 2,000 megawatts in 1969.

However, it will be necessary in future years to increase the power level to meet the growing demand for enriched uranium for nuclear power.

The 1969 budget also includes the startup of the Paducah UF_6 plant that was shut down in 1964. The Paducah plant will be the first AEC nuclear materials production facility ever to start up after having been shut down.

As the Chairman mentioned yesterday, we are using residual uranium discharged from the production reactors for use as feed to the diffusion plants. Thus, we are not purchasing any feed for the startup of the Palucah feed plant. This is due to the management of our entire uranium stockpile, using diffusion plant tailings first, and then going to stockpiled material from our production reactors, and also using concentrates later on, if necessary, for feed to the diffusion plant.

The 1969 operating budget of $334.3 million is about $141 million, or roughly 30 percent, below the 1964 budget, the last precutback budget.

The 1969 request is $6.4 million below the fiscal year 1968 estimate.

I would like to note at this time that the declassification action taken by the Commission has enabled us to expand the unclassified portion of the special nuclear materials budget. We now account for most of our categories in the unclassified section of the budget before you.

MANAGEMENT OF RADIOACTIVE WASTES

Last year I highlighted for the subcommittee our waste management program at the production reactor sites. These wastes contain radioactive fission products from the chemical reprocessing of irradiated material.

I would like to summarize for the committee the dollars in the budget for overall waste management to give you a feeling for the magnitude of the program. The cost of managing the radioactive materials at Richland increases by about half a million dollars in 1969, to $9.5 million.

The subcommittee might recall that last year I referred to the storage of these large amounts of radioactive wastes. While the cost-escalation accounts for a good portion of the half-million-dollar increase, the total level of $9.5 million reflects our concern for safe handling and storage of radioactive wastes at the sites.

The waste management program at the Savannah River plant will continue at about a $2 million level in 1969, but requires the construction of four additional storage tanks for aqueous radioactive wastes because additional storage capacity must be available during fiscal year 1972. Our construction budget includes a project, 69–1–b, $3.5 million, to meet this requirement.

The budget also includes $1 million in 1969 for the operation of a waste calciner facility at the AEC Idaho site. Because existing solid waste storage capacity will be filled some time in fiscal year 1971, we have included in the construction budget a project, 69–2–a, $2.1 million, that would provide for additional storage capacity.

The total fiscal year 1969 budget for management of radioactive wastes, including the projects mentioned for Savannah River and Idaho, is in excess of $18 million. The other items I did not mention are in the equipment budget as well as in R. & D. and these would take the total amount above $20 million in 1969.

This is an indication of AEC's effort to immobilize radioactive wastes and to provide storage in a safe form.

PROCESS DEVELOPMENT

The budget also has an increase in process development in 1969 of $2.3 million for the gaseous diffusion plant program. This stepped-up effort is necessary to provide new technology for improvements in operation of existing diffusion plants if requirements associated with the increased projection of power growth are to be met in timely fashion.

[Security information deleted.]

POWDER METALLURGY FACILITY AT SAVANNAH RIVER

In addition to the two construction projects I mentioned regarding the waste management activities, we have a third, a powder metallurgy facility at Savannah River, for $700,000. This would give the Savannah River plant the capability to provide routinely uniform alloys for the production of various materials other than plutonium and tritium in the production reactors at Savannah River.

At the same time, the reactor modes which have been developed for Savannah River for high enriched alloys would continue to produce plutonium and tritium as a main product.

Also in the budget we have $6.6 million for general plant projects, which is more than a million dollars less than our 1968 request. Despite the shutdown of two more reactors, we have a continued need for these general plant projects.

CAPITAL EQUIPMENT

The budget also includes an increase of $2.7 million for capital equipment in fiscal year 1969, which recognizes the urgent need for more funds to maintain an adequate base and economic production capability. At the end of March, 94 percent of our available 1968 equipment funds have already been obligated, which gives you an indication of how tight the budget is. We are using our funds fairly fast during the year.

The special nuclear materials budget also includes in the special activities category, safeguard and materials management costs. General Crowson, director of the recently established Office of Safeguards and Nuclear Materials Management, is here to discuss this program for the committee.

Mr. MORRIS. The committee will be glad to hear you, General Crowson. The General was formerly director of the Military Applications Division of the AEC, and has a distinguished career in both the military and AEC.

The committee is pleased to have you.

SAFEGUARDS PROGRAM

General CROWSON. Let me take about 5 minutes to tell you what safeguards are about, and a little bit of the background and what our budget problems are, and where we stand.

Initially, when the AEC processed material the Government owned it and it was processed in U.S.-owned plants. With the advent of private nuclear power and privately owned materials, there will obviously be increasing quantities of material that will not be in Government hands.

Therefore, a means, which is called safeguards, must be applied to these private operations, as it is to Government operations to make sure that this material is not diverted to other uses other than that for which it was intended.

Hopefully, going forward to the nonproliferation treaty, there will be a great demand throughout the world for safeguarding efforts to insure that the material that is produced in the reactor cycle, the power cycle, is not diverted to nonpeaceful uses.

It is the purpose of the program that I direct to insure that there are methods, scientific and otherwise, of measuring material, of insuring that inspectors are properly trained, and of insuring that the necessary work on the measurements and analytical work being done is correct and that we can account for the material within a known amount.

We have to set standards and we have to make sure that those things that we measure within the plant; that is, the amount of special nuclear

material, the amount of scrap that they have, and so on, does turn out to be truthfully what they say it is.

My budget is basically oriented toward getting that kind of job done. It is divided into two kinds of efforts. One is a systems studies effort which looks to analyzing plant and plant performance to insure that the materials unaccounted for can be accounted for, if I may put it that way. The other is our technical studies effort. This is an effort to develop capability to measure the materials through nondestructive testing, and so on. That appears on page SNM–12 of the justification, I believe.

On top of that, I have the task of training people. The additional numbers of people that we will require in the system as far as inspectors are concerned, have to be trained. We have money in our budget for training purposes.

I might add as far as our efforts in the technical studies are concerned, we have a very major effort going on at Los Alamos under G. Robert Keepin, who reported to me yesterday that they have been able, through measurement techniques which are nonchemical and nondestructive, to measure the isotopic content of materials as well as its actual amount; that is, the amount of the material there, to a precision that approaches that which we can do chemically. We are spending about $700,000 per year at Los Alamos for this purpose.

It does appear to be a very promising development. I would like to come back next year and report complete success on that subject.

That concludes my statement.

Mr. MORRIS. Thank you, General Crowson.

DOMESTIC AND FOREIGN INSPECTION

Mr. ROBISON. Could I ask General Crowson a question?

The emphasis of this new program relates to both the safeguarding methods private industry uses here for nuclear materials, and foreign users as well?

General CROWSON. That is correct.

Mr. ROBISON. Which would be the area of special concern—both?

General CROWSON. I believe they both are, sir, to this extent: The International Atomic Energy Agency, headquartered in Vienna, has essentially a worldwide charter, and we have from time to time put various kinds of U.S. industry facilities, like the Nuclear Fuel Services Organization near Buffalo, under international inspection. Their inspectors actually went up there and looked at the Yankee fuel that was being reprocessed.

Our basic concern, I think, is to insure that there is a system around the world that everybody agrees has a capability of protecting the material. So, our concerns are both domestic and foreign, to insure that the system is uniformly applied and uniformly administered.

INSPECTORS

Mr. ROBISON. When you speak of inspectors as you did in your statement, how do we arrange for them to inspect foreign installations?

General CROWSON. At the present time, they belong to the International Atomic Energy Agency, and they go around as teams from the Agency, with rights negotiated between the country and the International Agency.

Mr. ROBISON. These inspectors might or might not be U.S. citizens?

General CROWSON. Yes, sir. These are citizens of the world in that sense. They are citizens of countries that are detailed to work with the IAEA.

In the Inspection Division Directorate of IAEA, they have at least one permanent employee who, I believe, is from Argentina. The remainder are on terms of service. They go in and out. This creates a problem in that, obviously, certain countries are going to be worried about the citizenship and industrial affiliations of these inspectors. So, one of the primary objectives that we have in this system that we are trying to perfect is to depersonalize it to the extent that the numbers of people that will have to actually appear in the plant will be reduced to an absolute minimum.

So, we are looking toward instrumentation, and we are looking toward an analysis capability. We are also looking forward to putting all the information on a computer so we can instantaneously determine where material is at any one time.

Mr. ROBISON. We plan to spend in fiscal 1969 almost $2.5 million on this effort?

General CROWSON. That is right.

Mr. ROBISON. Other nations are contributing similar efforts? Some other nations?

General CROWSON. We are contributing to the IAEA. The Germans, for instance, have an effort that is between a half and three-quarters of a million dollars which they intend to expand to a million or a million and a half.

Mr. ROBISON. Yes, but this $2.5 million is not part of our specific contribution to IAEA?

General CROWSON. No, sir. This money is strictly for the United States.

RELATION TO NONPROLIFERATION TREATY

Mr. ROBISON. But the application of what we have contributed shows up in results in foreign countries?

General CROWSON. That is right, on a worldwide basis.

Dr. TAPE. I think you will agree with us, Mr. Robison, that this is an extremely important subject right now. It is most important to the nonproliferation treaty which will be up for discussion before the U.N. soon. The subject of safeguards is a most important subject there.

The Euratom organization has developed its own procedures for safeguarding material. The International Atomic Energy Agency has its procedures. One of the questions in the NPT has been the role of Euratom and the IAEA in the future there. Even before the work that General Crowson described, we had our own bilateral arrangements whereby, whenever we entered into agreements with foreign countries which involved material of this kind, we insisted on bilateral safeguards.

You asked how our inspection could take place in other countries. It was through these bilateral arrangements that our inspectors were able to go. When we moved an agreement into the IAEA area, then there were three parties—the country, ourselves, and IAEA—and IAEA took it over.

The President has also announced that at sometime in the future, if the NPT goes into effect, we would place many of our peaceful uses facilities under IAEA safeguard.

It is extremely important to us that the technical development of how one actually carries these out really goes forward expeditiously. We are behind. We know it.

This is where General Crowson's effort is really concentrated.

Mr. MORRIS. We want to do it because we want to be assured the technical developments are such that they are reliable.

Dr. TAPE. I feel, Mr. Morris, it is also an indication of good management. This is expensive material. The management itself, I think, should know where the material is at all times.

Mr. MORRIS. I think the committee agrees with that.

CONTROL OF SPECIAL NUCLEAR MATERIALS

Mr. DAVIS. Is the distribution of these special nuclear materials under tight Government control all over the world?

General CROWSON. In general, yes. I do not know of any situation where there is not some regulatory form, some form of penalty or some form of imprisonment with respect to the diversion of these materials. As far as I know, every country in the world has this kind of arrangement.

I assume that is what you mean by control, sir.,

Mr. DAVIS. So, in this area, there are no private, as contrasted to Government, activities going on outside of your cognizance and over which you do not have complete control?

General CROWSON. In general, that is right.

Let me say there is privately owned fissionable material in the United States and it is my purpose in life to assure that AEC knows who has it and what he is doing with it.

Mr. MORRIS. But it is licensed?

General CROWSON. They are licensed to possess that material. The license gives the Government the right to inspect. This is not uniform throughout the world. I think the United States at the present time is probably the only one that has privately owned material.

So, there is a problem for the future of how we insure that, indeed, if there is privately owned material in foreign countries it is properly accounted for. That is what I am worried about, basically, and the IAEA is worried about, and Euratom is worried about.

Mr. DAVIS. That is all.

FEED MATERIALS COSTS

Mr. MORRIS. As indicated on page SNM-9, explain the basis of the increase of $5,608,000 proposed for feed materials.

Mr. BARANOWSKI. The bulk of the cost increase is for the Paducah UF_6 facility, $4.1 million. It is for the conversion of UO_3 from the production reactor tailings to UF_6 feed for the diffusion plant.

Mr. MORRIS. Mr. Baranowski, do you remember how much money we said we were going to save when we shut that down in 1964?

Mr. BARANOWSKI. Offhand, I do not.

Mr. MORRIS. I am not blaming you. We are part of it, too. We just wonder what it was we said in 1964 when we announced this great program of shutting down and saving money.

Mr. BARANOWSKI. We did save money in the conversion of the concentrates and UO_3 to UF_6 by using diffusion plant tailings for about 5 years. So, for a period of 5 years we were actually saving hard budget dollars in the Government budget by stripping the tails.

Now we are starting up the Paducah facility and converting the UO_3 to UF_6, so there was a hard dollar savings actually realized in the 5-year period.

Mr. MORRIS. Why do we have to do this in 1969?

FEED FOR DIFFUSION PLANTS

Mr. BARANOWSKI. Because all of the tailings from the diffusion plants will be stripped by early 1969. We have no other feed available to go into the diffusion plants in 1969 unless we start up the Paducah feed plant.

Mr. MORRIS. In other words, if you did not start up the feed plant, you would not have any material for the gaseous diffusion plant, is that correct?

Mr. BARANOWSKI. That is correct, except for small amounts that will be coming in the latter part of the year from toll enrichment, but that will be inadequate for total feed to the plant.

Mr. MORRIS. That would make the gaseous diffusion an uneconomical operation?

Mr. BARANOWSKI. Very uneconomical.

Mr. MORRIS. And it would result in increased costs of operation per kilogram?

Mr. BARANOWSKI. Increased costs; yes, sir.

Mr. MORRIS. The committee would like, as we go along, for all the witnesses to address themselves to why these various programs are essential in 1969. I am sure all of you understand that the committee has a real problem in this regard, because of the very serious fiscal situation.

PURCHASE OF PLUTONIUM

As outlined on page SNM–10, please explain the request of $3,450,000 for the purchase of plutonium by power reactor operators.

Mr. BARANOWSKI. The Commission has a commitment to purchase from the power reactor operators up to December 31, 1970, plutonium delivered to the Commission.

Under this guaranteed purchase, our best estimates are that plutonium will be delivered to the Commission, and we have to fund for that delivery in the budget.

Mr. MORRIS. It is a guarantee——

Mr. BARANOWSKI. If delivered.

Mr. MORRIS. If delivered. What was budgeted for that last year?

Mr. BARANOWSKI. We have budgeted in the current 1968 column half a million dollars.

Mr. MORRIS. Can you carry over?

Mr. BARANOWSKI. No, sir. It is on an annual basis. In the 1968 column it is for U–233 delivery, not for plutonium delivery.

Mr. MORRIS. You did not have anything for plutonium?

Mr. BARANOWSKI. None in 1968, no, sir.

Mr. MORRIS. And you did not request anything for fiscal year 1969 for U–233?

Mr. BARANOWSKI. We see none being processed to be delivered in 1969.

One of our problems is if, for example, the U–233 is not processed in 1968, we would also have to absorb that kind of bill in 1969. So, there is an uncertainty in what our total will be in 1969.

If NFS is unable to process in 1968 and Consolidated Edison delivered it after NFS processing, in 1969, we would have to provide funds to fund the procurement of U–233.

Mr. MORRIS. You consider this $3,450,000 is a good estimate?

Mr. BARANOWSKI. It is a good estimate with the uncertainties which could occur in both 1968 and 1969 deliveries.

SAFEGUARDS TRAINING SCHOOL

Mr. MORRIS. General Crowson, a recent AEC press release announced the establishment of a safeguards training school at the Argonne National Laboratory which you mentioned in your statement. What is planned in connection with the school, and what will be the eventual annual operating cost?

General CROWSON. We plan to train about 25 students per class. These will be both supervisory as well as inspectors.

We expect to have about two classes a year. We expect the costs to be about $120,000 a year for these classes.

That amount is included in our budget at the present time. It is not broken out in our budget submission, but is included in our technical studies at the present time.

Mr. MORRIS. Why is this new school being established under this special office, rather than under the regular training, education, and information program?

General CROWSON. When we established the school, there was not sufficient money in the training budget to go ahead and put it in and we planned to train almost all AEC employees. However, this may not be the case, so we are, at the present time, looking at the possible transfer of dollars out of our budget over to the training budget, and then they will carry the budget in subsequent years.

INSTRUCTORS FOR SCHOOL

Mr. DAVIS. Is Argonne simply providing the physical site for the training program, or is the actual instruction itself to be handled by contract?

General CROWSON. The actual instruction, and so on, and the instructors themselves, will be provided by Argonne. We will use facilities that were there for the old reactor school. We expect that the school will have to run at least 2 years for purposes of getting a sufficient number of inspectors and with the turnover in AEC inspectors that we expect.

This will mean we are looking to train somewhere between 100 and 200 people.

Mr. DAVIS. Will they be all new people?

General CROWSON. There will be some retraining of old people, that is, some retraining of people who have some experience, and there will be some upgrading, however, mostly new people.

In general, we anticipate that we will train some international inspectors from IAEA, one or two, some from Euratom, and, obviously, some from U.S. industry. So, the total number of Government people going in may approximate half of that.

INCREASE IN PROCESS DEVELOPMENT

Mr. MORRIS. On page SNM–15, $26,499,000 is requested for process development under the Special Nuclear Materials program, an increase of $3,186,000.

I also note it has been going up every year, 1967, 1968, and now it is up about 14 percent in this fiscal year.

Why is it necessary to increase this program by such a large amount?

Mr. BARANOWSKI. Part of the increase is due to straight escalation of labor in the budget. However, as mentioned earlier, the major increase in the process development budget from 1968 to 1969 is to provide funds for the extra effort required in process development for improvement of the gaseous-diffusion plant.

The U.S. Government is the only source of technology for the gaseous-diffusion plants. Due to the security sensitivity of the data, all work on enriching processes is performed by the U.S. Government.

To absorb some of this increase, we now project for 1969 some cutbacks in other process development categories. In the budget, as it is projected today, for 1969 all of the increase in U^{235} is not shown by comparison of fiscal year 1968 and fiscal year 1969 totals. Some of the increase has been picked up by adjustments in the budget.

Mr. ABBADESSA. If you look at page SNM–27, the green page, there is a breakdown of increases from $23 million to $26 million. This is a very difficult activity and an extremely important one. It is difficult to defend because people think in terms of level of effort.

You will see several of these categories go down. The major increases are in the U^{235}.

This is extremely important work, and will have a very large economic payout in the upgrading of our gaseous-diffusion plants.

So, as a practical matter, although there is an overall increase, many activities have been projected to be reduced in order to provide for this increased effort in U^{235}———.

Mr. ROBISON. Mr. Chairman, this committee has been blessed by the addition to it of the acting chairman, the gentleman from New Mexico, Mr. Morris, who brings to the committee technical knowledge by virtue of his prior and present service on the joint committee.

Mr. MORRIS. Do not take that out of the record.

Mr. ROBISON. We are in a classified area, are we not?

EXPLANATION OF GASEOUS-DIFFUSION AND GAS CENTRIFUGE SYSTEM

Dr. Tape, I probably will be sorry I asked this question, because every time Mr. Davis or I do this sort of thing, we end up being more confused that we were in the beginning, but can you here, in layman's language, tell us the difference between a gaseous-diffusion system and a gas centrifuge system———.

Dr. TAPE. Let me try, although I have better experts here. I will try the layman's side.

For the gaseous-diffusion plant, one must visualize a membrane in which the two isotopes that naturally occur in uranium, U^{235} and U^{238} isotope, will diffuse through this membrane at slightly different rates because one is a little heavier than the other. So, by putting many such membranes in a plant, so that the material can diffuse through these many times, over a period of time, one ends up with the U^{235} more concentrated in the product than when you started in the beginning.

If you carry this to the extreme, one can get over 90 percent of U^{235} where one started with, say, 0.7 percent. The gaseous diffusion has to do with gas diffusing through a membrane.

In the centrifuge, it is the old cream separator applications of spinning the material. In spinning the material, because slightly different masses are involved, one can get a separation of the lighter from the heavier isotope in a way that then one can select out U^{235} enriched product like cream from the cream separator and end up percentage-wise with more U^{235} in the product than one did to start with.

So, here are two processes. There are other processes, but these are the two we are most interested in now. ———.

NEED FOR ENRICHED URANIUM

As you heard from Mr. Baranowski, we are going through a very low point with these plants. ———. But as we look down the road, the nuclear power electrical industry, which uses a lower enrichment, for example, 2 to 5 percent, enriched material for most of the reactors we have, and will be requiring large quantities of low enriched uranium not only in the United States but around the world. Therefore, as a commercial enterprise for supplying fuel to the power reactors, the plant operating levels must go back up.

In a few years, we expect these plants to be moving from the 2,000-megawatt level on up to 6,000-megawatt level. But Mr. Baranowski is also saying that we know how to improve the technology in those plants so we can get even more separated material out than we can today. So, the cascade improvement program is that technological program which would make those better plants.

This uranium enrichment step is the one element left in Government ownership in the whole civilian nuclear power program, and it is the one that will be producing revenue to the Government as long as the Government holds the plant. These are very costly plants to build in the first place. To build the size plant you need to make it economical, you need a large capital investment.

Mr. ROBISON. That is an excellent explanation. It is one of the few times I have asked such a question when I almost completely understand the answer, though I suspect not all of it will appear in our printed record.

ELECTRIC POWER FOR DIFFUSION PLANTS

Mr. MORRIS. On February 1, 1968, the Atomic Energy Commission advised the chairman of the Joint Committee on Atomic Energy that the Commission had determined that certain increases in the electric

power usage at the gaseous diffusion plant should be contracted for at this time to meet the needs of the nuclear power industry for enriched uranium.

Please outline what this commitment involves.

Mr. BARANOWSKI. This involves the addition of 1,520 megawatts to the 2,000-megawatt level which I mentioned we will reach in 1969.

The first increase occurs in 1971, so the commitment on power that we entered into will not be effective until 1971 as the first year.

That will increase total power level from 2,000 megawatts to 3,520 megawatts. It is a step toward increasing the production of enriched uranium material for the nuclear power program.

Mr. MORRIS. About a 75-percent increase?

Mr. BARANOWSKI. Seventy-five-percent increase in the power bill in about 1972 when we will reach the 3,520-megawatt level.

Mr. MORRIS. This is on the assumption that AEC is planning on providing the enriched uranium?

Mr. BARANOWSKI. Yes, sir.

Mr. QUINN. Tied to the fact that these are the only plants that can produce it.

Mr. MORRIS. And it is the assumption you intend to continue to operate them?

Mr. QUINN. We intend to supply the material needed for the civilian power program from these plants.

There is the separate question as to whether the plants should be sold to industry.

Mr. MORRIS. Suppose the Joint Committee on Atomic Energy and Congress were to determine that industry would do this. Would the Government still be committed for this power increase?

Mr. QUINN. No, sir. We have included in these power contracts provisions that would permit us to transfer the obligation to the new operator.

WASTE STORAGE TANKS AT SAVANNAH RIVER

Mr. MORRIS. On page SNM–50, $3,500,000 is budgeted for construction of waste storage tanks at Savannah River, S.C.

Why would it not be possible to defer this item similar to action taken during the current year by the administration on the replacement of waste storage tanks at Richland, Wash., as outlined on page SNM–56?

Mr. BARANOWSKI. Tanks at Savannah River are required by early 1972. If these tanks do not become available we run short on capacity in our facilities for storage of this highly radioactive material. It may be necessary then to perhaps shut down some of our facilities by having inadequate storage capacity.

Mr. ABBADESSA. Mr. Chairman, this is very important. First, the administration did not reduce the funding for the Richland tanks as part of the cutback. There is a deferral, but the deferral results from the fact we had to come to the Congress and ask for different types of tanks.

It turns out that the technology is such that it would be better in protecting our waste to build two banks with a double liner instead of the four tanks we requested. We advised both the Joint Committee

94–075 O—68—pt. 3——10

and this committee of this change, so there was a delay here which accounts for the money being deferred.

As a matter of fact, our guidance, which the Commission would have done anyhow, from the Bureau of the Budget said in the President's cutback two areas were not to be touched—one was the weapons activity which tied into the Vietnam war, and the other was waste management because of the health and safety factors.

The Commission considers this an extremely high-priority program

CAPITAL EQUIPMENT DEFERRALS

Mr. MORRIS. On page SNM–57, $17,950,000 is budgeted for capital equipment not related to construction.

DEFERRAL UNDER STRETCHOUT PROGRAM

In addition, as outlined on page SNM–60, $2,558,000 has been deferred from the current year to next fiscal year under the stretchout program.

What criterion was used for selecting these equipment items for deferral?

Mr. BARANOWSKI. From 1968?

Mr. MORRIS. Yes.

Mr. BARANOWSKI. Those projects which were not essential for continuity for operation in 1968.

Mr. MORRIS. Will you provide the committee with a list of the projects requested in the 1969 budget which are not essential for continuity in the special nuclear materials program in 1969?

Mr. BARANOWSKI. We will provide for the record that kind of a breakdown; yes, sir.

(Information requested follows:)

FISCAL YEAR 1969 CAPITAL EQUIPMENT FOR SPECIAL NUCLEAR MATERIALS PROGRAM

The AEC production facilities by their nature need to be in continuous operation to produce special materials for programs of national importance. These facilities supply products to meet the needs of other programs; to be useful, these facilities must be ready to produce materials at definite rates and within specifications. Also, planning must prepare for changes in requirements. The possible changes in requirements for nuclear materials were highlighted by the Joint Committee on Atomic Energy in its report on authorizing fiscal year 1968 appropriations for the AEC, as follows:

"Although the Commission has closed down four production reactors and will by the end of June 1967 have closed down a fifth, the major portion of the materials produced in the reactors remaining in operation will be used for weapons purposes. Increasingly, it can be expected that special isotopes produced in these reactors will be used for peaceful requirements. However, several days of executive session hearings earlier this year by the Joint Committee's Subcommittee on Military Applications concerning nuclear weapons materials requirements served to underscore the need for additional reactor products that might arise if certain affirmative decisions were to be made in connection with our present military posture. Specifically, the committee notes that increased production capability might well be required if the United States were to deploy an extensive antiballistic missile system or were to produce new strategic offensive weapons to counter the ABM system which is presently being deployed in the Soviet Union."

The reduced level of operation of production facilities places more emphasis now on maintaining these facilities in continuous operation. The deferral in January of $2.5 million in equipment funds from fiscal year 1968 to fiscal year

1969 was taken after the midpoint of the fiscal year had been reached and with the expectation of acquiring the deferred equipment early in fiscal year 1969. With priority placed on a continuous operation and a need to maintain a high degree of health and safety, the short deferral time involved made it possible to effect a temporary reduction in fiscal year 1968 equipment obligations of $2.5 million, of which $200,000 was for on-line operational computer requirements.

There are major distinctions between a decision on deferral of equipment funds for the last few months of fiscal year 1968 and on deferral of equipment for a period ending 15 months from now. In fiscal year 1969 an increase in the equipment budget is being requested as a result of a careful review of equipment needs in a budgetary environment of strict frugality.

The equipment installed in the various nuclear materials production plants is subject to wear, tear, corrosion, contamination, and obsolescence and thus more demanding on equipment funds with time. New requirements in both plants and laboratories need to be met as they arise to support Commission objectives. It is difficult, if not impracticable, to forecast with any degree of assurance which equipment items, if any, other than computers, in the fiscal year 1969 budget might not be needed to assure operations during that period to meet the variety of requirements in a safe manner. Some of the deferrals from previous years will necessarily be imposed on top of the estimated fiscal year 1969 requirements, with priorities changing within plants and between plants throughout the fiscal year. In a less critical budget year, a larger request for funds would have been made to meet needed equipment requirements. Even in the case of computers, acquisition will be authorized only when a clear demonstration of cost savings resulting from purchase rather than lease is made.

A review of the fiscal year 1969 budget, at this early date, in the context of equipment funding problems, has identified the following items of computer equipment that might be deferred on the basis of their relationship to continuity of plant operations. However, these equipment items are required to achieve a more effective and economical operation in future years.

Oak Ridge:	
Process control computer	$145,000
Terminal support equipment	150,000
Plotting capacity	125,000
Remote station equipment	60,000
Peripheral equipment	166,000
Richland:	
Magnetic tape certifier	55,000
Electronic accounting equipment	115,000
Terminal equipment	190,000
Savannah River:	
Magnetic drum	140,000
Direct access storage	65,000
Total	1,211,000

Mr. CORSO. I do not think Mr. Baranowski understood the question.

Mr. ABBADESSA. I don't think the question was understood, Mr. Chairman.

To better explain, Mr. Chairman, the need to defer equipment caused us to establish targets. Congress passed a law. We had to reduce our obligations to a fixed figure. We gave Mr. Baranowski, as well as our other division directors, a target that they had to reduce their equipment levels to.

I think what Mr. Baranowski's answer means is that he did not defer anything that was not essential. What he deferred was what he had to defer, this $2 million, and he took his lowest priority items.

If you remember, we took actual reductions in operating costs but on the equipment side we just took deferrals.

The chairman's question, as I understand it, is what are the nonessential items in the——

Mr. MORRIS. I did not say nonessential. I said the items that were not essential as far as continuity of his program in 1969, similar to the answer Mr. Baranowski gave me in reference to the basis for the 1968 deferrals.

I am not trying to be unfair but I hope you understand that we faced a tough decision on reductions last year, and it will be even tougher for fiscal year 1969. The sooner we realize that and face up to it the better off we will all be.

Mr. CORSO. Mr. Baranowski may have some items falling into this classification. I don't know. He will have to answer that.

For the record, however, it should be understood that while we were going through this cutback exercise in fiscal year 1968 we were also developing our fiscal year 1969 budget estimates. The climate in which those estimates were developed was every bit as stringent as that which caused us to defer the fiscal year 1968 equipment.

Again I say Mr. Baranowski may have some items of that character but in developing our estimates for fiscal 1969 we tried to identify precisely those kinds of things which were eligible for deferral in fiscal year 1968 and left them out of our fiscal year 1969 estimates.

That is why I interrupted before. I did not think he understood the question.

Mr. MORRIS. You have total for equipment of $176 million in new money. You have carryover of $36 and a half million.

Mr. CORSO. Right, sir.

Mr. MORRIS. You add that together and you have $212 million.

Mr. CORSO. That is correct.

Mr. MORRIS. The equipment category is an area the committee has had to look at carefully.

Mr. ABBADESSA. I agree, Mr. Chairman.

Mr. MORRIS. As far as your spending rate is concerned, if you spent it all there, your spending rate from this year would have probably a 30- or 40-percent increase, perhaps even more. The obligational authority would be about double.

Mr. CORSO. We do not quarrel with those figures at all. As the chairman indicated in his opening statement, we realized that this would impose very severe scheduling problems upon us and we hope we can cope with those problems.

Mr. MORRIS. Mr. Abbadessa, I think I interrupted you. I didn't mean to.

Mr. ABBADESSA. I think I will remain interrupted. I don't quarrel with the fact that this is an area where the committee has to take a look.

Mr. BARANOWSKI. This equipment includes our efforts on health and safety and programs which have been approved and on their way. This essentially would use up most of our dollars. We actually had cut back our dollars by several million dollars to stay within this level, so from the standpoint of continuity of operations, both to health and safety as well as programs which have been approved, this would be essentially all of our dollars.

Mr. MORRIS. The committee has a request of you to which you have responded. I know you will respond in the best way you can.

Mr. Davis?

WASTE STORAGE TANKS AT SAVANNAH RIVER

Mr. DAVIS. Getting back to this matter of the additional storage at Savannah River, this liquefied waste is put into some huge special tanks underground. What happens then?

Mr. BARANOWSKI. The material is stored for a period of time as the activity decreases by decay. Then it is sent to an evaporator. Water will be removed and as material is concentrated and sent back to the tanks it starts to precipitate and crystallize in the tanks and eventually the contents could end up as a solid.

Mr. DAVIS. And nondangerous?

Mr. BARANOWSKI. Nondangerous from the standpoint that the integrity of the tanks we are building are improved each and every time we build one to isolate the material from the environment. Yes, sir, we hope it will be for centuries—either by this storage technique or moving the material to some other place where the integrity can be assured over a long period of time.

Mr. ROBISON. These solids then sit wherever they are for hundreds of years?

Mr. BARANOWSKI. For centuries; yes, sir. This is one of our main concerns, to assure ourselves that whatever containment system we build as high integrity. At the present time at Savannah River in addition to tank storage we are looking at the possibility of storage of all this material in bedrock 1,500 feet underground, by building large caverns. After a temporary period of decay of this radioactivity in tanks then we hope, after all the tests have been made and the bedrock method accepted, to pump this waste material down into the caverns in bedrock and store the waste there for centuries.

This is a program under investigation and development now.

We hope in the next couple years we will proceed with actually building a cavern to do the final tests on the program.

Mr. ROBISON. It would be a good idea to get it underground eventually. I was getting visions of these nuclear "cemeteries" scattered all over our land.

Mr. BARANOWSKI. This is one technique. There are other techniques for the long-term isolation of this waste from the environment.

DECAY OF FISSION PRODUCTS

Mr. DAVIS. You spoke of decay. This is something we are talking about in decades?

Mr. BARANOWSKI. Yes, sir. For example, one of the fission products in the waste, strontium, has a half life of about 28 years. That is, half of it decays away in 28 years. You need roughly around 600 years before the strontium decays to levels at which it can be released to the environment within standards which are currently in existence although none of our thinking contemplates release of such wastes.

It is a long-term storage problem. It is something we look at cautiously and a lot of work has been done trying to improve methods of containment for this kind of waste.

Mr. DAVIS. That is all, Mr. Chairman.

BREAKDOWN OF MISCELLANEOUS ITEMS

Mr. ROBISON. On green page SNM–16, item 7, where various categories are shown. There is a so-called miscellaneous item of slightly over $4 million. What do you lump into this?

Mr. CORSO. It is spelled out on page SNM–11 of the white section.

Mr. BARANOWSKI. Page SNM–11 shows the breakdown of Oak Ridge, Richland, and Savannah River.

Included in the miscellaneous category is the operating costs at the New Brunswick Laboratory of $900,000; miscellaneous costs of warehousing residues which you cannot charge to any particular program so it is lumped in——

Mr. ROBISON. Don't go on to read them further. I see page SNM–11 does pretty well give us this breakdown.

That is all, Mr. Chairman.

Mr. MORRIS. Thank you, Mr. Baranowski and General Crowson, for your excellent statements.

WEAPONS PROGRAM

Mr. MORRIS. We will now proceed with the weapons program and shall insert pages W–1 through W–3, W–23 through W–31, and W–45, covering the budget request for the weapons program.

(Pages referred to follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

WEAPONS PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$840,790,000
Estimate FY 1968	722,450,000
Increase	$118,340,000

The weapons program provides for the development and production of safe and reliable nuclear weapons to meet national needs. Program objectives in FY 1969 require funding increases in production, research and development, and testing activities necessary to meet Department of Defense requirements and for the development of new systems needed to increase the effectiveness of future offensive and defensive capabilities.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
W 1	1. Production and Surveillance	$242,180,504	$244,800,000	$270,690,000
W 2	2. Research and Development	220,455,387	229,370,000	250,000,000
W 2	3. Testing of Atomic Weapons	193,181,782	242,730,000	314,600,000
W 2	4. Special Test Detection Activities	5,315,056	5,550,000	5,500,000
	Total Weapons Program	$661,132,729	$722,450,000	$840,790,000

JUSTIFICATION OF CATEGORIES

1. Production and Surveillance $270,690,000

The request for FY 1969 reflects the estimate of costs necessary for the production and surveillance of atomic weapons required to meet military needs, as approved by the President.

2. Research and Development $250,000,000

The estimate for FY 1969 provides for essential research and advanced development required to advance atomic weapons technology and to apply these advances to the weaponization efforts required by military needs. This effort, coupled with the testing activity, will yield information needed to assure the design integrity of weapons in development status and for advanced developments.

3. Testing of Atomic Weapons $314,600,000

The amount requested for FY 1969 provides for the increased requirements of the supplemental test sites program, for an underground test program necessary to support development activities, and for the maintenance of facilities and resources necessary to resume atmospheric testing should it be deemed essential to our national security or should the limited test ban treaty be abrogated.

4. Special Test Detection Activities ..... $ 5,500,000

Special test detection activities are in support of the national program to improve the capability to detect nuclear tests in outer space and underground (Vela Program). This program is the joint responsibility of the AEC and the Advanced Research Projects Agency of the DOD. The AEC activities include participation in underground events such as those at the Tatum Salt Dome in Mississippi, at Amchitka Island in the Aleutian Chain, and at the Nevada Test Site where data is obtained from other weapons tests. Other activities include participation in surface-based sensor programs of tests in space as well as satellite-based detection programs.

SUMMARY OF SPECIAL TEST DETECTION ACTIVITIES
(In Thousands)

a. Vela Uniform Program	FY 1967: $ 971	FY 1968: $1,275	FY 1969: $1,225
b. Other Vela Programs	4,344	4,275	4,275
Total Special Test Detection Activities	$5,315	$5,550	$5,500

a. Vela Uniform Program ..... $ 1,225,000

The Vela Uniform Program is concerned with improving our methods of detecting underground nuclear explosions. AEC-direct participation in this DOD program is generally confined to technical administration of specific

test events, including device and timing and firing costs, plus some research in the general area of seismic detection. In FY 1969, the general research will be continued at essentially the same level as planned in FY 1968. Efforts will continue to determine the feasibility of Project PAYETTE which consists of a plan to construct a large cavity in a salt dome in which a fully decoupled device will be detonated.

Costs by major organization follow:

		(In Thousands)				
Lawrence Radiation Laboratory	FY 1967:	$ 910	FY 1968:	$1,225	FY 1969:	$1,225
Nevada Operations Office		61		50		-0-
Total Vela Uniform		$ 971		$1,275		$1,225

b. Other Vela Programs ..... $ 4,275,000

Principal effort under this activity is directed toward the Vela Satellite-Based Detection Program with some minor emphasis given to work on the Vela Surface-Based Detection Program. AEC responsibilities in the satellite program include the development of detection sensors and space-based data processing instrumentation to be carried aboard satellites for detecting nuclear detonations at high altitude and in space. The FY 1969 estimate will provide for a continuation of this effort with emphasis on data reduction and analysis. Effort will be devoted toward the continued development and procurement of the new solid state instrumentation, which is to be included on Launch V, planned for FY 1969.

Costs by contractor follow:

		(In Thousands)				
Los Alamos Scientific Laboratory ..	FY 1967:	$1,313	FY 1968:	$1,275	FY 1969:	$1,275
Sandia Laboratory		3,031		3,000		3,000
Total Other Vela Programs		$4,344		$4,275		$4,275

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

WEAPONS - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$311,190,000
A Construction Projects	
A-1 Obligations for new projects	($215,400,000)
A-2 Obligations for prior year projects	($ 10,728,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 79,270,000)
B-2 Obligations from prior year appropriations	($ 5,792,000)
Estimated Obligations FY 1968	$178,286,000
Actual Obligations FY 1967	$ 92,146,800

Obligations for the Weapons Program for FY 1969 are estimated at $311,190,000, of which:

a. $215,400,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $10,728,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $79,270,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $5,792,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION A-1

The projects comprising Section A-1 which are required for authorization in FY 1969 are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-3-a	Rehabilitation of plutonium processing site, Los Alamos Scientific Laboratory, New Mexico	$ 3,500,000	$ -0-	$ 3,500,000	$ -0-
69-3-b	Weapons production, development, and test installations	10,000,000	-0-	10,000,000	-0-
69-8	General plant projects	14,200,000	-0-	14,200,000	-0-
68-2-a	New weapons production capabilities, various locations	285,000,000	100,500,000	184,500,000	-0-
66-2-d	Environmental test facility, Lawrence Radiation Laboratory, Livermore, California	5,500,000	2,300,000	1/ 3,200,000	-0-
	Total	$318,200,000	$102,800,000	$215,400,000	$ -0-

1/ $ 1,900,000 of this amount is being deferred until FY 1969. This project is, therefore, included in Section A-2.

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-3-a Rehabilitation of plutonium processing site, Los Alamos Scientific Laboratory, New Mexico ..... $ 3,500,000

This project provides for the replacement or rehabilitation of several utility systems, structures, and building services within the Laboratory's technical area primarily concerned with plutonium and heavy metals research. Plutonium is a radioactive material of long half-life which decays through emission of alpha particles. The metal exposed to normal atmosphere oxidizes rapidly and may even burn. The oxide is powdery and, hence, easily dispersed in the atmosphere. Alpha particles do not penetrate materials deeply, but rapidly lose their energy by ionizing the target material particles. This feature is a serious health and safety factor, should alpha emitters be inhaled, ingested, or contacted. Hence, plutonium must be handled with gloves in environmentally controlled and shielded boxes which are in special, limited access facilities.

At the Laboratory, old chemical laboratories built in 1945 have been converted to plutonium process facilities by adding and adapting, by renovating and innovating, and by "piecemeal" modification. Structural failures and obsolescence due to technological advancements make it essential that this rehabilitation be accomplished as soon as possible to avoid potential critical health and safety problems.

Details of Cost Estimate *

a. Engineering, design and inspection at approximately 10% of construction costs, Item b ..		$ 280,000
b. Construction costs		2,770,000
(1) Improvements to land (including surfacing, paving and drainage diversion) .	$220,000	
(2) Buildings		
(a) Replacement of outdoor corridors and outdoor equipment rooms (5)	460,000	
(b) Replacement of building supply and exhaust air systems (5)	670,000	
(c) Air dryer replacements (2)	100,000	
(d) Miscellaneous minor building services improvements	150,000	
(3) Utilities		
(a) Utility tunnel	320,000	
(b) Primary and secondary electrical power systems rehabilitation	390,000	
(c) Centralized cooling water system	260,000	
(d) Upgrading of miscellaneous utilities (including acid waste lines, steam and condensate lines, and compressed air system)	200,000	
Subtotal		3,050,000
c. Contingency at approximately 15% of above costs		450,000
Total Project Cost		$3,500,000

* Based on partial conceptual design.

2. Project 69-3-b Weapons production, development, and test installations ..... $ 10,000,000

This project provides for the construction and acquisition of such additional production, development, and test facilities or sites as may be required to assure the continuity of production, research, and test operations. Neither the need nor the scope and nature of these requirements can be foreseen in sufficient detail to include them as separate budget projects. Prior experience has proven the inestimable value of this type of project authorization. The magnitude and complexity of current and proposed production, development, and test programs indicate that we may expect requirements on short notice to provide development and/or production plant capabilities needed to meet new requirements and to assure the highest level of safety in daily operations.

Details of Cost Estimate

The indefinite nature of the anticipated work precludes inclusion of details of cost.

3. Project 69-8 General plant projects ..... $ 14,200,000

This project for general plant improvements includes construction and/or modifications of roads (on and off-site), utilities, minor structures, and technical facilities required in the operation of weapons program installations. Included are such items as (a) new minor research or production facilities, (b) minor additions or modifications to Nevada Test Site facilities, (c) additions to existing structures at the research and production site, and (d) improvements within existing facilities.

The project covers (1) all of the general plant requirements of the Lawrence Radiation Laboratory-Livermore and the Los Alamos Scientific Laboratory, (2) the main camp and forward weapons areas at the Nevada Test Site, (3) the general plant requirements of the Albuquerque Operations Office and its contractors, and (4) the general plant requirements of Y-12 at Oak Ridge.

4. Project 68-2-a New weapons production capabilities, various locations $285,000,000

This project, as currently conceived, provides for new capability and capacity required for the production of new nuclear warheads. It covers the cost of capital additions and improvements required at various plants comprising the weapons production complex, in order to provide adequate facilities, capabilities and capacities to produce the new warheads in the time frame and in the

currently estimated quantities required by the DOD. The facilities needed to meet the new requirements are not available within the weapons production complex. The new design features of the warheads require new techniques which will have varying impacts on the weapons production complex. Depending upon the finally selected configuration of warhead design features, the facilities needed may be somewhat different than that currently proposed.

This project was previously approved at an estimated cost of $100,500,000. With additional requirements identified, it was determined to be desirable to consolidate the expanded requirements with the previously approved program to obtain the maximum efficiencies in utilization of space and equipment as well as to hold to a minimum design and construction costs.

Details of Cost Estimate

a. Engineering, design and inspection at approximately 15% of construction costs, Item b ..			$ 26,400,000
b. Construction costs			178,560,000
(1) Improvements to land	$ 2,395,000		
(2) Buildings			
(a) New buildings and/or additions	45,280,000		
(b) Building modifications	23,930,000		
(3) Other structures	950,000		
(4) Special facilities	100,065,000		
(5) Utilities	5,940,000		
c. Standard equipment			36,165,000
Subtotal			241,125,000
d. Contingency at approximately 20% of above costs			43,875,000
Total Project Cost			$285,000,000

The FY 1969 appropriation request for this project totals $184,500,000.

5. Project 66-2-d Environmental test facility, Lawrence Radiation Laboratory, Livermore California ..... $ 5,500,000

This project provides for an environmental test complex consisting of a centrifuge building, a shaker building, a one-story reinforced concrete control building, and a central mechanical services building with a total of about 16,300 gross square feet. The centrifuge and shaker buildings will be underground and designed for high explosive blast and shrapnel containment.

The shaker building will include a large reinforced concrete reaction mass which will permit the mounting of low frequency, high amplitude hydraulic shaker actuators to allow triaxial loading of specimens. The control building will be designed to withstand the potential overpressure from a high explosive detonation in either the centrifuge or shaker building. The project is to be located at the remote LRL test area.

This complex is required to simulate, under laboratory-controlled conditions, the stringent environments which the new hardened warheads and anti-ballistic missile systems will experience. Data obtained from materials, components and systems exposed to these environments are required for the design and development of these new weapons. In addition, it is necessary to conduct tests under these conditions in order to confirm the design concepts that are under development.

Adequate environmental test facilities for the nuclear components of the new warhead designs do not exist. The shortcomings become more pronounced as the operating parameters of the new weapons systems are added. The laboratory has unsuccessfully attempted to cover the gaps between testing capability and system requirements by extrapolation and technical judgment. The design parameters require realistic evaluations of designs to avoid future costly retrofits to weapons entering the stockpile and to assure performance that meets the ensuing threat.

This test complex will provide facilities capable of simulating simultaneous environments such as vibration plus temperature, and steady-state acceleration plus random vibration. In addition, the capability will be available to simulate much higher acceleration and vibration forces than are possible with existing capabilities.

While the general technical objectives of this facility have not changed since initial FY 1966 authorization, it is now necessary to provide a facility that has a capability of simulating environments over a broader spectrum of size and weight to adequately support the laboratory's development programs required by the DOD. Authorization of this project is urgent due to the development schedules required to meet the deployment plans for systems now required by the DOD.

Details of Cost Estimate*

a. Engineering, design and inspection at approximately 15% of construction costs, Item b		$ 240,000
b. Construction costs		1,600,000
(1) Improvements to land	$ 120,000	
(2) Buildings:		
(a) Control building, approximately 2,200 square feet at about $42.00 per square foot 1/	92,400	

Details of Cost Estimate (Continued)

b. Construction costs (Continued)		
(2) Buildings: (Continued)		
(b) Central mechanical services building, approximately 6,400 square feet at about $76.00 per square foot 2/	$ 486,400	
(c) Centrifuge building, approximately 4,200 square feet at about $125.00 per square foot 3/	525,000	
(d) Shaker building, approximately 1,200 square feet at about $165.00 per square foot 3/	198,000	
(e) Tunnels and transition areas, approximately 2,300 square feet at about $14.00 per square foot	32,200	
(3) Other structures (solvent storage)	1,000	
(4) Special facilities	75,000	
(5) Utilities	70,000	
c. Standard equipment including:		$2,905,000
(1) Standard items: hydraulic centrifuge system ($880,000), electrodynamic shaker ($600,000), hydraulic shaker ($250,000), thermal chambers, cranes, etc.	1,905,000	
(2) Combined analog-digital readout system and instrumentation	1,000,000	
Subtotal		$4,745,000
d. Contingency at approximately 15% of above costs		755,000
Total Project Cost		$5,500,000

* Based on completed conceptual design.

1/ High building costs result from requirement to provide protection to personnel from potential blast overpressure in the event of an explosion in either the shaker or centrifuge buildings.

2/ This high unit cost is attributed to the inclusion as a building cost the complex mechanical, electrical, and hydraulic equipment required to service the other buildings of the entire complex, viz., air conditioning, compressed air, electrical switchgear, etc.

3/ High building costs result from safety requirements which dictate underground reinforced concrete up to nine feet thick for potential explosive hazard. In addition to these features, a large reinforced concrete reaction mass is required in the shaker building for instrumentation mounting.

The FY 1969 appropriation request for this project totals $3,200,000.

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over in FY 1969 are:

WEAPONS PROGRAM - continued

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-2-b	Weapons production, development, and test installations	$10,000,000	$ 3,442,000	$ 6,558,000	$ -0-
68-6	General plant projects	15,100,000	13,600,000	1,500,000	-0-
67-2-b	Weapons production, development, and test installations	10,030,000	10,000,000	30,000	-0-
66-2-b	Weapons production, development, and test installations	10,888,000			
	Non-reimbursable excess utilized	84,000			
	Net	10,804,000	10,769,000	35,000	-0-
66-2-c	Electron-positron accelerator facility, Lawrence Radiation Laboratory, Livermore, California	4,500,000	4,400,000	100,000	-0-
66-2-d	Environmental test facility, Lawrence Radiation Laboratory, Livermore, California	5,500,000	400,000	1,900,000 1/	-0-
66-3-a	Weapons test support facility, Los Alamos Scientific Laboratory, New Mexico	1,300,000	1,225,000	75,000	-0-
66-3-b	Supplemental water supply, Los Alamos, New Mexico	700,000	575,000	125,000	-0-
66-3-c	Physics analytical facility, Los Alamos Scientific Laboratory, New Mexico	830,000	810,000	20,000	-0-
65-2-c	Weapons production, development, and test installations	9,542,000	9,332,000	210,000	-0-
65-2-e	High velocity test facility, Sandia Base, New Mexico	1,350,000	1,330,000	20,000	-0-
65-3-b	Utility and supporting services additions, Rocky Flats, Colorado	2,335,000	2,315,000	20,000	-0-
65-3-d	Experimental physics facilities additions, Lawrence Radiation Laboratory, Livermore, California	4,090,000	3,990,000	100,000	-0-
64-d-2	Additions to administration and computer buildings, Los Alamos Scientific Laboratory, New Mexico	2,365,000	2,330,000	35,000	-0-
	Total	NA	NA	$10,728,000	$ -0-

1/ In addition to the $1,900,000 in deferred obligations, $3,200,000 in new FY 1969 obligational authority is being requested. This project is also included in Section A-1.

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
1. Production and Surveillance	$18,105,000
2. Nuclear Research and Development	16,330,000
3. Non-nuclear Engineering and Development	18,920,000
4. Testing of Atomic Weapons	14,450,000
5. Other Capital Equipment	11,465,000
Total	$79,270,000

JUSTIFICATION

The FY 1969 estimate of $79,270,000 provides for capital equipment additions, improvements, and replacements necessary for the development, test, production and surveillance of nuclear weapons required to meet military needs.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
1. Production and Surveillance	$1,392,000
2. Research and Development	1,350,000
3. Non-nuclear Engineering and Development	-0-
4. Testing of Atomic Weapons	2,250,000
5. Other Capital Equipment	800,000
Total	$5,792,000

Mr. MORRIS. The committee is very pleased to welcome General Giller, Director of the Military Applications Division of the AEC.

General, you may proceed in your own manner.

General GILLER. I do not have a prepared statement, Mr. Chairman, but I do have a small number of charts which will take us through the budget.

While they are setting up the charts I would like to make a few general comments about the weapons program as it looks at this moment.

WORKLOAD

As you are all probably aware, we are heading into what probably will be our biggest and most difficult production effort in terms of actual workload within the history of the AEC production system. The workload is not necessarily described by the number of weapons but by the number of man-hours per weapon times the number of weapons. I would like to talk about that a little more as we go through.

Our weapons are becoming very sophisticated, ———.

We have to design warheads ———. This requires new science, new technology, and new production capabilities.

WEAPONS OPERATING COST ESTIMATE

WEAPONS PROGRAM SUMMARY FISCAL YEAR 1969 BUDGET ESTIMATES

[In millions]

Operating costs	Fiscal year 1967	Fiscal year 1968	Fiscal year 1969
Production and surveillance	$242.2	$244.8	$270.7
Research and development	220.4	229.4	250.0
Testing of atomic weapons	193.2	242.7	314.6
Test detection	5.3	5.6	5.5
Total	661.1	722.5	840.8

We have broken down here on our first chart our budget in four main categories. The first item deals with the production within the plants and the surveillance of the existing stockpile.

The 1969 request over 1968 is some $25.9 million for production and surveillance. ———.

PRODUCTION AND SURVEILLANCE

Yesterday I think Mr. Robison asked about the breakdown between production and surveillance. ———.

The surveillance cost is ——— which is slightly less than fiscal year 1968 and is for the surveillance of the existing stockpile. ——— and testing them to see that the stockpile is, indeed, as advertised and is capable of being used.

Mr. ROBISON. Surveillance in that sense, then, is perhaps not the best word you can use.

General GILLER. Surveillance is used by another community here to mean observation. I guess you can say we are observing them. It is really a testing program of what exists. It is a quality test program.

Mr. ROBISON. Mr. Abbadessa points out that you call it stockpile sampling and quality assurance.

General GILLER. That is perhaps a better description than the word "surveillance."

PRODUCTION

Mr. ROBISON. Is production all in Government-owned and operated plants or is it done partly by industry?

General GILLER. The basic plants are owned by the Government. Each one is operated by a commercial contractor such as Dow Chemical, Bendix, and so on, under contract to us in what we call an integrated contract arrangement. In other words we control their operations as if they were actual Government employees.

Mr. ABBADESSA. Almost a contractor-in-house activity. They are in our facilities using our money and we pay them a small management fee in addition to covering all their costs.

General GILLER. Certain parts of the weapon, electronic parts, tubes, fittings, valves, and things of this nature are bought on the open market and go to Bendix and are assembled. All the special materials are completely handled in-house.

WEAPONS PRODUCTION WORKLOAD

I would like to show our coming production workload. This is the next chart. I think it is rather dramatic.

(Classified chart deleted.)

The chart shows the number of weapons being produced—not the complexity of their production. A more illuminating chart which could be built would be one based on man-hours of work and then you would see a different breakdown. This one shows the number of weapons we are being asked to produce by the Department of Defense. You might say these are firm orders. This is called the base case, ———.

Insofar as getting ready for the actual production of what will be Poseidon and Minuteman warheads we are ——— ahead of that chart in starting to build these systems, that is, ——— in order to meet the actual finished production schedules as required by the Department of Defense.

The Department of Defense has asked us to protect specifically two options for production capacity ———. This overlay shows you the facility workload that we have planned against; for example, we are asking appropriation of moneys to build the plant which will be able to produce at the rate shown by the orange section, ———.

They have asked that we protect the option. To us essentially that means prepare for it and you have to order the equipment and other facilities now ———.

That is the capacity to which we are planning facilities. The difference between the orange and the alternate A line would be a problem if they asked us for that full alternate, case A, production.

We will be using most of our capacity on a three-shift basis for critical items and two shifts on the items that are not as critical. There is not much more slack left in the system to add that alternate A case, if needed.

WORK SHIFTS

Mr. MORRIS. I assume you mean work shifts?

General GILLER. Yes, three shifts per day, 5 to 7 days a week. Some processes, like curing HE, takes 24 hours to cure. You cannot speed that up. They work three shifts all the time. Some other items you can get all you need in two shifts.

Alternate B shown on the chart is sort of an exceptional case or an extreme case, what some people might consider possible but not probable, ———.

If one were actually to plot out the man-hours per warhead it would exaggerate a mountain on the right because these warheads are more complicated.

NEW WEAPON TECHNOLOGIES

I would like now to address myself to some of the new technologies which we put into our new weapons and that will give you some idea of the problem of building them.

(Classified chart deleted.)

I have a list of them here. I will give you only a couple of examples to show you what we have in mind. ———.

WEAPONS RESEARCH AND DEVELOPMENT

That is all I was planning to say on the production system. We might change now to our research and development. We currently have in development, ordered by the Deparment of Defense, ———.

These are the systems which now have been ordered by the Department of Defense and are in development. We call this phase 3. This means we are committed to development. Phase 2 is when you think about it. Phase 3 is when you really have to develop it. Phase 4 and 5 is when you produce it.

Mr. ROBISON. Off the record.

(Discussion held off the record.)

General GILLER. These are the devices which the laboratories are committed to develop for a certain production date and the production system would be committed to start production. When we talk about phase 3 in testing you will see it means these devices are out in Nevada in holes being tested for various reasons. That is what we mean by phase 3 testing.

Our laboratories are very competent and they have lots of other ideas. On the next chart I would like to show some of the possibilities that we are considering at the moment and which the Department of Defense might order. They might order this year, next year, or never. We get from DOD from time to time certain priorities upon which to have our laboratories work for advanced development. We are committed not only to producing today's orders but also to work on what the next generation of weapons might be.

(Classified chart deleted.)

I can talk to any of the others if you wish but I shall go on.

TESTING

That is our present order and future ideas for development. We will go now to tests. The testing program in this case is identified by the numbers of shots, both by their category and by their location to give you some idea of the size of the test program.

(Classified chart deleted.)

Safety, for instance is always something on which we have to work. If you were to drop a bomb or have an accident such as at Thule, where the HE in the bomb is ignited by some inadvertent method, then we must be sure that it does not produce any nuclear yield. This is a requirement of the Department of Defense, so that it will not have nuclear yield if involved in an accident. ———.

Advanced technology involves the categories of the three items I spoke before——

Site calibration is next. One is the site in Amchitka, the new test site.

By location the present Nevada test site, which has been in existence over 15 years now, is divided into two areas, Pahute Mesa, and Yucca Flats. We shoot the bigger weapons at Pahute Mesa. This is where the shot which you read about recently is planned, so-called Boxcar.

Yucca Flats is out in the flats in the desert valley there where we shoot the smaller ones, ———.

SUPPLEMENTAL TEST SITES

The last two, Amchitka and central Nevada, constitute what is known as the supplemental test sites. Before I came on board a couple of years ago it became clear that if we were going to have a large yield we would have to find another test site. This program was put together and General Crowson, my predecessor, I am sure discussed it with this committee before it was approved.

That particular program is on schedule, both time and dollarwise.

CENTRAL NEVADA SITE

Central Nevada is in the Hot Creek Valley area, another 50 to 100 miles north of the present test site where we have found an area which is suitable to contain these devices.

The question in central Nevada is how large can you go. You have two restraints. One, after the yield gets to a certain point the damage you will inflict to expensive installations becomes excessive, either our own at the reactor test site or the public reaction which obviously is tied to that and becomes excessive.

We currently believe that we can get to about ——— in central Nevada. I can tell you a lot more about that after we fire on Friday. We are convinced we cannot go to ——— yield in central Nevada and therefore we must go to Amchitka.

We also have a problem in central Nevada. It is not called Hot Creek Valley for nothing. Temperatures down 5,000 feet where we put the weapon are 180° whereas at Amchitka it is 130°.

AMCHITKA SITE

Unfortunately I am sure we know Amchitka is perhaps one of the most expensive places in the world to do this sort of business, because of the weather and remoteness, but remoteness is what we are after and unfortunately the weather comes with it. ———.

These holes are 120 inches in diameter, a mile deep, and they take obviously a year to a year and a half to drill depending on how hard the rock is. We always drill little holes first to be sure we do not run into any problem.

This is all I had on the tests.

WEAPONS PLANT AND CAPITAL EQUIPMENT

The last portion covers our weapons program plant and capital equipment. Obviously the biggest one we have here is for our production system which is actually the fourth item on here. This is the new construction required throughout all of our locations, in production for all the weapons you saw on the mountain production workload chart.

WEAPONS PROGRAM PLANT AND CAPITAL EQUIPMENT, FISCAL YEAR 1969 BUDGET ESTIMATES

[In millions]

Number	Title	Total estimated cost	Fiscal year 1969 appropriation request
	Construction projects:		
69–3–a	Rehabilitation of plutonium processing site, LASL	3.5	3.5
69–3–b	Weapons production, development, and test installations, various locations	10.0	10.0
69–8	General plant projects	14.2	14.2
68–2–a	New weapons production capabilities, various locations	285.0	184.5
66–2–d	Environmental test facility, LRL	5.5	3.2
	Construction total	318.2	215.4
	Capital equipment not included in construction		79.3
	Total plant and capital equipment		294.7

Going back to the first item, this is to rehabilitate a very old site at Los Alamos where they handled the plutonium and have handled it for years. It has reached the point of no return in trying to repair the utility systems, the hoods, and it could become hazardous if we do not do something soon. If that happens we would shut down the——development at Los Alamos, which we cannot afford to do.

The second item is our project for unforseen requirements at all of our locations, as well as the third item which are the general plant projects, general support of all of the production and development sites.

These we have had in previous years and they are absolutely necessary to keep our $2 billion capital investment up to new program demands.

68–2–a is the large project which we previously discussed.

66–2–d is for a new facility at LRL and is directly in support of the development.

CAPITAL EQUIPMENT NOT INCLUDED IN CONSTRUCTION

The other item is capital equipment not included in construction for the whole system and it includes computers. The request is $79.3 million, including $20.7 million for computers. This includes $3.7 million for computers for the production system. Obviously, with such a complex production workload, computers are now a standard part of the production organization.

Research and development computers at the three laboratories total $12 million. ———

The test estimate includes no computers and we have $5 million of other computers, including a centralized computer for the Nevada complex and bits and pieces of smaller items for the rest of the system.

The noncomputing equipment, that which does not consist of computers, is the general equipment to keep up to date the production, research, and testing system. I will give you a few examples.

For production and surveillance we are asking for $14.4 million. ———. In the testing we find it to be to our advantage financially, as well as operationally, to buy a very large electric-powered drill rig and contract for its use rather than having it developed in industry and then contracting it and not owning it when a contract is over with. That is the kind of equipment included in the $79.3 million.

That is all of the charts I have except backup charts as they may be useful.

Mr. MORRIS. Thank you, General Giller, for your statement.

ATMOSPHERIC TEST READINESS

I have one question I want to ask now, and then in the interest of time, I will submit the written questions to you and ask you to furnish answers for the committee later.

Why is it necessary to continue to spend $20 million annually for the off-continent test readiness program?

General GILLER. As you know, we are charged with maintaining a readiness posture and one which has a quick response, like in 2 or 3 months.

In order to maintain that it is necessary that we maintain our capability to field the aircraft and drop vehicles which the aircraft carry on an instant basis.

We have three very complicated electronic aircraft which are stationed at Kirkland. Perhaps you have seen them. These have a lot of electronic and optical gear which must be exercised by the scientists at Los Alamos, Sandia, and elsewhere, and these have to fly regularly, have to be tuned and worked on.

Then we have a practice drop test in which we exercise them. In the meantime we can exercise them by scientific actions, such as certain sun spot work, certain solar eclipses, and other scientific type missions.

It would not be possible to maintain the readiness status without expenditure of something of this general level ———.

Unfortunately it will not be necessarily cheaper. We do not have and we have not finished our analysis both budget-wise and technical-wise, and we hope this summer to be able to discuss with you at least some of the ideas DOD and AEC will have concerning this program.

Dr. TAPE. This is one of the safeguards which was set forth at the time of the ratification of the limited test ban treaty.

Your question, Mr. Chairman, is more addressed to us not so much in why do we have it but what is the current program.

As General Giller has outlined here it is very important that we keep on top of what is the program that we feel is in our interest should there be an abrogation of the treaty.

Mr. MORRIS. You feel $20 million is necessary annually in order to carry out this responsibility?

Dr. TAPE. My feeling, Mr. Chairman, is that we need to update the program, as General Giller has said, ———: It is a bit like insurance. You have to ask yourself how much insurance you really want to carry for this type of program.

SUMMARY OF WEAPONS OPERATING COST INCREASE

Mr. MORRIS. Please highlight the basis for the proposed increase of $118,340,000 under operating expenses.

(The information follows:)

The increase of $118.3 million in weapons program operating cost by major activity is as follows:

	In millions
Production activities	$25.9
Research and development	20.6
Test activities	71.9
Test detection activities	—.1
Total	118.3

Production activities—the increase is required to produce the new weapons required by the Department of Defense. The increase is for production of the B61 bomb which increases by a factor of 3 over the current year and for the initial prebuild of parts and components necessary for the W68 Poseidon warhead which will be delivered in fiscal year 1970. All other activities remain relatively constant.

Research and development—the increase is primarily for the added effort required for the development of the ABM warheads. There is also included a small factor for wage and price changes which is essential to maintaining the existing laboratory level of effort.

Test activities—the increase of $71.9 million is made up of four major segments as follows:

	In millions
On continent (NTS) testing	$28.1
Supplemental test site activity	40.0
Atmospheric test readiness	.7
Laboratory test participation	3.1

These increases are required for the development of the new generation of weapons systems, for proof testing, for advance development, and for maintenance of the atmospheric test readiness posture.

CURRENT YEAR OBLIGATION PROGRAM

Mr. MORRIS. Is the obligation program for the current year on schedule?

(Information follows:)

We have just completed an in-depth review of our fiscal year 1968 weapons program and financial plan. The program is on schedule and we are convinced that we will use essentially all of our planned financial resources this year. The experience over the past year has shown that estimates and actual requirements in the weapons program are extremely close.

Mr. MORRIS. $28,100,000 of the increase is for continental testing of atomic weapons. Why is such a large increase necessary in 1969?

(Classified information deleted.)

SUPPLEMENTAL TEST SITES

Mr. MORRIS. $104,300,000 of the request is for supplemental test sites, an increase of $40 million. Specifically, why is this large increase essential?

(Information follows:)

As discussed with the committee during the fiscal year 1968 appropriation hearings, the supplemental test site program planning required for development of the Spartan ABM warhead is phased over a period of several years. The peak in construction was, and still is, planned for fiscal year 1969, with the actual large yield testing effort occurring shortly thereafter. The current $104.3 million estimate for the fiscal year 1969 construction and test effort is about $6 million lower than we had previously anticipated for next fiscal year. The increase of $40 million, over fiscal year 1968, is needed to continue the drilling of the large emplacement holes that were and are being started this fiscal year. The schedule for the development and deployment of the Spartan warhead is most demanding and depends on the successful testing of the warhead before the design is released to production. Without the increased funds, and in light of the construction leadtime, it would be necessary to delay the deployment of the ABM system.

OFF-CONTINENT TEST READINESS PROGRAM

Mr. MORRIS. Why is it necessary to continue to spend $20 million annually for the off-continent test readiness program?

(Information requested follows:)

The $20 million for the off-continent test readiness program is needed to continue to support the atmospheric test readiness safeguard established at the time of the ratification of the limited test ban treaty. Without this program at this minimum level, our ability to react promptly to a requirement for atmospheric testing could not be maintained. The funds are required for exercising the scientific teams and diagnostic equipment, for replacement of test vehicles and items expended in the test exercises, for replacement of rocket motors which have an 18–24 month life, and for maintenance and limited upgrading of the instrumentation and test capability.

CONSTRUCTION—NEW WEAPONS PRODUCTION CAPABILITIES

Mr. MORRIS. As outlined, beginning on page W26, $285 million is budgeted for construction of new weapons production capabilities at various locations, of which $184.5 million is scheduled for obligation in fiscal year 1969.

Please highlight what is involved in this request.

(Information requested follows:)

(Classified information deleted.)

Mr. MORRIS. What has been the cost experience to date on this program for which $100.5 million is currently available?

(Information requested follows:)

At the end of March 1968, $71.6 million had been obligated under contracts for facilities authorized under project 68–2-a (new weapons production capabilities, various locations). As of the same date, $16.6 million in cost had been incurred. The project is on schedule and it is anticipated that the design, construction and procurement will continue on an accelerated pace. By the end of the current fiscal year, the entire $100.5 million is scheduled to be obligated with cost incurred at that time estimated at approximately $50 million.

ENVIRONMENTAL TEST FACILITY—LRL

Mr. MORRIS. Beginning on page W27, $5.5 million is programed for construction of an environmental test facility at the Lawrence Radiation Laboratory in California.

What is the urgency of undertaking this item?

(Information requested follows:)

(Classified information deleted.)

Mr. MORRIS. Considering the urgency of this item, why was $1,900,000 referred from the current fiscal year until fiscal year 1969 for this project?

(Information requested follows:)

(Classified information deleted.)

EQUIPMENT DEFERRALS

Mr. MORRIS. As outlined on page W45, $5,792,000 has been deferred from the current fiscal year until 1969 for funds available for capital equipment not related to construction for the weapons program.

What criteria were followed in making these deferrals?

(Information requested follows:)

The equipment estimates for fiscal year 1968 were reviewed in detail to identify those items which could be deferred with minimal programmatic effect. The new production and development schedules permit some deferrals of items which can be obtained with a short leadtime or the continued use of equipment which should be replaced. Although a short deferral could be accommodated, further delays or cancellation of the planned acquisition or replacement will have a serious impact on the ability to meet the new weapons program requirements.

It should be noted that planning for replacement of wornout equipment also encompassed upgrading. This old equipment is also technically obsolete and must be upgraded and replaced by new high precision equipment in fiscal year 1969 to meet the new development and production workload.

CONSTRUCTION FOR WEAPONS PRODUCTION WORKLOAD

Mr. MORRIS. The gentleman from Wisconsin?

Mr. DAVIS. General, would you relate the fourth item on that chart in connection with the construction projects to the chart below it in which you outline the new weapons production workload? Which of those curves there are you trying to support?

General GILLER. The blue dotted curve encompassing the orange section. That is the production rate of finished weapons as requested by the Department of Defense within the years shown. In order for the production plants to be able to meet those dates we actually start building weapons parts, we have to build the production facilities now to meet those capabilities and those future rates.

ABM WORKLOAD

Mr. DAVIS. So you have not at this time any requests for gearing up or tooling up which would involve in the near future the establishment of the ABM system?

General GILLER. I am sorry, sir. The ABM is the green section. That will be within our capability. ABM really means Spartan and Sprint combined, or Sentinel.

Mr. MORRIS. Plus radars and other equipment.

General GILLER. We build only warheads. The Department of Defense has to have their part ready. This is their schedule and not ours. They set the schedule. ———.

Mr. ANTHONY. This chart is overly simplified. ———.

General GILLER. These data are just the finished complete weapons. ———.

Mr. DAVIS. Is this a fair evaluation of it? That any request that has come to you in this area actually amounts to the development of prototypes of these various ABM's?

General GILLER. We have a request to develop and produce the final device and the numbers, the final warhead.

Mr. MORRIS. Do you have a cross-section of the warhead?

General GILLER. We will show you what it is.

This is one version of the Spartan. ———.

We have an order for this device to be built, tested, certified, ———. It is all firm as far as we are concerned. Hard orders, you would describe it if you were in commercial business.

We can show you a picture of Sprint, ———.

For those which get through the Spartan defense, of which you have only a few, the Sprint is a different defensive missile. It sprints literally up to ——— feet and runs out of gas at that point. ———.

The two combined together make the Sentinel system. They are intermingled. We have firm orders for the Sprint device at a different rate than for the Spartan. ———.

Mr. MORRIS. They set the specifications of the warheads for you to develop and produce?

General GILLER. That is right. They set the gross specifications.

Mr. MORRIS. The evaluation of the entire system is someone else's responsibility.

General GILLER. That is for the Department of Defense, yes, sir.

LEADTIME

Dr. TAPE. I think you are reflecting a general problem which exists in major areas of technology these days, Mr. Davis. That is the long time it takes to go from a point of decision that we will do something, to the time at which it is in operation.

I suspect you can say the same is true of the ——— automobile, that in the automobile factories they are in process of design and thinking about it, and when they make a decision to go, it still is several years before that model is in the customer's hands. ———.

Mr. DAVIS. I am trying to put this into perspective with the discussion held on the floor with reference to the Defense appropriation bill last year. If you read that, some people think that no decision had been made to go ahead with this on the grounds of cost, and to other people it would indicate that all they had to do was to make up their minds to do it and install them tomorrow.

Dr. TAPE. It is a personal fault of all of us that, once we decide to do something, we assume it is done. ———.

General GILLER. If you remember the bar chart of the various weapons, those show you the times that our laboratories have to work on them before the production system even gets them. The end of that line is their first production unit. The beginning of the line is the decision. ———.

Mr. ABBADESSA. He is talking about the advanced work they are doing.

General GILLER. They are just ideas, not even orders.

Mr. ABBADESSA. It is doing this advanced work that will allow us to be talking about specific systems in a couple of years which still will have a further leadtime.

Dr. TAPE. If we did not do that advanced development under these circumstances and then one had a decision to proceed this leadtime would be even longer.

Mr. DAVIS. So, we are talking about, let us say, roughly something in the neighborhood of ———, as far as leadtime.

General GILLER. As an average.

Mr. DAVIS. For developing a prototype.

Dr. TAPE. Especially for the more complex systems.

Mr. DAVIS. Once we have the prototype, is there any particular leadtime problem as far as quantity production to make them an effective defense system?

General GILLER. Our production rate starts slowly and builds up rapidly on most systems. It is tailored to the Department of Defense's portion of what will carry the weapon.

You want it to come out even in the sense of the warhead and the missile. We tailor to that. ———.

You always have that problem. We tailor our production to their demands. Sometimes they want a lot. ———.

Dr. TAPE. There is an important point to make, though, that for some of these systems we may have the production capability now in hand, so one could move into production without having to do the design and actual building of the production facility.

On others, we may not have the production facilities in hand, and then we have to anticipate this at an even earlier date.

That is why in the big construction item that you see here, last year there was an initial appropriation of $100.5 million to move the critical parts of the Poseidon fabrication complex forward; and then, if you noticed, on 68–2–a the total estimated cost of the facilities is now $285 million, and we are requesting an additional $184.5 million, the $100.5 million having come in last year because Poseidon was on an earlier schedule and we had to get on with the program.

Now we know more about the Poseidon requirements in terms of fabrication facilities and, in addition, we have the ABM on top of that, so the total complex improvement to meet these two major systems is estimated at $285 million.

SUPPLEMENTAL TEST SITE

Mr. DAVIS. Is the Amchitka site ——— a permanent testing site?

General GILLER. It is presently conceived as a temporary supplement test site ———.

The crystal ball is a little cloudy as to what might follow in a couple more years. At the moment, the site is temporary. The construction aspect will always be temporary, in any event. We never will use the site except as a last resort, so to speak, because of large yields.

Central Nevada is in the same category. It is obviously cheaper to do tests in central Nevada than Amchitka. ———.

Mr. MORRIS. That is development. I think we also ought to realize—I am guessing now, and no one knows—after ———.

General GILLER. We do not know, that is correct.

BOXCAR EVENT

Mr. DAVIS. One further thing, General. When do you expect to be in a position to make an initial report and evaluation on your testing?

Dr. TAPE. About 5 minutes after the shot.

General GILLER. About 5 minutes after the shot we can tell you.

Actually, finding out how it went technically requires us to drill back to the center and bring up some rocks ———. That takes several months.

It most likely will take a week for public reaction really to be understood, and several months, 3 to 5, before the technical aspects are completely understood.

Mr. DAVIS. Mr. Chairman, the reason I inquired is that I wondered if we could ask the general and whomever else he thinks might be necessary, to give us a report on this test sometime within the next couple of weeks or so.

Mr. MORRIS. The committee so requests.

Dr. TAPE. We shall be glad to do that.

Mr. DAVIS. I had in mind a report sitting across a table just as we are this morning.

Mr. MORRIS. The committee so requests of the AEC, and I assume you will comply with the request.

Mr. DAVIS. That is all, Mr. Chairman. Thank you.

Mr. MORRIS. The gentleman from New York.

WEAPONS PROGRAM COSTS REVIEW

Mr. ROBISON. General, the Commission certainly operates from the budgetary standpoint under great difficulties in this program, difficulties related to technical development, some of which can only be guessed at, and those related to uncertainties in demands and changing priorities and considerations that the Department of Defense might put upon you.

I do not know who can really say whether what you ask is enough or too much. We know very well that the Federal budget is going to have new demands on it in new areas of concern, such as those related to urban needs. How can you be sure that what you present to us here will be the minimum need and represents an austere budget request, as far as that can ever be in such an area of sensitivity and such prime importance as this?

Dr. TAPE. You are asking General Giller, whose responsibility is to come to the Commission with his recommended program in this area of military affairs and development. He and we in the Commission are in close contact with the Defense Department on a back-and-forth basis essentially all the time in order to have an understanding of their requirements and for them to have an understanding of what we can and cannot do.

When the program request comes to the Commission our responsibility is to ask just the sorts of questions you have asked. Not only do we have the military weapons requirements to consider, but we have other aspects of the AEC program as well. We do want to see whether or not the last dollar is necessary in weapons as compared with the last dollar in reactors and the last dollar in research, etc. In that context we ask these questions.

I think the situation with all of our defense spending is that we want to be sure we are adequately covered but on the other hand we want to be prudent and make sure we are not moving faster than we have to. So it is at the overall general manager and Commission level that it finally gets this examination.

I could add, too, that the authorization side of the legislative process examines this carefully. I think your Chairman can attest to that.

Mr. ABBADESSA. To answer it from another point of view, when I first joined the Commission and in the 1962–64 period this program, and the record will show, underran by large amounts up to as high as $50 million. Strong budget pressures have been put on. We have looked very hard at this program. We have also, of course, tried to protect our options. It is a priority program.

In fiscal year 1967 we almost had an overrun and the division worked very hard to bring it in within our budget ceiling. We have a pretty good system of financial management. You will find in 1967 there was only a small underrun in this program.

In 1968, when we had the President's cutback and we had this carryover of $70 million, there is nothing in the carryover for the weapons program. There is actually an increase of $7.4 million.

We just had a major review for fiscal year 1968 because we are getting near the end and we have a legal limitation to hit. This division with a very large amount of money, some $722 million, is within a few million dollars of their planned level.

The point I am making is that we worry about this, too. We consider it to be our priority program but you heard the Chairman who wants to do as much in the peaceful uses as possible. We will cover the needs of this program but we will not waste money on the program so we try to bring you our very best estimates.

It seems like a large figure, yet on a $600 plus million level in 1967 we were within a few million dollars.

On the $700 plus million for this year we expect to be within a few million dollars. We have gone over the 1969 estimate, which is larger, $840 million, and we feel it is the minimum figure.

I can assure you that if this Commission felt this figure was even $20 million too high, there are many, many things on the peaceful side they would have done; but this is the minimum figure they thought could discharge their responsibility in this priority program.

That is another way to look at it.

Mr. ROBISON. That is all, Mr. Chairman.

Mr. MORRIS. The committee wants to commend General Giller, Commissioner Tape and the other staff people who have testified this morning for their testimony and their very candid and forthright answers.

We shall resume at 2 o'clock.

AFTERNOON SESSION

REACTOR DEVELOPMENT PROGRAM

NAVAL PROPULSION REACTORS

Mr. MORRIS. The committee will be in order.

This afternoon we shall hear the naval propulsion reactors program, headed by Admiral Rickover. We will insert page RD–56.

(The page follows:)

5. Naval propulsion reactors $115,300,000

The objective of the naval reactors program is the design and development of naval nuclear propulsion plants and reactor cores in a wide range of power

ratings to meet military requirements specified by the Department of Defense. The pressurized water nuclear propulsion plants and cores under development by the Atomic Energy Commission's naval reactors program are suitable for installation in ships ranging from small submarines to large combatant surface ships. Emphasis continues on research and development to provide advanced naval reactor cores of higher energy density and longer life with the ultimate objective of developing cores which will last the lifetime of a ship. Testing, design, operation, and evaluation of naval reactor prototype plants and cores including long-term operating effects on core materials and work to develop advanced core and submarine and surface ship concepts and to improve naval reactor systems, components, materials and operating techniques will continue. During fiscal year 1969 a high level of effort will continue on development of a very high-powered, longer fuel life reactor for application to two-reactor nuclear-powered attack aircraft carriers and on an improved destroper-type reactor core for present and improved destroyer plants.

Mr. MORRIS. Admiral Rickover, I am pleased you can be with us this afternoon.

We have a lot to cover but we want to receive any testimony you wish to give on the progress of the naval nuclear propulsion program. As you know, I was present when you testified this past February before the Joint Committee on Atomic Energy and I heard your testimony on the problems you were having. You said we are faced with "trying to drag the Department of Defense into the 20th century" on the question of nuclear power for naval warships.

SOVIET NUCLEAR SUBMARINE PROGRAM

This is a very serious matter. In addition to your testimony, the Joint Committee was briefed ——— concerning the progress being made by the Soviets in their nuclear submarine program. These were highly classified hearings and I will not go into detail here today. However, I can say that these hearings disturbed me greatly as they did the other members of the Joint Committee. There is little doubt that the Soviets have decided to substantially expand their nuclear powered submarine program both in quantity and quality. ———. Our survival could well depend upon what we do in this vital area. Yet with complete knowledge of this, the Department of Defense has decided that we should not build anymore nuclear powered submarines after fiscal year 1970. In addition, they have delayed action on providing the necessary approval to proceed with the development and testing of a new ——— submarine ———. This is the submarine that you have been working on for 4 years and have been trying to get approval to build for about 2 years. Once again it looks like Congress is going to have to take the lead in forcing the United States to have the world's best Navy.

Admiral Rickover, I know you discussed this subject in detail when you testified before the Joint Committee. However, some members here today were not privileged to hear you testify then. So, I would like you to review briefly, if you would, some of the reasons you believe the Department of Defense is so reluctant to pursue applying nuclear propulsion to the Navy, and your reasons for believing they should proceed more quickly. I would also like you to tell us what has happened since February in both the areas of nuclear submarines and application of nuclear power to surface warships.

CONSTRUCTION OF NUCLEAR POWERED SHIPS

I understand the administration has now agreed to build one of the nuclear frigates authorized by Congress last year, the DLGN37, as well as the DLGN36 authorized by Congress 2 years ago. Further, the administration announced also a commitment to building two more nuclear powered guided missle escort ships in the fiscal year 1970 shipbuilding program and two more in fiscal year 1971. I also understand they have agreed to reassess the need for additional nuclear powered escort ships.

As you know, Admiral, I have long believed that you are right in fighting to strengthen the defense of our country. I am also aware that in these matters you have had the proper foresight to anticipate correctly the needs of the Navy while some officials in the Department of Defense have either been in opposition or have wanted to wait for more studies. I would like for you to tell us your opinions concerning our nuclear Navy and what you think we should be doing for the future.

LIGHT WATER BREEDER REACTOR

Another area we would like to receive your testimony on is the light water breeder reactor. I understand from your testimony to the Joint Committee in February that your fiscal year 1969 budget request for this program was reduced $8.2 million by the Bureau of the Budget due to the stringency of funds, but that you felt you could and should proceed now with fabrication of a breeding demonstration core in spite of the reductions. Because of the extreme pressure on funds, the Joint Committee recommended a further reduction in the fiscal year 1969 funds for this project from the $15.5 million in the President's budget to $13.5 million. However, the Joint Committee report made it clear that "The committee continues to endorse proceeding with the light water breeder reactor demonstration." The Joint Committee also authorized the obligation authority requested by the administration for core procurement. Would you please tell us today whether, with the funds and obligation authority authorized for fiscal year 1969, you can proceed with the breeding demonstration and your reasons for believing you should.

I know this gives you a lot of territory to cover this afternoon, Admiral, but we will gladly listen to anything you want to tell us in these areas or others you may wish to discuss. We will hear from the other reactor development division directors after you finish.

Mr. MORRIS. Admiral, you may proceed in your own way.

Admiral RICKOVER. I understand you would like me to say a few words about the status of the naval nuclear propulsion program before I get into the two major questions.

Mr. MORRIS. If you will make it brief, I think we should hear it.

REVIEW OF NAVAL NUCLEAR PROPULSION PROGRAM

Admiral RICKOVER. Through fiscal year 1968, there has been authorized 107 nuclear powered submarines, of which 41 are Polaris. The most recent, the nuclear attack submarine Hammerhead, completed sea trials yesterday morning.

94-075 O—68—pt. 3——12

We now have 76 operating nuclear powered submarines, including the 41 Polaris. By the end of December 1968, we should have seven more nuclear powered submarines in operation, and this will include the NR–1, a research submarine designed to operate at ——— feet. Congress appropriated funds 2 years ago for this submarine.

Our nuclear powered ships, surface and submarine, have now steamed over 11 million miles.

We now have 98 naval reactors in operation, 91 in ships and seven in prototypes. In addition we have the one installed in Shippingport. We have built or placed orders for a total of 260 reactor cores.

Through fiscal year 1968, the Navy will have invested $11.5 billion in construction costs and spares for nuclear-powered ships, and $0.4 billion in R. & D., making the total Navy investment $11.9 billion.

During the same period, the AEC will have invested $1.2 billion in research and development, and $0.4 billion in plant and capital equipment. So, the total AEC-Navy investment in R. & D. is $1.6 billion, compared with a resulting $11.5 billion invested in nuclear ships.

We now have trained approximately 2,800 naval officers and 15,300 enlisted men to operate naval nuclear propulsion plants.

I think the significant part of this is that all of this R. & D. work over the last 20 years has been done for about $2 billion. That includes the cost of laboratories, prototypes, and all the development effort we have carried out. I think that is quite a modest sum.

Now, if it is satisfactory to you, sir, I will get on to the question you asked concerning the submarine problem. I will provide a summary of the nuclear ship program for your record.

Mr. MORRIS. We would like you to do that, Admiral.

(The information follows:)

NUCLEAR SHIP PROGRAM SUMMARY AS OF APR. 22, 1968

SUBMARINES

Type	In operation	Under construction	Contract not awarded	Total authorized
Polaris	41	0	0	41
Attack	35	22	8	65
Deep submergence research vehicle	0	1	0	1
Total	76	23	8	107

SURFACE SHIPS

Aircraft carrier	1	0	1	2
Guided missile cruiser	1	0	0	1
Guided missile frigate	2	0	3	5
Total	4	0	4	8

MILES STEAMED

Submarines	9,950,000
Surface ships	1,050,000
Total	11,000,000

Admiral RICKOVER. Mr. Chairman, portions of the testimony I am about to give are classified———. Last year in testimony before Congress, I stated that in my opinion the Soviet Union would surpass us in their nuclear submarines within 5 years. I not only hold to this view now, but I think I was optimistic in thinking it would take only 5 years.

In my testimony before the Senate Preparedness Investigating Subcommittee I was asked the question———I said I would rather———. I think this gives you some idea of my overall opinion of how deeply I feel about this matter and why I am so disturbed.

The Russians have established, as a matter of national priority, the design, construction, and operation of a submarine fleet second to none. They have given it priority status in their military establishment.

They make decisions quickly as opposed to how we make decisions. Once these decisions are made, they are implemented rapidly without the huge overhead administrative effort which in the United States delays all projects and greatly increases our leadtime.

There is a new expression for "leadtime" coined by Senator Jackson. He calls it "lag time." I think this may be the better one to use.

To give you some idea of what they are doing:———.

The logical question one must ask is, ———. They were able to build ——— diesel submarines in just one post-World War II year. This fact alone should convince the most skeptical.

The maximum number of nuclear submarines we have built in 1 year is ———, and that was when we had the highest priority on the Polaris submarines. The Soviets have the ability to now build ———. Of course, a nuclear submarine is much more difficult to build than a conventional submarine.

We estimate—the most authoritative ——— people in the United States—that———.

The United States capacity today is about ——— new nuclear submarines per year, due to our facilities being tied up with conversions and repairs. After the Poseidon conversions are completed, we could build ——— nuclear submarines a year.

Mr. Chairman, if I am going into too much detail, please stop me, but I personally think it is good to get the threat and the story out on the line so you will understand it.

Mr. RHODES. This is all in the clear and will be printed in the record?

Admiral RICKOVER. No, the information I am giving you is classified ——— and it will not be issued in public print. That is why it is important, if the members wish to hear it, for me to go ahead.

The Soviet submarine fleet is entirely post-World War II. They do not operate a single old submarine such as comprise a large portion of our submarines. Their submarine force is the main threat to Allied control of the seas.

Their newly announced submarine ballistic missile has a range of 2,300 to 3,000 miles with a 1,500-pound payload, and 1,600 to 2,400 miles with a 2,500-pound payload.———.

They have established mobile submarine task forces where the submarines are repaired from tenders while they are actually underway at sea. This vastly expands their submarine operating capability.

It is estimated that ———.

In contrast to what the Soviets are doing, we have a lack of adequate building and repair capacity in the United States. It takes about ——— years to build a Russian submarine; ——— years to build one in the United States. These are construction periods for comparable submarines. There is also lack of an adequate submarine design capacity in the United States. In fact, it is deteriorating.

The Secretary of Defense was notified by ——— last year as follows: ———.

That is the end of that quote.

Mr. RHODES. May I ask a question? ———.

Admiral RICKOVER. Mr. Rhodes, ———.

Nearly all Soviet submarines are less than ——— years old, while two-thirds of our attack submarines were built during World War II, and so they are about 25 years old.

They have vastly improved operational proficiency even in the case of diesel powered submarines.

For years our naval leaders kept on telling the country that the Soviets were second-rate at sea, both on the surface and underwater. I think everyone here knows the tremendous strides they have been making.

As I previously mentioned when I was asked by one congressional committee, ———.

Mr. MORRIS. That is the terms in which you are speaking of it.

Admiral RICKOVER. Yes, sir.

———. We should be concerned over the situation that will obtain in just a few years.

The Navy and the Joint Chiefs of Staff recommended ——— nuclear submarines be built a year after fiscal 1969. The Department of Defense studies ———.

This is the basis of our decision not to build any more submarines.

SUBMARINE THREAT DURING WORLD WARS I AND II

As you are well aware, we almost lost World Wars I and II because of submarines. In 1917–18, the worst years of the submarine war in World War I, the average number of U-boats at sea was 47. These 47 sank about 1 million tons of shipping per month in the early months of 1917. During this period, only 10 to 15 of the 47 U-boats were stationed around the British Isles. In April 1917, these 15 submarines sank 155 ships totaling more than 500,000 tons.

At one time in April 1917, there were only 4 days of munitions and food remaining in France for the Allied armies. In World War I, the German subs sank 5,700 Allied ships, totaling more than 11 million tons.

Yet, these German submarines could operate only to a depth of 250 feet, they could make only 9 knots submerged for 2 hours, and they could remain at sea for only 30 days.

During World War II, by the end of 1942 the Germans had about 65 submarines at sea at any one time in the Atlantic, with 20 actually

on station off the U.S. east coast. Their average time at sea was 40 days, of which 21 were on station. Yet, in June 1942, these 20 submarines were able to sink 69 ships totaling 365,000 tons in the Western Atlantic.

During World War II the Germans sank 2,759 merchant ships and 66 Allied warships of destroyer escort size or larger, including six aircraft carriers, for a total of more than 14 million tons. Of this number, 130 tankers were sunk in the Atlantic.

That 130 is a very significant figure. Those were small tankers. During World War II we had a large number of tankers, so sinking a tanker at that time did not have anywhere near the significance as if you sink one of those huge monsters we have today which carry so much more fuel and are much easier to sink because of their larger size.

The Department of Defense studies say that gains from having additional submarines is not cost-effective because the number of merchant ships saved would not justify the cost. They say that ———.

Another point to remember is that in World War II, 20 percent of the entire Allied war effort was tied up in antisubmarine warfare. That gives you some concept of the magnitude of the problem with relatively slow submarines that could not stay submerged very long.

We face a strong potential enemy whose capabilities must not be underestimated, and we had better move quickly and, effectively toward achieving improved capabilities in our own submarines.

The Soviets are embarked on a major national program to build nuclear submarines. They are striving for ———.

We must produce whatever it takes to counter the Soviet submarine threat. In my opinion, this means we must continue our attack submarine program at the rate of about ———, which is what the Navy and the Joint Chiefs of Staff recommended, maybe even more if that is what knowledgeable people can prove it takes. I cannot overestimate the importance of this matter. The United States must be willing to ———, or we may be very sorry later on.

As you know, I probably follow the broad outlines of the entire submarine program as much as anyone else. I concluded several years ago that the Russians would improve their submarine capability, and the essence in military affairs is to stay ahead of the other man. Four years ago I started working on a ——— submarine. All of the Department of Defense figures are based on ———.

If they were to use realistic data, it would show that the cost effectiveness analyses are in error. They cannot afford to be realistic because if some people proved that their figures were wrong, others might start questioning why the Department of Defense has all those cost-effectiveness jobs.

As a Congressman, you can readily understand that, Mr. Rhodes.

Mr. RHODES. I understand that. They might also start checking on that F–111.

Admiral RICKOVER. Sir, I am no expert on airplanes.

The Navy approved the ——— submarine, which is ———. The Chief of Naval Operations and the Navy approved it. They went to the Department of Defense, and it was turned down.

The issue here this afternoon is that I have been trying to get money to start procuring the long-leadtime propulsion plant items for this submarine. We have reached the point in the design that every day we delay means a day's delay in launching the ship.

But the Department of Defense continues to make studies. Their first study said the submarine was not ———. The next study said it was ———. There now have been some 19 studies. Another one said it is more important to have a ——— submarine.

We received a copy of a letter just the other day asking for another series of studies. These studies can go on forever. God help us if a war comes, because then all we will be able to do is to throw the studies at the enemy. That is what we are up against.

Therefore, the way it is now, the earliest possible time we can have a ——— submarine, ———, is ——— years from now. If we proceed with these studies, it will be ——— years. That is the stark fact we are facing.

Mr. MORRIS. Just exactly what do you mean by a ——— submarine?

Admiral RICKOVER. ———.

Furthermore, the Senate Armed Services Committee recommended that we be given $16.4 million in fiscal year 1969 for starting a submarine of ———. They not only approved of this ——— submarine, but they authorized me to go ahead and develop ——— one because it takes ——— years of development and ——— years to build. So, on the ——— submarine, if I could get the go-ahead today, I could have one in the water ——— years from now.

I told the Senate committee and I tell your committee that if I were doing it, and I am sure I can build them, I would build two ——— submarines in fiscal year 1969 and ——— next year, and keep on going, ———.

Even the ——— I had to get on my own. When I asked the Department of Defense to build a ——— submarine several years ago, they said, "No, we don't want it." The Navy said, "We want a ——— submarine." So we built a ——— submarine against my recommendation.

Meanwhile, I went ahead on my own with Atomic Energy Commission funds and developed the propulsion plant for the submarine ———.

This is another case where, when you deal with a huge organization, even a huge bureaucracy that manages to keep most of its business secret, it cannot combat even one individual, when he knows what he wants to do and knows how to do it.

Mr. RHODES. Is the ——— a point of controversy?

Admiral RICKOVER. Yes, sir.

Mr. RHODES. ———.

Admiral RICKOVER. In the ——— submarine, I am taking advantage of the latest information that we have ———. The real issue we are facing is that the Soviets are getting ahead of us, and we are not facing that issue. We continue to make studies. As I just mentioned, there is a recent Department of Defense letter asking for more studies.

Mr. MORRIS. Admiral, can you provide a copy of the letter for the record?

Admiral RICKOVER. I will have to find out, sir. It is not my letter.

Mr. MORRIS. We would like you to submit that letter to the committee.

Admiral RICKOVER. All right, I will work it out with Mr. Wilhelm, sir.

Mr. MORRIS. We are officially requesting the letter having to do with studies from the Department of Defense.

(The letter follows:)

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., April 19, 1968.

Memorandum for Assistant Secretary of the Navy (R. & D.).
Subject: Accelerated nuclear submarine R. & D. program.

In reviewing current studies and development programs which address or are applicable to the performance of our nuclear submarines, it appears that we are deficient in certain capabilities and have not taken full advantage of a number of promising developments. Accordingly, I desire that experimental work and studies applicable to submarine concept formulation be accelerated to ensure the United States maintains viable submarine developmental programs that will provide a superior capability against current and projected threats.

I would appreciate being advised of the present status of developmental work in the areas described below and request that you submit a detailed plan to accelerate work in these areas, including developmental steps and funding schedules on a 5-year basis.

(Classified material deleted.)

In requesting submission of a detailed plan to accelerate work in these areas, including developmental steps and funding schedules on a 5-year basis, I am not requesting an exhaustively detailed plan. But, rather, the plan should explain in clear, concise, and logical exposition the means and the funding required to accomplish the objectives of accelerating submarine research, exploratory and advanced development programs in order to lay the groundwork for advanced-classes of nuclear submarines.

I would appreciate receiving your plan prior to June 1, 1968, so that it can be evaluated and acted upon as part of the fiscal year 1969 apportionment action.

JOHN S. FOSTER, Jr.

(The above is the unclassified portion of the three-page letter.)

Admiral RICKOVER. Would the committee like to discuss the specific sums of money needed for this project?

Mr. MORRIS. The committee would like to hear about that.

REPROGRAMING FOR NEW DESIGN NUCLEAR PROPULSION PLANT

Admiral RICKOVER. The first issue is the AEC request to reprogram $3 million of fiscal year 1968 funds. These funds are needed to accelerate the AEC portion of the research and development work for this submarine propulsion plant. Before the reprograming can take place, your committee must approve the request. Perhaps you have some questions on this issue?

Mr. MORRIS. This is fiscal year 1968 money and separate from the action taken by the Joint Committee on Atomic Energy to authorize an $8.5 million increase in fiscal year 1969. Is that correct?

Admiral RICKOVER. That is correct.

USE OF FUNDS AUTHORIZED BY JOINT COMMITTEE

Mr. MORRIS. Would you please outline for the committee how the funds authorized by the Joint Committee on Atomic Energy would be utilized.

Admiral RICKOVER. The action taken by the Joint Committee on Atomic Energy authorized the funding of the long-leadtime components for the propulsion plant of the first of these new design ——— submarines. The total cost of the long-leadtime components is $26.5 million. Of this $26.5 million, $8.5 million would be required for actual expenditures in fiscal year 1969. We would need to place contracts for the full $26.5 million of which we expect to cost $8.5 million in fiscal year 1969.

Mr. MORRIS. Could you furnish the committee with your schedule of funding the total $26.5 million?

Admiral RICKOVER. Yes, sir; I can do that.

(The information follows:)

The total estimated cost of $26.5 million provides for the design, development, and procurement of all the long-leadtime nuclear propulsion plant components. AEC laboratory research support work is funded separately. Costs will be incurred for these long-lead components as follows:

Fiscal year:	*Millions*
1969	$8.5
1970	9.2
1971	8.0
1972	.8
Total	26.5

Mr. ABBADESSA. It might be helpful to put in the record here, Mr. Chairman, two paragraphs from the Joint Committee's report where they discuss the $8.5 million and the $26.5 million.

Mr. MORRIS. Without objection, this will be made part of the record at this point.

(The information follows:)

The additional authority recommended by the committee for design and development of an advanced nuclear propulsion plant for a new class of higher performance attack submarines will provide the initial funding necessary for the research, development, design, fabrication and testing of the nuclear propulsion plant components, design a full scale propulsion plant mockup and the necessary plant systems and arrangements work to insure suitability for shipboard installation. It is estimated that nuclear propulsion system components for this application will cost about $26.5 million over a 3- to 4-year period, and it is the committee's intent that this work proceed as rapidly as possible.

For fiscal year 1969, $8.5 million is authorized to proceed with this program. The $8.5 million of the $26.5 million is estimated to be expended in fiscal year 1969, and, additionally, commitments will be incurred in fiscal year 1969 which would represent allowable costs in fiscal year 1970 if the project were discontinued in the unlikely event that future funding for this project were not available. Accordingly, the committee is authorizing $8.5 million for appropriation in fiscal year 1969, and is further authorizing commitments in fiscal year 1969 that may constitute costs reimbursable in fiscal year 1970 should the project be discontinued, the latter costs to be defrayed from any appropriation available or made available to the Commission for operating expenses. The committee notes that the foregoing authorizations are in addition to the research and development support for this project provided under the overall naval propulsion reactors program.

Mr. ABBADESSA. The Joint Committee has also cleared the $3 million reprograming action.

Mr. MORRIS. Without objection, we will also put in the record a letter of February 19 to Chairman Seaborg from Mr. Conway, the executive director of the Joint Committee on Atomic Energy, concerning this.

(The letter follows:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., February 19, 1968.

Hon. GLENN T. SEABORG,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. SEABORG: In furtherance of the Joint Committee's review of the Atomic Energy Commission's fiscal year 1969 authorization bills (H.R. 14905, S. 2880), the committee held an executive hearing on February 8 to examine the current status and future plans of the Naval Reactor Division. Commissioners James T. Ramey and Gerald F. Tape were present, along with Mr. Robert E. Hollingsworth, the General Manager, and Vice Adm. H. G. Rickover.

During the hearing the acting chairman, Congressman Chet Holifield, and other members of the committee expressed their concern over the failure of the Department of the Navy and the Defense Department to effectively and expeditiously exploit the developments of the Commission's naval reactor program. Of immediate concern to the Committee members was the failure of the Defense Department and the Department of the Navy to design and build advanced performance attack submarines, notwithstanding the fact that the Commission has developed the basic naval reactor technology needed to permit taking this step. As you know, the Joint Committee has had access to sensitive intelligence information which highlights the need for the United States to develop and construct as quickly as possible faster submarines and antisubmarine warfare nuclear surface ships.

In previous discussions with representatives of the AEC, Congressman Chet Holifield and other members of the committee have suggested that the AEC assume responsibility for the funding of the first of a kind, new fast attack submarine reactor propulsion plant. As you will recall, there is precedent for this action. Back in the 1950's, when the Department of the Navy was reluctant to support the nuclear submarine program, AEC funds were used to pay for the first four nuclear powerplants. Two land-based submarine prototypes were built by the AEC and are still being used today to train Navy officers and enlisted men. In addition, the nuclear propulsion plant, for the first two nuclear submarines—the *Nautilus* and the *Seawolf*—were funded by the AEC.

During the hearing on February 8, the Joint Committee unanimously agreed that the fiscal year 1969 AEC authorization bill should have sufficient funds allocated to the construction of a new fast attack submarine nuclear propulsion plant. I have been directed by the committee to confer with the AEC's General Manager and Controller in an effort to work out the details of how this may be accomplished within the existing administration's recommended budget.

In view of the urgency to proceed with this project as soon as possible, the Joint Committee is of the opinion that it should not be delayed pending the passage of the fiscal year 1969 authorization and appropriations bills. The Joint Committee is of the opinion that the project should not wait until fiscal year 1969 but should commence as soon as possible. Accordingly, the Commission is requested to review its current fiscal year 1968 budget and determine if sufficient money is available to be reprogramed with the objective of commencing construction of this project immediately.

Acting Chairman Chet Holifield is in California this week but he will be available next week when he returns to discuss this matter personally with you.

Sincerely yours,

JOHN T. CONWAY,
Executive Director.

Admiral RICKOVER. At this point, Mr. Chairman, it may be useful to put in the record a description of the ——— submarines. I provided this information in a letter to the Joint Committee on Atomic Energy and to the Senate Preparedness Investigating Subcommittee at their request.

Mr. MORRIS. Without objection, it will be placed in the record.

(The material follows:)

——— SUBMARINE

The new design submarine proposed by the Navy for $26.5 million long-lead funding in fiscal year 1969 ($22.5 million SCN plus $4 million R.D.T. & E.(N)) and to be fully authorized in fiscal year 1970 is a ——— nuclear-powered attack submarine ———.

Efforts are presently underway by a Board appointed by the Chief of Naval Operations to determine ———. Results of this review may ———. However, any recommendation of this Board ——— can be incorporated in the present design without delaying the submarine.

In summary, the primary objective used in designing the ——— submarine is to obtain ——— using engineering developments and shipbuilding capabilities currently available so that we can take immediate action to maintain our lead over the Soviets in this vital area.

ADVANCED DESIGN ——— SUBMARINE

The development of a new higher performance nuclear-powered submarine is intended to provide a submarine in the late 1970's ———.

This submarine and its propulsion plant is, of course, not yet designed and its characteristics are not determined. The $16.4 million requested for this effort is required to initiate design studies and development of an advanced nuclear propulsion plant for this submarine.

FUNDING RESPONSIBILITY

Mr. MORRIS. Admiral, the question frequently comes up when we get into the division of responsibilities of the various agencies—and it has come up now—why shouldn't the nuclear propulsion plant components be budgeted for in the Department of Defense budget?

Admiral RICKOVER. The nuclear propulsion plant components for this development could be included in either the AEC or Department of Defense budget. Historically, the Department of Defense has been against nuclear power. The Department of Defense was against the *Nautilus*. In order to get the first two nuclear submarines going, it was the Joint Committee, this committee, and the Atomic Energy Commission that got the appropriations and paid for the propulsion plants.

I hope this answers your question.

Mr. Chairman, today you could not get the Department of Defense to authorize *Nautilus*. You could never get anything like that done again.

Mr. MORRIS. Why? Because of cost-effectiveness studies?

COST-EFFECTIVENESS STUDIES

Admiral RICKOVER. Yes, sir; cost-effectiveness studies. They are nothing but excuses for procrastination—putting off decisions.

Back in 1948 when this problem was considered, they turned it over to their cost-effectiveness people then, and they proved that an atomic submarine would cost twice what a conventional submarine cost, and calculated that it was only 1.41 times as effective. Here, clearly, is an example of a complete failure of imagination. They just could not

figure out the military effectiveness increase that unlimited high speed submerged endurance means in submarine warfare. Since the Navy was only getting one conventional submarine a year, they would get only two every 3 years and, therefore, it was not worthwhile. That was the basis on which they were against the atomic submarine.

We are very fortunate that we have some other agency, such as the Atomic Energy Commission, backed by the Joint Committee and by your committee, that understands these things, or we would be in one fix.

As far as Congress is concerned, the money comes out of the Treasury, out of one pocket. The people have to pay for it one way or the other. Today the nuclear submarine is the best weapon we have against the Soviet submarine threat. Congress deserves a little credit for this, too. Congress had the imagination to understand the value of better submarines.

REPROGRAMING FOR NEW DESIGN NUCLEAR PROPULSION PLANT

Mr. DAVIS. Mr. Chairman, I am still not clear how the $3 million relates to the $8.5 million. The $3 million is a current year reprograming. Where is the money being reprogramed from?

Mr. MORRIS. The $3 million is a reprograming, and it is coming from R. & D. funds in the AEC appropriation for fiscal 1968. The Commission has furnished written information on the reprograming action.

The Joint Committee on Atomic Energy put in the authorization bill authority for this committee to appropriate an additional $8.5 million for this program in 1969. This is outside the budget.

Mr. DAVIS. Do we have justification material on that?

Mr. MORRIS. There is no written justification on the $8.5 million beyond that provided in the Joint Committee's report which is based on testimony received during the authorization hearings.

Mr. RHODES. The $8.5 million, as I understand, is for long-leadtime items.

Admiral RICKOVER. Yes, sir, the long-leadtime components are controlling in the development and construction of this ship. These are the items that take the longest time to manufacture.

Mr. ABBADESSA. The $3 million is the R. & D. We would normally do that activity. This would be done by reprograming from current year's available funds. As a matter of fact, we have the $3 million in hand, and we are just waiting on congressional clearance. We have it from the Joint Committee, and we need it from this committee.

Admiral RICKOVER. I might amplify that. The $3 million would go for the research and development in fiscal year 1968. We requested a total of $115.3 million for the naval reactors program in our 1969 budget. We plan to use about $4.5 million of that money, the $115.3, for the R. & D. work on the high-speed submarine.

The $8.5 million is for long lead components for the nuclear propulsion plant for the ship.

Mr. MORRIS. It is the actual start of the propulsion plant for this ——— submarine.

Mr. RHODES. Will the $3 million complete the R. & D. phase?

Admiral RICKOVER. No, sir. There are additional AEC R. & D. funds required in later fiscal years. These funds are required for the design and verification of the reactor plant portion of the submarine. We will use $4.5 million of the $115.3 million in the fiscal year 1969 AEC budget for this purpose.

Mr. MORRIS. Within the $115.3 million?

Admiral RICKOVER. Yes, sir. A breakdown of the Atomic Energy Commission R. & D. funds required is included in the reprograming request. We provided you an estimate of the AEC R. & D. funds required each year through fiscal year 1973. It totaled $29.9 million.

The Navy is providing R. & D. funds for its portion of the work. In addition to the reactor plant work, which is funded partly by the AEC and partly by the Navy, we have to ———. The Navy has reprogramed $4 million in fiscal year 1968 research and development funds for this purpose.

Mr. RHODES. There is nothing unusual about this division of funds?

Admiral RICKOVER. No, sir. This is a normal division of responsibility between Navy and Atomic Energy Commission work.

Mr. MORRIS. Without objection, this letter from Dr. John Foster, Director of Defense Research and Engineering, approving the reprograming of the $4 million, will be made a part of the record, as much of it as can be made a part of the record.

(The material follows:)

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., April 8, 1968.

MEMORANDUM FOR THE SECRETARY OF THE NAVY

Subject: Program approval of Navy fiscal year 1968 R.D.T. & E. program element reactor propulsion plants.

Reference: (*a*) ASN (R. & D.) memo to D.D.R. & E., subject: Reprograming funds, dated March 15, 1968.

The following program approval action is taken, subject to the availability of funds:

[In thousands of dollars]

Program element No.	Title	Previously programed	Programed	Program previously approved	Program approved by this action	Total program approved
6.42.06.36.N	———	12,222	8,222	0	0	0
6.32.03.21.N	Reactor propulsion plants	12,500	16,500	12,500	4,000	16,500

Based on reference (*a*) program approval is granted for the execution of the above program elements in the amounts as indicated. This approval provides for a $4 million program adjustment from element 6.42.06.36.N to 6.32.03.21.N and will allow the necessary design, development, and component testing of the ——— plant to proceed without a commitment to production hardware until the results of Navy studies are reviewed in June 1968.

This action has been coordinated with the ASD (Comptroller) as to availability of fund resources and for amendment of listings of programs approved for financing, subject to appropriate reprograming procedures.

JOHN S. FOSTER, Jr.

(Classified material deleted from above letter.)

Mr. MORRIS. In reality, if I understand it, the committees of Congress are being asked to take the same course on this fast submarine that they took on the development of the *Nautilus* and *Seawolf*. They were funded essentially from funds outside the normal channels of the Department of Defense to get them started, but after they were underway, it was a great thing.

(Off the record.)

Mr. MORRIS. There are a few other questions which we will submit in writing, Admiral. Mr. Wilhelm will get together with your staff for that purpose.

(The material follows:)

ANSWERS TO SUPPLEMENTAL QUESTIONS ASKED BY THE HOUSE APPROPRIATIONS COMMITTEE ON THE NAVAL PROGRAM FISCAL YEAR 1969 AEC BUDGET

SUBMARINE ADVANCED REACTOR

Question. A total of $13,520,000 is budgeted for the submarine advanced reactor, an increase of $3,080,000. How will this increase be utilized, and why is it essential in fiscal year 1969?

Answer. About $2 million of the fiscal year 1969 increase in the submarine advanced reactor project is required for ———. This core, when completed, will be installed in the modifications and additions to reactor facilities, West Milton construction project, which was authorized for construction in fiscal year 1967. It is important that development work in this project proceed ———.

About $1 million of the increase is due to an increase in irradiation unit charges allocated to this project, primarily as a result of costs for the first full year of operation of the advanced test reactor (ATR) at NRTS, Idaho.

NEW DESIGN NUCLEAR PROPULSION PLANT

Question. Please outline for the committee the nature and need for the spending or reprograming of $3 million in the current year to expedite work on the new design nuclear propulsion plant for the attack submarine.

Answer. As described in the fiscal year 1968 and fiscal year 1969 congressional budgets, naval reactors has been carrying out development work on ——— work has reached a level that it is now appropriate to proceed ——— to a specific submarine plant; and in view of the rapidly expanding and improving Soviet nuclear submarine capability, it is of utmost importance that this work be carried out on an accelerated basis. The $3.0 million reprograming action has been requested to accelerate this work since the ——— reactor plant is the pacing item for the ——— ship.

Question. The Joint Committee in the authorization bill authorized an unbudgeted increase of $8.5 million in 1969 to proceed with this program. Please outline how these funds would be utilized in 1969.

Answer. The $8.5 million increase will provide the initial funding necessary for the design, development, and procurement of the long-lead-time nuclear propulsion plant components needed for ——— an attack submarine.

TOTAL COST

Question. The total cost of the project is estimated at $26.5 million. But just what does this cost cover, and what is the time schedule for funding?

Answer. The total estimated cost of $26.5 million provides for the design, development, and procurement of all the long-lead-time nuclear propulsion plant components. AEC laboratory research support work is funded separately. Costs will be incurred for these long-lead components as follows:

Fiscal year:	*Millions*
1969	$8.5
1970	9.2
1971	8.0
1972	0.8
Total	26.5

BUDGETING OF COMPONENTS

Question. Why shouldn't the nuclear propulsion plant components be budgeted for in the Department of Defense budget?

Answer. The nuclear propulsion plant components for this development could be included in either the AEC or the Department of Defense budget. In authorizing the $8.5 million increase for this purpose and as a result of hearings held on the status of U.S. and Soviet submarine programs, the joint committee's report states:

"In the committee's opinion, the current situation is not unlike that which prevailed in the early 1950's when, in the face of the Defense Department's unwillingness to provide adequate support to a nuclear submarine research program, the Congress intervened and authorized the necessary facilities and funds for this purpose. Subsequently, when the Navy refused to seek the funds necessary to build a nuclear submarine, Congress stepped in again and voted funds for the nuclear powerplants for the first two nuclear submarines, the *Nautilus* and the *Seawolf*. Because of the Navy's reluctance, the money was appropriated to the AEC where it was used to build the powerplants that were then turned over to the Navy Department * * * . Again, the Congress finds itself in the position of having to prod the Department of Defense to take actions, the need for which is manifest."

Question. Why wasn't this special project reflected in the present budget request?

Answer. The Navy, in its fiscal year 1969 budget submission to the Department of Defense, requested $26.5 million for the procurement of long-lead nuclear propulsion plant components for the ——— nuclear attack submarine. These funds were not included by the Department of Defense in its budget submission to Congress. The Joint Committee considered that proceeding with this work is important enough to justify its inclusion as an AEC project; the committee report states,

"The committee is also disturbed that the Department of Defense has not proceeded with the engineering development of higher performance nuclear attack submarines. In view of the rapidly expanding and improving Soviet nuclear submarine capability, the committee considers most questionable the Defense Department's plan to limit future construction to only four more nuclear submarines (two for fiscal year 1969 and two for fiscal year 1970) and then to terminate the nuclear submarine building program. As noted above, the committee recommends the addition of $8,500,000 to AEC's request to expedite work on the new design nuclear propulsion plant for the attack submarine, the details of which are set forth in a classified letter to the Joint Committee dated March 20, 1968, from Admiral Rickover. The committee considers this matter to be of utmost importance, since testimony taken in executive session indicates that the Nation's superiority in the vital field of nuclear submarines is being threatened."

DESTROYER TYPE DUAL REACTOR

Question. The budget estimate includes $19,200,000 to continue work on the destroyer type dual reactor, an increase of $3,110,000. What is the status of this project, and why is the large increase proposed essential in fiscal year 1969?

Answer. About $1.5 million of the fiscal year 1969 increase in the destroyer type dual reactor is for ———. The development of this core by the Bettis Atomic Power Laboratory is proceeding on a schedule for testing in the D1G land prototype at the K. A. Kesselring site, West Milton, N.Y.

In addition, $1.6 million of the increase is due to an increase in irradiation unit charges allocated to this project, primarily as a result of costs for the first full year of operation of the advanced test reactor (ATR) at NRTS, Idaho.

LIGHT WATER BREEDER REACTOR

Question. We will insert pages RD–16 and 17 covering the budgeted request of $15,500,000 for continued research and development on the light water breeder reactor. The Joint Committee in the authorization bill made a reduction of $2 million in this request. Please outline the status of the work on this seed blanket reactor concept and tell us the revised plans for fiscal year 1969 in the light of the authorization allowance.

Answer. Development work in the LWBR program has now progressed to the point where the next logical step is to proceed with fabrication of a breeding

demonstration core. The fiscal year 1969 request includes the initial funds necessary to proceed with this work. Present plans call for completing fabrication of the core by fiscal year 1973, followed by an approximately 3-year breeding demonstration in the Shippingport reactor plant. The $2 million reduction in fiscal year 1969 will result in delay of some important research and testing work. The LWBR program can be continued at the lower budget figure by deferring some of the supporting physics, reactor engineering, and fuel element development effort until later years, with the risk that identifying some potential technical problem areas would be delayed. It will be more expensive in the long run to correct any such problems that might come up, than it would be if they were found earlier.

The LWBR program is the only known approach for increasing the fuel utilization of light water thermal reactors significantly beyond the 1 to 2 percent achievable with present types of light water reactors. Successful demonstration of breeding in light water reactors would provide the basic technology which could make available for power production about 50 percent of the energy in the thorium reserves, a source of energy many times greater than known fossile fuel reserves. Since this concept is based on the proved technology of the pressurized light water system, it is devoid of many of the technical problems that must be solved to obtain high fuel utilization using other systems.

Mr. MORRIS. Are there further questions?

Mr. DAVIS. I think I get the relationship between those two figures now, which I did not have before.

Mr. RHODES. No questions.

Mr. DAVIS. No questions.

Admiral RICKOVER. I would be very happy, either here or at another time, to answer your question.

Mr. DAVIS. I think I get it.

Admiral RICKOVER. May I proceed with the next phase of my testimony? Is the committee finished with the submarine part?

Mr. MORRIS. Yes.

DISCUSSION OF NUCLEAR GUIDED-MISSILE ESCORT ISSUE

Admiral RICKOVER. In response to your opening statement, Mr. Chairman, I'll briefly summarize the status of the nuclear guided-missile escort issue.

The Navy has concluded that each nuclear-powered aircraft carrier should be accompanied by four nuclear-powered guided-missile escorts. The Department of Defense has accepted the need for nuclear escorts for two nuclear carriers, and has agreed that the Navy should solicit options for nuclear escorts for the planned third and fourth nuclear carriers.

Thus far, the nuclear carrier *Enterprise* (CVAN65) and three nuclear escorts, the cruiser *Long Beach* (CGN9) and the frigates *Bainbridge* (DLGN25) and *Truxtun* (DLGN35), are in the fleet. Usually the *Long Beach* is not available to escort the *Enterprise*. ———.

The Navy expects to award a contract soon for the fourth nuclear escort, the nuclear-powered guided-missile frigate DLGN36, which Congress originally added to the fiscal year 1966 program and then reauthorized for the fiscal year 1967 program. The DLGN36 will join the fleet in 1972. Thus the *Enterprise*, will have been serving in the fleet 11 years before she has four nuclear escorts—assuming the *Long Beach*, which is seldom available to operate with the *Enterprise* because of her other important missions, can be counted as one of these four.

The second nuclear carrier, *Nimitz*, CVAN68, which was authorized for the fiscal year 1967 program, is also expected to be delivered in 1972. Under current plans the Department of Defense will complete the first nuclear escort for the *Nimitz* in 1973; this is the DLGN37 which Congress substituted for a conventional guided-missile destroyer requested by the Department of Defense for the fiscal year 1968 program. The President informed the Secretary of Defense on March 29, 1968, of his decision to proceed with the DLGN37; however, the funds for this ship have not yet been released to the Navy. The DOD does not plan to build the DLGN38 authorized by Congress for fiscal year 1968, which could also be completed in 1973.

The DLGN37 has already been held up 22 months because the Department of Defense has not released funds appropriated for procurement of long leadtime items for this ship in fiscal year 1967. Even so, the Navy expects that if this ship is released for construction now it can be delivered to the fleet in 1973, within a year after completion of the *Nimitz*.

In addition to DLGN36 and DLGN37 the President has agreed to build four nuclear-powered guided-missile destroyers of a new class yet to be designed, called DXGN's, in order to attain two all-nuclear carrier task groups. The DOD plans to include two DXGN's in the fiscal year 1970 program and two in the fiscal year 1971 program.

Both the DLGN and the DXGN use the same type nuclear propulsion plant. The principal differences between the two ships are that the DLGN has two anti-air warfare (AAW) missile systems and two 5-inch guns; whereas, there is only one of each specified in the conceptual design of the DXGN proposed by the Department of Defense.

The DLGN36 and DLGN37 are already designed, and the Navy has received bids. The Chief of Naval Operations has stated it will be 2 years before a procurement contract can be placed for DXGN's.

Even if we build the DLGN36 and DLGN37 and follow these with ships of the DXGN class as now planned, it will be 1976 before we have four nuclear escorts for the *Nimitiz*, which will then have been in operation for 4 years. By this time the third nuclear carrier, the CVAN69, for which $50.5 million was appropriated in fiscal year 1968 and $82.4 million is included in the Department of Defense fiscal year 1969 budget request, will also have been delivered with no nuclear escorts available for her. The fourth nuclear carrier, the CVAN70, will join the fleet in 1976 with no nuclear escorts available for her either, according to present Department of Defense plans. In this regard, the foreword dated February 21, 1968, to the Joint Committee hearing record on the "Naval Nuclear Propulsion Program 1967–68" stated:

"The Joint Committee recommends that the Congress do everything within its power to see that the DLGN–37 and the DLGN–38 are built as soon as possible. Even if this is done, the nuclear-powered carrier *Enterprise* will have been in operation more than 10 years and the second nuclear carrier *Nimitz* will have been in operation several years before they have a full complement of nuclear escorts.

"The fiscal year 1969 budget provides for starting a large new construction program for destroyers. The Department of Defense now proposes to request authorization over the next 5 years for about five dozen conventional destroyers of the DX and DXG types, and only five nuclear-powered destroyers, despite repeated urging by Congress to build more nuclear surface warships.

"The Secretary of Defense says the Department of Defense has decided to build five more nuclear escorts so as to provide two all-nuclear carrier task groups. However, he has not presented to Congress the reasoning behind the position of the Department of Defense that it does not plan to build any nuclear escorts for the planned third and fourth nuclear carriers, or for the many other uses for which nuclear escorts have advantages.

"The fiscal year 1969 Department of Defense budget includes $20 million under the research, development, and test category for the contract definition of conventional DXG's, despite the prohibition in the House-Senate Armed Services Committee Conference Report No. 270 of May 22, 1967, on the fiscal year 1968 defense authorization bill that the funds authorized for fiscal year 1968 for contract definition of ships of the DX and DXG types: 'could be used to study nuclear and conventional power for the DX class of ships but that this authorization may be used only to study nuclear power for the DXG class of ships.'

"The Joint Committee again recommends that the Congress take the action necessary to insure that all new guided-missile escorts for our naval striking forces are nuclear powered. . . .

"The subject of nuclear propulsion for major surface warships has been studied and debated for many years. It is repeatedly commented how 'complicated' this issue is. The Joint Committee considers the issue of nuclear-powered surface warships is not complicated. The Congress, through its numerous committee reports, has stated it believes it has all the information needed to properly decide to provide the U.S. Navy with nuclear-powered guided-missile ships—without requiring further studies from the Defense Department. "It was Congress that had to take the initiative to provide nuclear propulsion in submarines, it was Congress that had to take the initiative to provide nuclear propulsion for aircraft carriers, and it is Congress that must take the initiative to provide nuclear propulsion in the Navy's new surface guided-missile ships."

The Joint Committee Report No. 1074 of April 3, 1968 on the fiscal year 1969 AEC authorization bill stated:

"* * * the committee continues to be distressed by the pace at which the Department of Defense is utilizing the Nation's nuclear propulsion plant technology for building nuclear-powered surface warships. The evidence is in. It clearly demonstrates that the Defense Department has failed to take anywhere near optimum advantage of the tremendous potential of this revolutionary development in naval warfare. The Defense Department's reluctant, half-hearted, and piecemeal approach to a nuclear navy has forced the Congress in the past 2 fiscal years to add three nuclear-propelled surface ships to the Department's authorization legislation. Now, after an 18-month delay, work has finally been started on one such ship. It is hoped that appropriate action by the concerned committees of Congress during this session will succeed in overcoming this procrastination and spur more rapid action toward the construction of a first-line nuclear surface warship fleet."

Senate Armed Services Committee Report No. 1087 of April 10, 1968, on the fiscal year 1969 defense authorization bill stated:

"DXGN OR DLGN

"The Department of Defense request for authorization for the construction and conversion of naval vessels includes $52 million for long leadtime components for two nuclear-powered guided missile escort ships designated DXGN intended to be funded in fiscal year 1970. This authorization request antedated the decision to proceed with the construction of one of the two DLGN's in the fiscal year 1968 construction authorization. The DLGN is a larger ship than the DXGN and has two surface-to-air missile systems instead of one. The cost estimates on the DXGN are indefinite at the moment, but from the information now available it appears that the DLGN will cost $20 to $30 million more than the DXGN. Considering the difference in the antiair capability of the two ships, the committee believes that the decision to procure DXGN's instead of more DLGN's should be reviewed. Consequently, the committee has amended the bill to provide that the $52 million in authorization is available only for components that would be used in either a DLGN or a DXGN."

94-075 O—68—pt. 3——13

It is essential that adequate air and submarine defense be provided for our carrier striking forces. This is particularly so for our new nuclear carriers. Since they are the most modern and the best we have, they will be expected to carry out the most difficult assignments and will thus need the best possible protection. The rapidly improving and expanding Soviet nuclear submarine fleet makes the need for additional nuclear powered escorts for attack carriers especially urgent.

Mr. MORRIS. We would also like you to mention the light water breeder reactor briefly.

DISCUSSION OF LIGHT WATER BREEDER REACTOR

Admiral RICKOVER. Yes, sir. As this committee is well aware, the primary program that the Atomic Energy Commission has for breeders, which they see as an essential part of atomic power, is the sodium-cooled reactor, called the fast breeder.

There is another effort underway in the Atomic Energy Commission for which I am responsible, which is the light water breeder reactor, called LWBR. This breeder will use thorium, and it is expected that the LWBR technology will make available for power production about 50 percent of the energy potentially available from thorium.

We have been working on this for several years. We are now at the point where we must order the core. It is planned to place this breeder core into the Shippingport reactor, which was the first central station nuclear power plant built in the United States. It was designed, developed, built, and is operated under the technical direction of the naval reactors program for the Commission.

This breeder has the advantage that it can breed with light water, which is the same basic system being used in practically all the power reactors in the United States. There are two kinds of light water reactors being built in the United States today, pressurized water reactors and boiling water reactors. The LWBR, as presently designed, is a pressurized water reactor.

It would be capable of being installed in the same pressure vessels that utilities using pressurized water reactors are building now—it does not require a new or different plant.

The LWBR will open the possibility of increasing about 25 times the energy one can get out of fissionable material now.

With present types of light water reactors the utilities are building—either boiling or pressurized water—you only get about 1 or 2 percent of the energy potentially available from the uranium mined. With the light water breeder concept we expect to get up to 50 percent utilization of the energy potentially available from the mined ore, in this case thorium, or 25 times as much fuel utilization.

We expect to put this breeding demonstration core into the Shippingport reactor. It will be ready to go into Shippingport in fiscal year 1973. There will be an operating period of about 3 years. At that time we will determine whether breeding was achieved, and this will determine to a large extent what the future of this concept is. In the long term, this concept may be the most practical way of obtaining the energy potentially available from nuclear fuel, which is needed to insure a source of electrical power for future generations. This concept is devoid of many of the tough technical problems that face the people working on the fast breeders.

Mr. RHODES. What is light water?

Admiral RICKOVER. It is ordinary water.

Mr. RHODES. Drinking water?

Admiral RICKOVER. Yes, sir; H_2O.

Mr. RHODES. You do not have to pick out the light atoms. It is just the way they appear in nature.

Admiral RICKOVER. That is correct, sir, we call it "light water" to distinguish it from "heavy water." In the LWBR, we use the same coolant and basic technology used in existing reactors. But in the fast breeders you use sodium and a great deal of expensive new technology. It will take a long time and a great deal of development work to make the fast breeders practical for widespread use. They have many tough technical problems to solve. I believe the work on developing fast breeders must proceed; the payoff if it is successful is worth a substantial investment. But, some of these tough technical problems may prove insurmountable and then the LWBR technology will be invaluable. That is, of course, the reason the Joint Committee on Atomic Energy, the Atomic Energy Commission, and the Bureau of the Budget continue to support going ahead with the light water breeder demonstration.

Mr. MORRIS. Admiral, the committee wants to thank you for a very excellent statement.

Admiral RICKOVER. Thank you very much. I appreciate very much your courtesy.

SPACE NUCLEAR SYSTEMS PROGRAM

Mr. MORRIS. The committee will next hear from Mr. Klein, the Director of the Division of Space Nuclear Systems.

Mr. Klein, is this still a joint office of AEC and NASA?

Mr. KLEIN. The Space Nuclear Propulsion Office (SNPO) portion of the Division is still a joint office, just as it has been in the past.

Mr. MORRIS. You may proceed.

Mr. KLEIN. Mr. Chairman, I appreciate the opportunity to discuss with you the AEC space nuclear systems program.

As is true in other areas, the AEC has the job of assuring that the benefits of nuclear energy are available to the Nation's space activities. In doing so, the AEC works very closely with the Department of Defense and the National Aeronautics and Space Administration.

During the past year, good progress was made in a variety of areas, while at the same time we encountered the technical problems which are characteristic of advanced technology.

In addition, the severe fiscal constraints facing the Nation required a careful assessment of these efforts to make sure that within these limits we preserved the country's capability to meet essential civilian and military space program needs.

The budget before you, then, represents, as you can see, major reductions, and includes only those efforts which are believed essential to meet these needs.

NUCLEAR ROCKET PROGRAM

First, I would like to comment on the nuclear rocket program. In that program the major effort is Nerva, which consists of a technology phase and a flight engine development phase. The technology phase

is the work we have been engaged in for some years, and has had as its purpose the accumulation of data and experience on which to base the flight engine program. The major remaining work to be done in that phase is the testing of two experimental engines, which should be taking place over the next 12 or 15 months. This phase has paved the way for the flight engine development phase.

Some of the scientists and engineers who designed the experimental engine have moved into the design of the flight system as their work on the experimental engine has passed its peak. Similarly, the test engineers will move into testing the flight engine components and systems as their work on the experimental engine is completed.

ADVANCED REACTOR TECHNOLOGY

Apart from Nerva, the space propulsion program includes advanced reactor technology—that is, work to advance the capability beyond the initial Nerva performance objectives—and this work can be fed right into Nerva as it is achieved.

The past year has been an active one, and I will refer briefly to what we have done with the money you appropriated in the past year. Good progress was made. There have been four active test programs since the beginning of last year. One was the Phoebus IB tests conducted by Los Alamos early last year which for the first time tested a reactor at a higher power density than the already high power density that previously had been achieved. With a reactor which had been operated at about 1,100 megawatts this operated up to 1,500 megawatts, in the same size system.

Later on in the summer we tested the cold flow version of the Phoebus II which is a larger reactor in physical size—the one which was aimed at the Nerva II which is no longer in the program. However, the Phoebus power test which will be coming up is still useful; we have the hardware on hand and it will provide information on high density operation applicable to the smaller engine.

Mr. MORRIS. At this point will you explain for the record the decision on the Nerva I?

DISCUSSION OF NERVA I

Mr. KLEIN. Yes, sir. As you know, last year we discussed with this committee proceeding with the development of an engine of about 200,000 pounds of thrust. This would have entailed a larger system using the same technology but a scaleup of the hardware which we had been working on. In view of the budget situation which arose after our last discussions on this, particularly as it affected the space program budget, that choice of thrust level was reconsidered. There were two factors which were important in this. First, the 200,000-pound-thrust system had been selected out of extensive studies which showed that the 200,000-pound thrust was a level which would provide a capability for doing all of the missions that we could foresee in the use of nuclear rockets. This included a manned planetary landing mission.

We had found that the thrust level in the range of 60–70,000 pounds on up to 200,000 pounds or more had relatively little effect on per-

formance for missions short of the manned planetary mission. However, for the manned planetary mission one had to get to a higher thrust. The 200,000-pound-thrust decision was made in an attempt to have a single system do all of these things.

The budget situation indicated very clearly, first, that the manned planetary landing mission was of no priority so that it was appropriate not to give that particular mission very much weight in making an engine-thrust decision.

Secondly, since the hardware that we had been working on in the technology phase was of the size that would give a thrust of approximately 75,000 pounds, the cost of proceeding on that basis, particularly in the current and near future time period, was substantially reduced. We didn't have to proceed with new test facilities, for example. We can use facilities, with some modification, which we had in existence.

I have a chart (fig. 1) which shows the relative size of these systems, which might be useful.

The chart shows three configurations. To the left is the ground experimental engine. This is the size system we have been working on in the technology phase. The reactor can be seen in the center of the engine.

The 75,000-pound thrust system shown in the center of the chart uses the same size reactor and uses other components of essentially the same size as the experimental engine. There is a nozzle skirt which has to be added for flight use. We did not employ such a skirt, nor certain other components, in the ground experimental engine for testing simplicity and to save cost in that phase.

On the other hand, if you look to the right side of the chart at the 200,000-pound thrust system you can see that it is a significant scale up in all respects. That in an over-simplified way indicates why it is substantially less expensive in the near term to proceed with the hardware class we now have.

To summarize, the thrust level decision was reexamined and we came to this conclusion for these two budgetary factors—one, manned planetary landing mission is put off indefinitely; secondly, there is an economic saving in proceeding in these years with the smaller system.

COST OF NERVA I

Mr. MORRIS. We had a cost estimate of approximately $1.5 billion for the 200,000-pound thrust as I recall. What is the approximate cost of the Nerva I as we speak of it now, the 75,000-pound thrust? I realize these are estimates.

Mr. KLEIN. Our estimate for the 75,000-pound thrust system is about $1.1 billion. Of that amount—and this is for both NASA and AEC—approximately $600 million is for the engine development and about a half billion dollars for stage development. That is over a period of 10 years or so.

Another feature of this is that the cost, as you can before you, is down from what it was in preceding years. We do not expect the costs to have to rise on an annual basis very much from the level that is before you now.

EFFECT OF NASA AUTHORIZATION REDUCTION ON ROVER PROGRAM

Mr. MORRIS. The authorization bill for NASA, which has been reported by the House Legislative Committee, provides for a drastic reduction in the NASA participation in the Rover program.

Please outline for the record the nature of this authorization action and the effect it would have on the AEC request should this be the final version of the bill. I am personally hoping that will not be the final version.

Mr. KLEIN. We are, too, sir, obviously.

That action would mean immediate termination of all the NASA-funded work. The amount might provide for termination costs and that is all. It would be a very serious thing in the way of effect on the program. It would eliminate it.

On the AEC side, as you know, the Joint Committee on Atomic Energy reported out favorably on the program and reduced it, due to budgetary stringency, by an amount of $3 million, they indicated reluctantly, and came out strongly in support of the program.

Mr. MORRIS. Even if the drastic action of the House Committee in the NASA program should prevail; would it still make sense to go ahead with the AEC development portion?

Mr. KLEIN. We would like to, and it would make sense to do so. It becomes much more difficult without the NASA funded portion, but it is very clear from all the actions, including even the House Committee action, that there is a belief that the program is a good program and I think we are all convinced that we will need to have this capability. We believe now is the time to proceed.

Mr. RAMEY. I think the House Committee mentioned they were deferring rather than canceling but it would make it rather difficult to defer.

Mr. KLEIN. I think it is important that people understand, and that the Congress understand, that a simple deferral here is really not possible. This is a continuation of the program. It is not a new program starting up from scratch.

If we defer this, that means disbanding the capability that we have. So deferral really means a cancellation.

PORTION OF ESTIMATE FOR FINAL PHASES OF TECHNOLOGY PROGRAM

Mr. MORRIS. How much of the estimate for fiscal year 1969 is for the final phases of the technology program as compared with the funds requested to initiate the program to provide the nuclear subsystem for the Nerva I engine?

Mr. KLEIN. The technology phase in 1969 in the AEC budget amounts to—if that were the only thing we were doing, and I guess that is the framework of the question—the budget estimate would be about $58 million, including the necessary termination costs. This is the best we can estimate at this point.

Mr. MORRIS. Please give us a breakdown for the record.

(Information requested follows:)

	Thousands
Nerva	$25,000
Advanced rocket reactor technology	23,000
NRDS operations	10,000
Total	58,000

This funding would provide only for completion of the Nerva technology program and necessary termination costs, and continuation of the LASL advanced reactor technology program. Thus, essentially all of the Nerva design staff would have to be released in fiscal year 1969, and it would lead to termination of the remainder of the Nerva program early in fiscal year 1970.

Mr. RAMEY. We do feel very strongly that this program has gotten to the stage where we are really set to go forward on it. We have had such success with all of these tests compared with the difficulties that we had, say, 6 or 7 years ago when we got this industry laboratory team together, it is ironical now that we run into these budget stringencies just at the time when this system is showing that it will be the main propulsion system for anything beyond the Apollo program.

Mr. MORRIS. Chairman Seaborg made a very forceful statement on opening day in response to a question from the distinguished gentleman from Arizona.

Mr. RAMEY. I regret I could not have been here.

POWER TESTS

Mr. KLEIN. As Commissioner Ramey mentions, the program has been very successful. Last December, which was the most recent power test, we operated one of these systems for 60 minutes at full power. This compares to the time a few years ago when we were overjoyed to be able to operate for a few seconds. Sixty minutes actually is a capability fully adequate for most of the missions that we envision for the system.

In addition to that, this was only the most recent in a series of nine consecutive systems tested without a failure. This is a very good record in this kind of development. The first engine we put together a couple years ago operated at full power, and worked well, which is an unusual thing in rocketry. The system has proven to be a very predictable and high performance system.

FUTURE PROPULSION CAPABILITY

The purpose is to provide a system that will give the Nation the needed propulsion capability in the period after the Apollo phase. We are now using for Apollo the so-called Saturn V booster and launch vehicle. As we look downstream in the space program it is very clear we will need to have enhanced propulsion capability. The most effective way the Nation can get it is through this nuclear rocket. It is a long lead-time system. It is one which, by proceeding now, we will have available in an orderly fashion in the mid to late seventies. At that time it is very clear that the missions for which the nuclear rocket appears advantageous are the missions the Nation will be looking to: that is, for extended lunar activities, heavy unmanned payloads to the planets or close to the sun, and earth orbital activities.

One very interesting application is the ability to propel heavy payloads on maneuvering missions in earth orbit, for example, to service synchronous orbit space stations—that is, a space station fixed over one part of the earth. It takes a lot of energy to do that—about as much energy as it takes to get to the moon. The nuclear rocket shows to real advantage for all of these types of missions, and it is for this reason that NASA and the AEC look to this really as a vital program in maintaining a continuity in the Nation's space activities.

Mr. RHODES. You have to get the Nerva into earth orbit by use of the Saturn V or some other very heavy booster, do you not?

Mr. KLEIN. Yes, sir. The Saturn V first two stages would be used, and the nuclear rocket would replace the third stage of the Saturn V. It would be started probably shortly before orbit, so the first two stages will not put it completely into orbit.

In some other applications, the nuclear rocket engine would be started in earth orbit.

Those are the early applications we can envision for it. They are very clearly the types of missions that the Nation will likely be moving into in the next 10 years.

Mr. RHODES. I hope you are right.

Mr. KLEIN. This is certainly what we think.

Mr. MORRIS. We will insert pages RD–57 through RD–61 covering the budgeted request of $72 million.

(Pages referred to follow:)

6. Space Propulsion Systems.....$72,000,000

a. Reactor Propulsion (Rover)			
Research and Development.....	FY 1967: $36,227,969	FY 1968: $33,830,000	FY 1969: $33,200,000
Fuel Fabrication	10,645,927	8,920,000	9,600,000
Operations	24,310,917	22,450,000	23,500,000
Reactor Experiment Fabrication	7,161,751	5,300,000	5,700,000
Irradiations	2,793	0	0
Other	36,588	0	0
Total	$78,385,945	$70,500,000	$72,000,000
b. Isotopic Propulsion	$ 205,849	$ 0	$ 0
Total Space Propulsion Systems	$78,591,794	$70,500,000	$72,000,000

The overall objective of the Space Propulsion Systems program is the development of nuclear rocket propulsion systems required to accomplish heavy payload, high-energy missions in space.

A schedule of funding requirements and discussions of program requirements on a functional basis is presented in the following schedule and program justifications.

a. Reactor Propulsion (ROVER)			
(1) NERVA	FY 1967: $39,945,943	FY 1968: $35,480,000	FY 1969: $39,000,000
(2) Advanced Rocket Reactor Technology	28,499,395	25,620,000	23,000,000
(3) Nuclear Rocket Development Station Operations	9,940,607	9,400,000	10,000,000
Total	$78,385,945	$70,500,000	$72,000,000
b. Isotopic Propulsion			
Isotopic Thruster Technology	$ 205,849	$ 0	$ 0
Total Space Propulsion Systems	$78,591,794	$70,500,000	$72,000,000

6. Space Propulsion Systems - continued

The Rover Program comprises three functional areas as follows: NERVA, Advanced Rocket Reactor Technology and Nuclear Rocket Development Station Operations.

a. Reactor Propulsion (ROVER)

(1) NERVA

	FY 1967:	FY 1968:	FY 1969:
Research and Development	$22,883,170	$22,010,000	$22,000,000
Fuel Fabrication	7,523,862	5,320,000	7,000,000
Operations	5,134,227	4,150,000	5,000,000
Reactor Experiment Fabrication	4,365,303	4,000,000	5,000,000
Irradiations	2,793	0	0
Others	36,588	0	0
Total	$39,945,943	$35,480,000	$39,000,000

The NERVA Program during FY 1967 was primarily directed toward extension of the operating limits of the reactor with emphasis on improvements in fuel life. Configuration and system studies and analyses were initiated to define a 4200 megawatt nuclear subsystem and fuel required for a higher powered nuclear rocket engine (NERVA II) having a thrust capability in the 200,000 pound thrust region. However, recent changes in space program planning have led to a re-evaluation of engine requirements. A decision has recently been made to initiate the development of an approximately 1500 MW, 75,000 lb thrust engine (NERVA I) to use in a variety of space missions. Work in FY 1968 and FY 1969 will be directed toward the completion of the technology program and the definition and design of the NERVA I reactor subsystem. This will lead to the first NERVA I reactor test in the latter part of FY 1970.

The technology program reactor for the XE-1 engine was completed, assembled into the pressure vessel, and delivered to the assembly building at NRDS in the fourth quarter of FY 1967 and will be tested in early CY 1968. Redesign, development, manufacture and assembly of the reactor for NRX-A6 was completed in early FY 1968 and the reactor assembly was delivered to NRDS for testing in mid-December 1967. Improvements in fuel development and fabrication, including coating improvements to provide better corrosion resistance to hot hydrogen, are expected to extend the operating life of the NRX-A6 reactor to approximately 45 minutes of full power operation; an increase of 50% over that demonstrated in NRX/EST and NRX-A5. Fuel of this

6. Space Propulsion Systems - continued

capability will be incorporated in the XE-2 which will be tested in CY 1969. Post-mortem evaluation of the NRX-A6 will occur in FY 1968.

During FY 1968 and 1969, NERVA I system studies and analyses will be conducted, and design of the NERVA I nuclear subsystem components will be completed to the point that developmental components can be fabricated and tested. Design, development, modification, fabrication and testing of fabrication, assembly and shipping equipment and test cars necessary to support the development of the NERVA I test will proceed in parallel with development of the nuclear subsystem. Technical liaison with LASL and Y-12 will be continued throughout this period to assure maximum interchange of information and utilization of developments from other organizations.

In summary, this budget estimate covers the final phases of the technology program terminating with the testing, disassembly and post-mortem evaluation of the NRX-A6 and XE-2 nuclear subsystem as well as the initial phase of the program to provide the nuclear subsystem for the NERVA I engine which will lead to completion of Pre-Flight Rating Test (PFRT) testing in 1975. The technology program has provided a basis of design information and test data on which to proceed with the development of the NERVA I components and systems. A comprehensive program of component development, evaluation and analysis is essential to provide future major nuclear rocket performance. As the desired component characteristics are achieved in the development program, it is essential that the process variable affecting the characteristics be identified and process controls be developed and established to permit efficient, repeatable, and timely production of the flight-type components required for the NERVA I Program.

(2) Advanced Rocket Reactor
Technology..... FY 1967: $28,499,395 FY 1968: $25,620,000 FY 1969: $23,000,000

The advanced rocket reactor technology program is directed to the establishment of the technology for the development of advanced graphite systems in the higher power range and a supporting technology program.

6. Space Propulsion Systems - continued

(a) Graphite Reactors (Phoebus)

Research and Development...	FY 1967: $12,820,038	FY 1968: $11,300,000	FY 1969: $10,700,000
Fuel Fabrication	3,122,065	3,600,000	2,600,000
Operations	9,236,083	8,900,000	8,500,000
Reactor Experiment Fabrication	2,796,448	1,300,000	700,000
Total	$27,974,634	$25,100,000	$22,500,000

The Phoebus phase of the Rover program at LASL will be completed with the testing of the Phoebus 2A reactor in the First Quarter CY 1968. Upon completion of the Phoebus work, the Los Alamos effort will be shifted to the development of new fuel materials of the carbide composite type which will be compatible with the NERVA flight engine design but will be tested in small "test bed" reactors by LASL. These small reactors designated Peewee's will permit realistic testing of fuel elements at a relatively modest cost since the fuel element inventory is small and test hardware (pumps, nozzles and pressure vessels) in this size is relatively inexpensive. Turn-around time between tests is also minimized because of the small core volume. The first test bed reactor should be ready at the end of CY 1968, with tests continuing at the rate of one or two per year.

(b) Supporting Graphite Technology ..... FY 1967: $ 524,761 FY 1968: $ 520,000 FY 1969: $ 500,000

These funds provide for the investigation of advanced concepts and specific research and development tasks where the unique capabilities of selected laboratories and contractors are used to supplement and support the graphite reactor program in selected areas of technology.

(3) Nuclear Rocket Development Station Operations ..... FY 1967: $ 9,940,607 FY 1968: $ 9,400,000 FY 1969: $10,000,000

This estimate represents the cost of general support and station operations for the Nuclear Rocket Development Station including a pro-rata share of Camp Mercury costs. Station operations

6. Space Propulsion Systems - continued

include such items as maintenance of facilities, communications, radiological safety, bus service, utilities, guard service, and various general services.

In March 1966, EG&G was established as the electronics support service contractor at NRDS for all electronics support functions. Pan American World Airways, Inc., continues to provide all other support services for SNPO-Nevada and their contractors, either directly or through purchase order contract, with Reynolds Electrical Engineering Company (REECo). Pan Am operates and maintains NRDS facilities and systems such as general shops, warehouse facilities, water pumping stations and distribution systems, electrical distribution, sanitary sewer, technical common-use laboratories, and maintains all buildings and structures.

Other services include data processing, photographic services, rad-safe, janitorial, sanitation, and other labor services, reproduction, graphic art, technical library, mail and messenger, S.S. accountability station operation, materials procurement and supply, and others.

Services coordinated by Pan American, but obtained through REECo are telephone, teletype, telegraph and radio communications, motor vehicles, cafeteria and food vans, commuter bus service, laundry and linen, road maintenance, medical, and other.

b. Isotopic Propulsion ..... FY 1967: $ 205,849 FY 1968: $ 0 FY 1969: $ 0

Commission support for this activity was phased out in FY 1967.

SPACE ELECTRIC POWER DEVELOPMENT PROGRAM

Mr. MORRIS. Please describe the space electric power development program, Mr. Klein.

Mr. KLEIN. That is the other portion of the space nuclear systems program of the AEC.

The space electric power development program encompasses more varied types of technology than the nuclear rocket. In this case we are providing the technology and the systems to meet various needs on spacecraft in various missions. I have a chart here (figure 2) which I think show the kinds of power levels involved.

This chart shows simply, along the left-hand side, that for missions from unmanned science probes and orbiters up to the very advanced missions different power levels are required. It starts from a range of a few watts up to the kilowatt range and to many kilowatts. These systems to provide the power are different, depending upon what the mission needs may be.

In this part of the program, therefore, we are not talking about a single technology but we are talking about those which cover a spectrum of needs.

This range of power is provided in various ways. Batteries are used today, fuel cells are used, and solar cells are used.

It turns out that when one gets into power requirements lasting more than a relatively few days, the chemical systems—batteries and fuel cells—are not practical and one has to look either to solar cells or nuclear power supplies. The competitor to the nuclear power system, therefore, is the solar cell.

NUCLEAR POWER

The situations in which nuclear power appears particularly advantageous and are required are: where there is a lack of sun, which is true in many of these missions; where we have to get into high power and huge solar arrays that would be involved are just infeasible; or another situation is where you want radiation hardening. This is of particular interest to the Department of Defense. Solar cells are more susceptible to damage from radiation than the nuclear power source.

In this program we are working in two types of systems—in the radioisotope power system area and in the reactor area. Radioisotope systems are good up to a few kilowatts. Beyond that they become overly expensive and we move into the use of nuclear reactors as a more effective way of supplying power.

SNAP 19 SYSTEM

We have been working on, and are nearing completion on, two systems that will be used in the near future. One is the SNAP 19 which will be used to provide part of the power for the Nimbus-B spacecraft. This is a weather satellite that will be launched next month. It will have a 50-watt nuclear power supply on it to supplement the solar cell capability it will have.

SNAP 27 SYSTEM

Another system nearing completion is the so-called SNAP 27 which will be used to power experiments that are left on the lunar surface by the Apollo astronauts. There will be experiments left there to radio data back from the lunar surface long after the astronauts have returned, and these experiments will be powered by a nuclear power supply, the SNAP 27.

NAVIGATION SATELLITE

In fiscal 1969 we will also be embarking on the development of a navigation satellite in response to a request from the Department of Defense. The interest here is in a very long life system, radiation hardened and very light weight.

HIGH POWER SYSTEMS

As we go into higher powers it is necessary to look for more efficient systems. These low power systems can get by at very low efficiencies. For higher power uses it is imperative that we get to higher efficiency. This means a higher temperature capability in the nuclear source itself, and that is the other major portion of the isotope generator technology program. In addition to the higher temperature capability, we are working to improve the efficiency of the power conversion system, all to provide a cheaper way of supplying this power.

As I indicated, as we look to higher powers in the kilowatt range, we go into the use of reactors. There are now two reactor systems in the program: one for the near term, the zirconium hydride liquid metal cooled reactor, which is good for powers up to the order of 50 to 100 kilowatts. That kind of power supply will be needed for manned space stations, such as advanced space stations which DOD might have and the workshops that NASA is working on. That level of power also is needed for direct broadcast communications satellites.

LIQUID METAL COOLED SPACE POWER REACTOR

For longer term needs and higher power and higher performance needs, we have been working on two types of systems—one, the advanced liquid metal system, and the other the thermionic system. The Joint Committee, in its report as subsequently passed by both Houses of Congress, did not authorize any further work at this time on the advanced liquid metal system.

According to the report they believe this work to be important but felt we were not providing enough funds for it to make it a sensible program, so they recommended its deletion.

This leaves for our higher power needs only the thermionic system.

Mr. MORRIS. Before you go to that, will you tell us what would be involved in the termination of the liquid metal cooled space power reactor?

Mr. KLEIN. Yes, sir; as you know, there were no funds provided in fiscal 1969 for that. Yet we are very close to the end of fiscal 1968. There was language in the report which provided authority to incur costs in fiscal 1969 but there were no funds provided for the work.

We are doing everything we can to terminate this program immediately. There are several individual tasks that are midstream. For example, there is an irradiation that is midstream and it would be undesirable to pull it out before it has provided at least some useful information. There are several of these kinds of things that will carry on into the next fiscal year.

What we have to do at the Livermore Laboratory in terminating immediately is to reduce the staff from the 170 people who have been assigned.

Mr. MORRIS. Will you submit the details of the termination of this program to the committee for the record?

Mr. KLEIN. Yes, sir.

(Information requested follows:)

The termination will be nearly completed by the end of fiscal year 1968. The reactor engineering work has been stopped and final reports will be written by the end of fiscal year 1968. All materials development tasks will be brought to a conclusion by the end of fiscal year 1968, except that consideration is being given to allowing work on the following tasks to continue into fiscal year 1969 in order to gain some benefit from the work underway:

1. Completion and evaluation of the static and dynamic lithium/tungsten alloy corrosion experiments.
2. Completion of the uranium nitride thermodynamic stability experiment.
3. Completion and examination of the two fuel irradiation experiments.
4. Completion of the 5,000-hour fuel-clad compatibility experiment.

To complete these four tasks will take about $350,000 in fiscal year 1969. No funds have been provided for this purpose in fiscal year 1969, but we are trying to find some way of finishing as much of this work as possible in a logical fashion.

The reactor development staff of 170 people at LRL is being disbanded. The staff level will go to zero by July unless funding for the closeout tasks can be found. In the latter case, the staff level will go to zero at a later time in fiscal year 1969.

THERMIONIC REACTOR PROGRAM

Mr. KLEIN. The last item, as I indicated, is the Thermionic reactor program. This is a very long term effort and a very interesting one because it holds promise of good high-power performance without any moving parts. It does, however, involve a very complex reactor. All the power conversion is right in the reactor fuel element, which makes it, I believe, the most complex reactor fuel element that we have ever attempted. The present work is principally in the area of developing the thermionic diodes, getting experience on their radiation behavior, and initiating work on the design of a first experimental reactor which would incorporate these diodes.

The other work in the space nuclear systems program, that is, the fuels work, the safety work, are all in support of the activities that I have just described.

That briefly summarizes the program, Mr. Chairman.

Mr. MORRIS. We will insert pages RD–62 through RD–84 covering the request of $52,650,000 for Space Electric Power Development.

(Pages referred to follow:)

7. Space Electric Power Development ..... $ 52,650,000

a. Radioisotope Power Development	FY 1967:	$ 28,048,958	FY 1968:	$ 19,890,000	FY 1969:	$ 18,750,000
b. Reactor Power Development		20,797,161		18,235,000		14,700,000
c. Power Conversion Development		6,893,694		3,720,000		4,900,000
d. Space Nuclear Safety		4,744,792		4,011,000		4,200,000
e. Isotope Fuel Development and Heat Source Fabrication		8,477,609		9,684,000		10,100,000
Total Space Electric Power Development .		$ 68,962,214		$ 55,540,000		$ 52,650,000

The Space Electric Power Development program involves the development and testing of long-lived lightweight, compact, nuclear electric power sources for space applications. This program was initiated in 1955 in recognition of the long development time required to provide these unique power systems with the required reliability and endurance. The program has five major divisions: (1) the development of electrical generating systems in the low power range (up to a few kilowatts) utilizing radioactive isotopes as the heat source, (2) the development of advanced technology and electrical generating systems in the medium and high power range (in the tens of kilowatts to megawatts) using nuclear reactors as the heat source, (3) the investigation and development of advanced technology of power conversion systems to be used with future radioisotope or reactor electrical generating systems, (4) the safety analysis, investigation, and experimentation, as required in the review of the development contractor's effort to assure the adequate protection of the general populace, operating personnel and crews at all times during the development, transportation and use of nuclear space electric power systems, and (5) the development of isotope fuels technology and the fabrication of isotope heat sources for use in nuclear space electric power systems.

7. Space Electric Power Development - continued

a. Radioisotope Power Development

(1) Pu-238 Space Generator Development	FY 1967: $ 18,391,772	FY 1968: $ 9,950,000	FY 1969: $ 6,500,000
(2) Po-210 Space Generator Development	7,154,337	6,700,000	6,000,000
(3) Large Heat Source (KW) Generator	0	900,000	3,000,000
(4) Thermionic Space Generator Development	198,078	0	750,000
(5) Supporting Technology - Radioisotope Power ...	2,089,910	2,340,000	2,500,000
(6) Completed Projects	214,861	0	0
Total	$ 28,048,958	$ 19,890,000	$ 18,750,000

(1) Pu-238 Space Generator Development

30-Watt Generator (Nimbus B) SNAP-19B	FY 1967: $ 4,004,710	FY 1968: $ 2,700,000	FY 1969: $ 0
50-Watt Generator (ALSEP) SNAP-27	13,551,132	6,630,000	1,500,000
250-Watt Generator (Earth Satellite/Planetary Probe).....	665,930	0	2,000,000
NAVSAT	170,000	620,000	3,000,000
Total	$ 18,391,772	$ 9,950,000	$ 6,500,000

7. Space Electric Power Development - continued

SNAP-19B (Nimbus-B) ..... FY 1967: $ 4,004,710 FY 1968: $ 2,700,000 FY 1969: $ 0

A 30-watt generator (SNAP-19B), under development for NASA Nimbus-B weather satellite program will be successfully completed with the delivery of flight systems (each system comprised of two generators) to NASA for a launch in FY 1968.

SNAP-27 (ALSEP) ..... FY 1967: $ 13,551,132 FY 1968: $ 6,630,000 FY 1969: $ 1,500,000

A 50-watt radioisotope power system (SNAP-27) is under development for the Apollo Lunar Surface Experiment Package (ALSEP) to provide power for experiments placed on the moon by Apollo astronauts. The delivery of flight systems is now planned to begin in late FY 1968. In FY 1969 safety analysis will be continued and support will be provided for integration and launch operations; life testing of generators will continue.

250-Watt Generator ..... FY 1967: $ 665,930 FY 1968: $ 0 FY 1969: $ 2,000,000

NASA and the DOD have asked the AEC to establish the technology of isotopic power supplies of a few hundreds of watts for various orbital long-life missions. Technology will be developed by such a system for use by NASA's planetary exploration programs such as Voyager and DOD's programs for multi-purpose satellites. This program constitutes a technology development effort aimed at providing a family of long-lived isotope power units for a broad class of future missions. The planned initiation of the development of this technology has been deferred until FY 1969 in order to assign funding to other higher priority radioisotope generator programs in FY 1968. A systems integrator will be selected in FY 1969 to perform analyses and tests using the most attractive features of the three studies of both Pu-238 and Sr-90 systems which were completed in FY 1967. This effort will be the basis for the initiation of the development and test of generator components in FY 1969. Use of either Pu-238 or Sr-90 material as the fuel will be considered so that this unit will have sufficient flexibility to be considered as a multi-hundred watt long-lived RTG for a variety of missions.

NAVSAT ..... FY 1967: $ 170,000 FY 1968: $ 620,000 FY 1969: $ 3,000,000

The need exists for extremely lightweight, relatively low power electric power systems for space navigational (NAVSAT) and communications systems applications. In order to develop the technology

7. Space Electric Power Development - continued

to fill this need, and in conjunction with the DOD's expressed interest in such a system, a preliminary technology evaluation was conducted in FY 1967 and the engineering development of the lightweight converter (ISOTEC) thermoelectric panels was initiated. This effort is continuing in FY 1968 and will provide the basis for the planned initiation of a system design during the last half of the fiscal year. In FY 1969, materials investigations, safety analysis, and component development will begin. The current program planning is directed to the objective of developing this lightweight system technology by the early 1970's, which is a timing consistent with the DOD's request for this system.

(2) Po-210 Space Generator Development (SNAP-29)

System Direction, Evaluation and Integration	FY 1967:	$ 1,541,337	FY 1968:	$ 3,200,000	FY 1969:	$ 1,700,000
Safety Evaluation and Integration		837,000		1,400,000		800,000
RTG System Development		4,722,000		1,900,000		2,900,000
Aerospace Ground Equipment Development		54,000		200,000		600,000
Total		$ 7,154,337		$ 6,700,000		$ 6,000,000

This program provides for the demonstration of system technology for a Po-210 thermoelectric generator in the multi-hundred watt range. This approach will accommodate power requirements in the range of a few hundred watts (e) to 2 KWe. Po-210 systems will have application in both manned and unmanned short-lived space missions, and the development and demonstration of this technology is supported by DOD and NASA. This technology is a significant advance in heat source and isotopic fuel development, as well as generator design. The ground test of a unit comprising the thermoelectric converter, heat source, thermal control system and radiator is now planned for FY 1970. During FY 1967, effort was devoted to the investigation of heat source and thermoelectric materials, the establishment of test procedures and equipment and preliminary safety analyses and testing. Material specimen fabrication and testing, system design and integration and component design, fabrication and testing will continue through FY 1968 and FY 1969.

7. Space Electric Power Development - continued

(3) Large Heat Source (KW) Generator

Capsule Materials and Fabrication Techniques	FY 1967:	$ 0	FY 1968:	$ 850,000	FY 1969:	$ 2,150,000
Heat Source Design Studies		0		50,000		300,000
Component Development		0		0		550,000
Total		$ 0		$ 900,000		3,000,000

The objective of this program is to develop high temperature heat source technology for use in space power systems capable of producing electric power from 100 watts up to ten kilowatts. Such systems have potential application to many missions including a Manned Orbiting Laboratory (MOL), the Apollo Applications program, and TV satellites. The program objective includes the development of an isotope capsule to operate at 2,000°F for at least 5 years. NASA has expressed interest in isotope-powered Brayton cycle systems and has requested the AEC to collaborate in the test of a complete Brayton cycle system. The AEC has agreed to participate in such a program and to provide a 25 KW (thermal) plutonium-238 heat source in FY 1971 to be used in the ground test of the Brayton cycle system. Effort has begun on capsule material investigations and the development of fabrication processes. Proposals are planned to be solicited in FY 1968 for the conduct of the heat source design studies and techniques needed for comparative assessment of vented capsule systems. An additional effort will be initiated in FY 1969 to investigate a new technique involving graphite encapsulation which has the potential of providing an economical intact re-entry heat source. This effort will include experimental capsule fabrication and testing. In FY 1969, it is also planned to initiate the investigation and development of critical components in the heat source in addition to the capsule efforts.

7. Space Electric Power Development - continued

(4) Thermionic Space Generator Development

Design Study	FY 1967:	$ 198,078	FY 1968:	$ 0	FY 1969:	$ 0
Component and Module Development		0		0		750,000
Total		$ 198,078		$ 0		$ 750,000

A radioisotope-fueled thermionic space power system has the potential of significantly smaller size and greater efficiency than thermoelectric systems. The preliminary design of a Curium-244 fueled thermionic module was completed in FY 1967. A limited program directed toward solving specific thermionic diode and module-housing problems was planned to begin in FY 1968, but will be deferred until FY 1969 in order to make FY 1968 funding available for higher priority radioisotope generator programs. This work may possibly begin late in FY 1968 if funding permits. It is anticipated that the initiation of module development will begin in FY 1969 to achieve a ground test demonstration of a fueled thermionic module in FY 1971.

(5) Supporting Technology - Radioisotope Power

Technical Direction and Evaluation	FY 1967:	$ 1,501,455	FY 1968:	$ 1,685,000	FY 1969:	$ 1,900,000
Insulation Development		420,185		435,000		396,000
Other Studies and Investigations		168,270		220,000		204,000
Total		$ 2,089,910		$ 2,340,000		$ 2,500,000

This activity includes the technical direction and evaluation of the radioisotope generator development program performed by the Sandia Laboratory. In FY 1969, it is necessary to expand the currently modest in-house effort to investigate areas that hold promise for future applications, as well as to adequately review and analyze system designs. In addition, the diversification and complexity of the radioisotope generator program requires that increased effort be devoted to adequately monitor and direct the program. The insulation development effort and the development of an advanced spherical capsule will continue in FY 1969 at approximately the FY 1968 level.

7. Space Electric Power Development - continued

(6) Completed Projects

SNAP-13	FY 1967:	$ 13,435	FY 1968:	$ 0	FY 1969:	$ 0
SNAP-11 (Surveyor)		201,426		0		0
Total		$ 214,861		$ 0		$ 0

The testing of the SNAP-13 low-power thermionic system was completed in FY 1967. In FY 1967, a SNAP-11 unit was fueled and successfully completed a 90-day operating test. The program was brought to a conclusion with the delivery of developmental systems for test and evaluation by the NASA Jet Propulsion Laboratory and the Manned Spacecraft Center and the completion of developmental system testing at the Martin Company.

REACTOR DEVELOPMENT PROGRAM - continued

7. Space Electric Power Development - continued

b. Reactor Power Development

(1) Zirconium-hydride Reactor Technology	FY 1967: $ 7,456,185[a]	FY 1968: $ 6,018,000[a]	FY 1969: $ 6,000,000
(2) Advanced Reactor Technology	12,541,981	11,525,000	8,000,000
(3) Supporting Technology - Reactor Power	798,995	692,000	700,000
Total	$ 20,797,161	$ 18,235,000	$ 14,700,000

(1) Zirconium-hydride Reactor Technology

Design and Analysis	FY 1967: $ 1,213,351	FY 1968: $ 1,104,000	FY 1969: $ 1,225,000
Reactor Physics	0	0	250,000
Fuels and Materials Development	3,945,460	2,190,000	1,890,000
Reactor Component Development	1,059,363	694,000	1,105,000
Experiment Fabrication .	992,107	1,240,000	210,000
Test Experiment Operation	62,904	740,000	1,220,000
SNAP-8 Support to NASA .	183,000	50,000	100,000
Total	$ 7,456,185	$ 6,018,000	$ 6,000,000

The zirconium-hydride reactor program provides for the development of a zirconium-hydride reactor heat source for use with various types of power conversion equipment to provide a space electric power capability in the mid-1970's in the tens of kilowatts electric power range. This program is directed primarily toward eventual use with either a thermoelectric power conversion system in the several 10's of KWe range or the mercury Rankine cycle power conversion system being developed by NASA in the 35 to 50 KWe power range.

a/ Includes comparability adjustments from Supporting Technology - Reactor Power in FY 1967 of $492,888 and in FY 1968 of $518,000.

7. Space Electric Power Development - continued

The first area of the program provides for the development, fabrication, and test of an experimental reactor to prove out the technology developed to date. This is the only reactor currently under development that has the potential to meet the space power range contemplated for the 1970's.

The most recent experimental reactor of the zirconium-hydride type (designated the S8ER) completed a year of power operation in FY 1965. Post-test examination of the core revealed extensive cracking of the fuel element cladding. In order to evaluate the causes of the cracking and to take corrective action for the SNAP-8 Development Reactor (S8DR) intended for use in a ground system demonstration, an augmented fuel examination program was conducted. Fabrication and assembly of the S8DR was delayed pending results of the fuel examination. During FY 1967, data on zirconium-hydride fuel and Hastelloy-N cladding materials were obtained and analyzed. These data and analyses showed that the most probable cause of the fuel element cladding cracks in the S8ER was insufficient clearance between the fuel rods and the cladding tubes. Whereas S8ER was a core test of a non-flight configurated reactor, S8DR is a flight configured (but not yet flight qualified) reactor. During FY 1968, the fuel elements for the S8DR reactor will be fabricated; the reactor will be assembled and installed in the test facility; and the reactor and test facility will be checked out.

Power operation of the S8DR is scheduled to begin in FY 1969. The test will include automatic startup and control followed by approximately 10,000 hours of endurance testing. The test facility includes space for installation of the NASA SNAP-8 mercury power conversion system; however, this is not now scheduled with the S8DR reactor test.

The principal objective of the second area of this program is to extend the reactor life capability from 10,000 to 20,000 hours. In FY 1968, thermoelectric power systems will be defined jointly with potential using agencies for three potential mission classes: communications and television satellites, manned orbiting space stations, and a lunar base. In FY 1969, long term (20,000 hours) irradiation testing of several sub-length fuel elements will be started. This test will be performed in order to verify conclusions concerning the several-year life potential of the reactor. The current conclusions are based on 10,000 hour tests with accelerated burnup rates. A prototype DC conduction NaK pump, suitable for use with a thermoelectric system, will begin testing in FY 1969. The development of primary loop components, such as a reactor control system for use with thermoelectric systems, will begin. Work to advance the technology to permit operation of the reactor in a four pi

REACTOR DEVELOPMENT PROGRAM - continued

7. Space Electric Power Development - continued

shield will also be started. The development of a BeO reflector and poison backed drums is also planned including a critical experiment.

In addition, needed studies will be performed and close liaison maintained with NASA to assure appropriate mating of the reactor development activities with the NASA SNAP-8 power conversion development efforts.

(2) Advanced Reactor Technology

Liquid Metal Cooled Reactor ...	FY 1967:	$ 5,151,849	FY 1968:	$ 4,900,000	FY 1969:	$ 2,500,000
Boiling Metal Reactor		283,405		25,000		0
Gas Cooled Reactor (710)		2,915,013		1,600,000		0
Thermionic Reactor Development		4,191,714		5,000,000		5,500,000
Total		$ 12,541,981		$ 11,525,000		$ 8,000,000

Liquid Metal Cooled Reactor

Design and Analysis	FY 1967:	$ 1,824,919	FY 1968:	$ 1,210,000	FY 1969:	$ 200,000
Fuels and Materials Development		3,326,930		3,690,000		2,300,000
Total		$ 5,151,849		$ 4,900,000		$ 2,500,000

The objective of this effort, centered at the Lawrence Radiation Laboratory, is to develop the technology for high performance liquid-metal-cooled space power reactors for advanced applications in the 1980's. Emphasis is being placed on a reactor concept for use with Rankine cycle power conversion; however, this technology is also applicable to other power conversion approaches. The power conversion technology is being developed by NASA in a complimentary program. Electrical powers ranging from a few hundred kilowatts (for secondary power and unmanned electric propulsion applications) to multi-megawatts (for manned electric propulsion applications) are being considered.

7. Space Electric Power Development - continued

During FY 1968, it is planned to complete studies of several liquid metal Rankine cycle systems and the design of an experimental reactor suitable for ground operation.

The reactor concept being considered in this program is a lithium-cooled, uranium nitride fueled, tungsten-alloy clad, fast reactor designed to operate with a coolant outlet temperature in excess of 2000°F. A carefully planned experimental program has been initiated to determine the performance limits of the materials of this reactor. During FY 1968 and FY 1969, the materials research will include lithium/uranium nitride/tungsten alloy compatibility tests, uranium nitride irradiation experiments, a pumped lithium/tungsten alloy loop test, and fabrication development and physical properties testing of tungsten alloys.

In FY 1969, the system studies and reactor design effort will be greatly reduced. The program will concentrate on high temperature materials development. This will include fuel irradiation tests to determine the temperature and fuel burn-up limits of uranium nitride, continued compatibility studies of fuel/clad/coolant systems and limited development of tungsten alloys. There will be a focusing of this effort on the materials performance requirements of the reference design reactor.

Boiling Metal Reactor ..... FY 1967: $ 283,405 FY 1968: $ 25,000 FY 1969: $ 0

The termination of the boiling metal reactor (MPRE) will be completed in FY 1968. This termination was the result of a decision made in FY 1966 to reduce the number of advanced power concepts under development rather than reduce effort on all concepts uniformly.

Gas Cooled Reactor (710)

Design and Analysis	FY 1967:	$ 752,295	FY 1968:	$ 100,000	FY 1969:	$ 0
Reactor Physics		241,652		0		0
Fuels and Materials Development		1,921,066		1,500,000		0
Total		$ 2,915,013		$ 1,600,000		$ 0

7. Space Electric Power Development - continued

This program, primarily a fuel element development effort, is being closed out in FY 1968 in order to apply existing resources to the liquid metal and thermionic reactor projects which have a potentially wider range of application than does the 710 reactor.

Very significant progress has been made in the 710 program and this fuel element technology will be applicable to the liquid metal and thermionic reactor concepts.

Thermionic Reactor Development

Materials Technology	FY 1967:	$ 470,000	FY 1968:	$ 625,000	FY 1969:	$ 800,000
Converter Technology		2,261,841		2,150,000		2,490,000
Converter Testing		741,000		980,000		1,000,000
Reactor Technology and Program Direction		718,373		945,000		970,000
System Technology		500		300,000		240,000
Total		$ 4,191,714		$ 5,000,000		$ 5,500,000

Thermionic reactor technology is being developed for application to space electric power systems in the power range of 0.1 to 10 MWe. The thermionic development effort performed through FY 1967 under Advanced Systems Research and Development category has been transferred to this activity.

The thermionic reactor will convert fission heat to electricity inside the reactor. Since the reactor core is composed of many thermionic diodes, it is believed possible to electrically connect the diodes in such a way that failure of a few diodes will not cause failure of the whole power supply. To achieve this reliability potential, a practical diode and reactor design must be evolved and a fuel and emitter temperature capability of about 3000°F must be developed.

In FY 1968, the program will continue to emphasize development of a long-lived thermionic fuel element. In addition, reference designs will be established for each of the attractive concepts of thermionic reactor space powerplants. These reference designs will serve to guide the development program and will provide component performance requirements against which to assess development status and predict the realistic performance of thermionic reactor systems.

7. Space Electric Power Development - continued

In FY 1969, it is anticipated that the first long term in-pile tests will be completed on diodes which incorporate the features required in a thermionic reactor. If these results are successful, a component development program will be initiated leading to a reactor experiment in the 1970's.

(3) Supporting Technology -
Reactor Power ..... FY 1967: $ 798,995 FY 1968: $ 692,000 FY 1969: $ 700,000

This program encompasses the development of an advanced reactor shielding code, using the latest developments in computer technology, for use in designing shields for the space power reactor development program. The results of the code are verified using a modified SNAP-10A reactor as a radiation source in the ORNL Tower Shield Facility (TSF). Various shield configurations are analyzed and their application to various conceptual systems identified. Nuclear data on shielding materials of interest is also obtained in an attendant experimental program. This activity also includes the continuing support of the interagency Power Information Center.

7. Space Electric Power Development - continued

c. Power Conversion Development

(1) Thermoelectric Power Conversion Development	FY 1967:	$ 3,838,271	FY 1968:	$ 3,088,000	FY 1969:	$ 4,300,000
(2) Dynamic Power Conversion Development		3,055,423		632,000		600,000
Total		$ 6,893,694		$ 3,720,000		$ 4,900,000

(1) Thermoelectric Power Conversion Development

Direct Radiating Converter	FY 1967:	$ 1,336,509	FY 1968:	$ 300,000	FY 1969:	$ 150,000
Compact Converter		1,931,143		1,700,000		2,200,000
Lightweight Converter ..		323,376		350,000		350,000
Modules and Materials Investigations		247,243		738,000		1,600,000
Total		$ 3,838,271		$ 3,088,000		$ 4,300,000

Direct Radiating Converter	FY 1967:	$ 1,336,509	FY 1968:	$ 300,000	FY 1969:	$ 150,000

The objective of this program is to improve the silicon germanium (Si-Ge) thermoelectric converter previously developed under the SNAP-10A program. Experimental 1300°F modules have been fabricated to achieve a two-fold increase in power. These experimental modules are now on long term endurance testing and are planned to be continued on test for a five year period, ending in FY 1972. In FY 1968, the results of the prior years development and fabrication will be documented and specifications prepared. In FY 1969, the program will be confined to the continuation of the endurance testing.

7. Space Electric Power Development - continued

Compact Converter ..... FY 1967: $ 1,931,143 FY 1968: $ 1,700,000 FY 1969: $ 2,200,000

The development of a compact converter will permit greater flexibility in radiator and system design, since the converter is not an integral part of the radiator cone as was the case in SNAP-10A. This converter concept will also simplify shielding problems in manned space systems. Both silicon-germanium and lead-telluride concepts have been investigated to date. In FY 1968, effort on the silicon-germanium effort will be redirected to a technology program under the Modules and Materials Activity. The lead-telluride concept will be continued toward the objective of a full compact converter demonstration, for potential use with the zirconium-hydride reactor and isotope heat source.

The objective of the lead telluride tubular compact converter program is to provide power system designers a void-free, metal encapsulated module capable of sustained operation in the extremely hostile environments typically experienced in aerospace applications. Current experimental modules produce approximately 75 watts of electrical power; however, the future sizing of modules will be largely at the discretion of the system designer. It is expected that modules will be placed in multi-module arrays to produce at the high kilowatt level in reactor applications or, in the case of isotope applications, coupled with heat pipes to produce electrical power up to the low kilowatt level.

Lightweight Converter ..... FY 1967: $ 323,376 FY 1968: $ 350,000 FY 1969: $ 350,000

The research and development effort to improve components currently comprising the lightweight thermoelectric converter (ISOTEC) will continue through FY 1969. During this period effort will be directed at the improvement of thermoelectric bonding technology as it relates to the ISOTEC concept. Simultaneous testing of experimental modules and panels under expected operating temperatures and at elevated temperatures for accelerated life test purposes will be accomplished. Research and development will be conducted on the concept of applying lightweight silicon-germanium thermoelectric elements in thermal cascade with ISOTEC lead telluride panels and of utilizing heat pipes as a technique of distributing a high thermal flux from a radioisotope heat source to ISOTEC panels.

Modules and Materials Investigations ..... FY 1967: $ 247,243 FY 1968: $ 738,000 FY 1969: $ 1,600,000

This activity provides for the experimental effort required to improve existing materials, investigate promising module concepts, and develop fabrication techniques for application

7. Space Electric Power Development - continued

to thermoelectric converters. The completion of the investigation of a fabrication technique to ultrasonically cast thermoelectric material (thereby increasing its density and power potential) will be completed in FY 1968. A technology effort will begin during FY 1968 to establish the characteristics and the thermal and electrical properties of a new P-type alloy composition and a new single phase lead telluride material. The demonstration of the capabilities of these materials will be accomplished through element, couple, and module fabrication and testing beginning in FY 1969. The technology effort on silicon-germanium, transferred to this activity from the Compact Converter activity, includes material investigation, fabrication processes, and improved modular designs, and the effort will be expanded in FY 1969. Included in this technology is a planar module concept which has the potential of using a higher temperature heat source and permitting a simpler, more rugged thermoelectric converter design. This effort will continue on a long-range basis to provide the design and fabrication technology required to develop high temperature radioisotope thermoelectric space power systems.

(2) Dynamic Power Conversion Development

Mercury Rankine Cycle	FY 1967:	$ 1,850,632	FY 1968:	$ 100,000	FY 1969:	$ 0
Potassium Rankine Cycle		475,767		70,000		0
Organic Rankine Cycle		729,024		462,000		600,000
Total		$ 3,055,423		$ 632,000		$ 600,000

Mercury Rankine Cycle ..... FY 1967: $ 1,850,632 FY 1968: $ 100,000 FY 1969: $ 0

This program will be phased out during FY 1968. The testing of combined rotating units was terminated at the end of FY 1967, and post-test analysis and the preparation of final reports will be completed in FY 1968.

Potassium Rankine Cycle .... FY 1967: $ 475,767 FY 1968: $ 70,000 FY 1969: $ 0

This program involves the analysis of the electrical components (generator, pump motors, and power conditioning equipment) in a potassium Rankine cycle reactor space power plant. The work will be completed in FY 1968 with the preparation of a final report. NASA will continue its activities in this area to establish the technology base that will be required for future potassium Rankine power conversion system development.

7. Space Electric Power Development - continued

Organic Rankine Cycle ..... FY 1967: $ 729,024 FY 1968: $ 462,000 FY 1969: $ 600,000

The organic Rankine cycle concept is unique in that high conversion efficiencies (heat converted to electricity) are obtainable at low operating temperatures. Overall conversion efficiencies approaching 20 per cent, with specific radiator area of around $40Ft^2/KWe$, are believed possible with turbine inlet temperatures of 650^oF in the 1-10 KWe range. At these low temperatures, using the organic fluids of interest, normal engineering construction materials such as stainless steel can be utilized throughout the power conversion loop. The low operating temperature and high efficiency provides flexibility in the selection of a heat source. The required heat source temperatures are below those temperatures demonstrated for reactor systems and isotopic sources, and the high efficiency extends the useful power output from existing heat sources.

The current program is directed primarily at verifying the thermal stability of the organic fluids and obtaining the data necessary to specify the operating limits of a power conversion system, i.e., boiling temperature, turbine exhaust pressure, bearing operating conditions, pump conditions, etc., so that long operating life can be achieved. In FY 1968, these tests will be completed. If the tests are successful, a selection of working fluid and operating conditions will be made and the initiation of development of the principal components of a prototype system is planned.

94-075 O-68-pt. 3—15

7. Space Electric Power Development - continued

d. Space Nuclear Safety

(1) Radioisotope Systems Safety Support	FY 1967: $ 2,604,985	FY 1968: $ 2,161,000	FY 1969: $ 2,500,000
(2) Reactor Systems Safety Support	505,012	350,000	500,000
(3) Advanced Safety Technology	1,634,795	1,500,000	1,200,000
Total	$ 4,744,792	$ 4,011,000	$ 4,200,000

The Space Nuclear Safety Program has the following three primary elements: (1) support of space electric power programs in terms of safety analyses and experiments using the expertise, analytical techniques, and test equipment developed by the AEC over the past 5 years, (2) pre-flight safety reviews of contractor supplied space nuclear systems during the development program and when integrated with DOD or NASA spacecraft, (3) improvement of the state-of-the-art of safety technology. This program is required to fulfill the responsibility for assuring flight safety approval both prior to and concurrent with system development and flight activities.

The radioisotope system safety support includes the establishment of nuclear safety design criteria prior to system design; monitoring of the development contractors' safety program to assure compliance with safety design criteria; and providing analytical and test support to the development contractors for each system. The systems now under development, or planned to begin in FY 1968, include SNAP-19B (Nimbus), SNAP-27 (ALSEP), SNAP-29, NAVSAT and the Large Heat Source. The increase in this area in FY 1969 is primarily for increased safety effort on NAVSAT and the Large Heat Source, for the initiation of safety analyses on the 250-watt generator and the safety investigation of the exposure of Po-210 fuel to impact, vibration, and accident environments.

The reactor system safety support provides for the investigation of reactor disposal modes, as well as the investigation of the feasibility of designing space reactors to be intrinsically subcritical if immersed in water. This latter effort will increase slightly in FY 1969, and preliminary safety analyses of the thermionic and liquid metal reactor concepts will be initiated.

7. Space Electric Power Development - continued

The advanced safety technology activity covers (1) the investigation and development of safety system concepts including the improved capability to track, locate, and recover space nuclear systems if aborted; (2) the continuous review, analysis and updating of safety criteria; (3) the development of experimental and analytical techniques for determining the reentry behavior of a system and defining radiological consequences of accidents; and (4) the conduct of special safety studies and analyses as requested by other agencies. This effort will continue at a reduced level during FY 1969.

7. Space Electric Power Development - continued

e. Isotope Fuel Development and Heat Source Fabrication

(1) Plutonium-238 Fuels	FY 1967: $ 4,482,608	FY 1968: $ 5,532,000	FY 1969: $ 5,020,000
(2) Polonium-210 Fuels	2,708,044	2,730,000	3,700,000
(3) Curium Fuels	968,247	1,280,000	1,150,000
(4) Fission Product Fuels	232,710	62,000	30,000
(5) Materials Development	86,000	80,000	200,000
Total	$ 8,477,609	$ 9,684,000	$ 10,100,000

(1) Plutonium-238 Fuels

Fuel Development	FY 1967: $ 1,681,347	FY 1968: $ 2,817,000	FY 1969: $ 2,420,000
Heat Source Fabrication	2,801,261	2,715,000	2,600,000
Total	$ 4,482,608	$ 5,532,000	$ 5,020,000

The fuel development effort includes the major areas of fuel form development and process and engineering development. The fuel form development area is concerned with determining chemical, physical and nuclear properties of Pu-238 fuel forms in order to predict the behavior of isotopic fuels and encapsulating materials for long-term space applications. The current effort is primarily concerned with characterizing plutonium dioxide for space applications operating at less than 1000°C, with a small effort directed at higher temperatures (1000-1500°C). A shift of emphasis to the higher temperature will take place starting in FY 1969.

Process development effort in FY 1968 will focus on improving the present methods of plutonium fuel form production and defining and establishing parameters for alternate production methods. The preparation of fuel is currently accomplished by an inefficient, time-consuming process which generates a considerable amount of scrap. In FY 1968, the new solgel process is expected to be available for incorporation into the production system. The solgel process holds the promise of increased process efficiency (from the current efficiency of about 60% to an efficiency of over 90%) as well as producing a more uniform fuel. Assuming incorporation of this process into the program, effort directed at the refinement of the solgel process will continue in FY 1969.

7. Space Electric Power Development - continued

Process development related to the scrap recovery activity will receive continuing support; rapid efficient methods of recovery are essential to maintain a reduced scrap inventory and assure a sustained high level of material utilization.

Heat source fabrication includes the processing of the required fuel form, development of capsule welding techniques for specific systems, welding of capsules, establishment of fueling and welding procedures, encapsulation of fuel, and recovery of scrap Pu-238 generated during processing. The heat sources fabricated under this activity are required for use in fueling isotopic systems developed for space applications. The fueling of SNAP-19 and SNAP-27 heat sources will be completed in FY 1968. During FY 1969 capsule welding and testing development will be initiated for the NAVSAT Generator and the Large Heat Source.

(2) Polonium-210 Fuels

Fuel Development	FY 1967: $ 1,789,044	FY 1968: $ 1,580,000	FY 1969: $ 1,500,000
Heat Source Fabrication	919,000	1,150,000	2,200,000
Total	$ 2,708,044	$ 2,730,000	$ 3,700,000

The fuel development effort includes the major areas of fuel form development, process development and engineering. The fuel form development effort will focus on determining the chemical, physical and nuclear characteristics of selected rare earth polonides for operation above 1000°C. Experiments in compatibility, vapor pressure, thermoconductivity, solubility, etc., will be continued to provide design information for space power systems using polonium-210. Matrices of rare earth polonides and refractory metals will be fabricated in varying ratios to determine matrix strength and power density relationship, and efforts will continue to develop a chemically inert fuel form. A limited continuing effort will be directed toward higher temperatures (1000 to 1500°C) in support of thruster and thermionic applications.

7. Space Electric Power Development - continued

Alternate methods of separating polonium from bismuth will be investigated under the process development activity, and emphasis will be directed toward increasing the processing capacity over the present wet chemical separation and electrodeposition methods. Development of alternate processes are essential to arrive at the production of kilogram quantities of polonium at reduced costs. Present program planning assumes the scheduled production of kilogram quantities of polonium by the early 1970's.

Heat source fabrication currently involves the production of gram quantities of polonium by the present process in support of the fuel development activity. These costs include the procurement, shipment and irradiation of bismuth. An increase in production and encapsulation of Po-210 is planned in FY 1969, leading to a production level of 900 grams in FY 1970. Concurrent with this increase in production levels, the effort on capsule development and establishing welding procedures will be increased directed at providing fueled capsules for the SNAP-29 ground test in mid-FY 1970.

(3) Curium Fuels ..... FY 1967: $ 968,247 FY 1968: $ 1,280,000 FY 1969: $ 1,150,000

In FY 1968, three kilograms of this isotope will become available to support the isotopic power development program. The development effort will continue in FY 1969 to acquire experimental data on fuel form processing, melting point measurements and phase equilibrium, and compatibility with encapsulation materials. Effort will also be applied to process development in the investigation of a microsphere fuel form, hot pressing, welding development and source testing. It is the purpose of this program to provide system design data for thermoelectric applications (1000-1200°C) and thruster and thermionic applications (2000°C) for use in early 1970 time period. Fuels will be developed to provide sources to withstand exposure to long-term high temperature environments. Determination of thermal stability will be a part of this program. Methods of fuel processing, conversion and encapsulation, geared toward the fabrication of kilowatt sources, will be investigated.

7. Space Electric Power Development - continued

(4) Fission Product Fuels ..... FY 1967: $ 232,710 FY 1968: $ 62,000 FY 1969: $ 30,000

The testing of an experimental Promethium 147 heat source for application in a microthruster designed by NASA will be continued in FY 1968. Further work on this concept will depend on NASA future program plans for this system. The FY 1969 funding is to complete the testing of the heat source and perform a destructive, analytical analysis of the long term effects on the isotopic fuel and containment materials.

(5) Materials Development ..... FY 1967: $ 86,000 FY 1968: $ 80,000 FY 1969: $ 200,000

This phase of the program is concerned with developing, evaluating, and characterizing heat source materials (other than fuel) and fabrication methods to be used in the isotopic heat source program. Such areas as welding, brazing, mechanical testing, helium venting, protective coatings, and inter-metallic compatibility will be investigated. The data resulting from this program will provide engineering design data and technical input for current and future isotopic SNAP programs.

The utilization of isotopes for space power greatly depends upon the assurance of isotope containment of satisfactory disposal under all credible situations. This assurance is to a large extent dependent upon the nature and behavior of the heat source capsule materials. The evaluation of helium vent materials began in FY 1967. This program will continue and be expanded in FY 1969 with the objective of designing and testing materials which will be permeable to helium in the temperature range of 1000 to 2000°C. Development of such a material is a necessity, particularly at the higher temperatures where material strengths are inadequate to contain helium pressures over extended periods of time.

REDUCTION IN AUTHORIZATION BILL

Mr. MORRIS. As outlined on page RD–63, of the $18,750,000 budgeted for the Radioisotope Power Development program, the authorization bill has made a reduction of $3 million.

Can you outline briefly for the committee the nature of this reduction made by the authorizing committee?

Mr. KLEIN. Yes, Mr. Chairman.

One part of the reduction was the deferral, the elimination of work in fiscal year 1969 and deferral to a later time, of the multi-100-watt generator that we had proposed proceeding with in response to an interest expressed by the Department of Defense and by the NASA. They are both interested in that size of generator.

That work was eliminated.

In addition to that, there was a reduction of $500,000 from $3 million for the high temperature heat source technology I referred to a moment ago, which is really the basic step we have to take in order to go from the very few watt generators we have now developed on to higher powered systems. There is a reduction in that most important work.

There was also a reduction of $500,000 in the development of a power supply for the Department of Defense's navigation satellite, which is a 20-watt power supply.

NAVSAT PROJECT

Mr. MORRIS. The reduction still leaves $2,500,000 for the development of the light-weight, low-powered generator project for the space navigational and communications systems applications (NAVSAT).

This compares with a funding level of only $620,000 for the current fiscal year. Why is it essential to expand this program to this extent during fiscal year 1969?

Mr. KLEIN. Mr. Chairman, in this case we are dealing with the development of a very specific system. It is a relatively short-term development, over a period of 3 years essentially. In that kind of development, and in that kind of situation I know you will recognize there is a beginning, a peak, and an end.

In 1969 and 1970 we will be at the peak and then it will trail off beyond that. This is the start of a program which will end in the early seventies.

Mr. RHODES. I have no questions, Mr. Chairman.

Mr. DAVIS. I have no questions, Mr. Chairman.

DISCUSSION OF ROVER PROGRAM

Mr. ROBISON. What effect did you tell us the authorization recommended by the House Science and Astronautics Committee will have on this program? I know your Space program is authorized by the joint committee, which is separate in that way, but they do have to go forward together.

I believe you responded to the chairman that you felt you should go ahead with Rover regardless of whether or not there are cutbacks in NASA's program.

Mr. MORRIS. Will you also explain your combined office?

Mr. KLEIN. This space propulsion effort, Rover, is all one program. We have a joint office of the NASA and the AEC which I am responsible for so we have a fully integrated program in this area.

Mr. ROBISON. For whom do you work?

Mr. KLEIN. I report to both agencies.

Dr. TAPE. We pay him.

Mr. KLEIN. I have not found a way of getting two paychecks.

Clearly it is very important that the programs go together and that both parts go together. They are integrated. It will be very difficult to proceed with the AEC work without the NASA work. It is only because we believe this is so important that even though this situation might come about, which we hope will not, we believe it would be important and desirable to proceed with the AEC portion of the work. Work could go on in that area and we are convinced we will want to have this done.

Mr. ROBISON. Then you will hope NASA will catch up on its portion?

Mr. KLEIN. It will certainly be a stretchout. It is inevitable that that work would pace the activity, but at least you would have continuity in one part of the program.

Mr. MORRIS. I sometimes like to think of this program in this way: AEC provides the engine and NASA provides the automobile. You have the reactor and they have the flight vehicle.

Mr. KLEIN. That is right. The reactor is a component of the system.

Mr. ROBISON. The propulsion system and the submarine.

DISCUSSION OF PRIORITIES IN PROGRAM

I confess that I have problems with priorities. I am disturbed about this program this year and somewhat depressed about all the various items you have in here which are somewhat beyond my ability to put together and get them all in focus.

I know they are focused in your eyes but I still have concern.

Mr. KLEIN. I understand the concern that you express. With respect to the latter part of the question, regarding the number of activities, it is important to note that these activities are not alternate ways of doing the same thing. In the electric power area, for example, there are many power supplies that are in use today. Each one has a place where it fits and other places where it does not. That is the same situation we have here. We have eliminated from the program any areas where there are alternate paths to one objective. We are working only in areas where we see a specific need, some of which are in the near future. Each of these meets a very critical need as we look downstream. You will note that many items have been eliminated or stretched out in this area. It has already been substantially reduced from previous levels.

Turning to the first part of your question and commenting specifically with respect to the nuclear-rocket, we recognize the severe budgetary restrictions and problems. We believe it is important to the country that we maintain some vitality in these advanced technologies because if we do not this will rise to haunt us as a nation. The space program is very important in maintaining our technological strength and nuclear propulsion is necessary to the future of the space program. We have cut back just to maintain the most crucial elements.

Mr. ROBISON. You want to hold your team together. You want to keep some esprit in the projects you are working on.

Mr. KLEIN. It is more than that. These programs are at the forefront of the Nation's technology. This country is strong in no small part because it has had a vitality in its industrial and technological and scientific developments. These programs, we feel, are essential to keep something going in this field. As I described earlier, they are essential to the future at the space program and, more broadly, to our technological health as a Nation.

These programs are also what I would call the cutting edges of the technology, and it is that which really focuses the talents of the country toward maintaining a dynamism in technology, which we believe will be crucial not only to solving our immediate national problems but to making sure we do not have worse ones downstream.

Dr. TAPE. This morning we were talking about the long leadtimes in any program involving advanced technology as we are experiencing it today. Those leadtimes we were talking about were based on having a team, facilities, and a going organization.

If, in something like this, we actually disband the team and close down the facilities, then to take a later decision to proceed with the system means that the leadtime is even longer than we are talking about today because one has to reactivate, reassemble, and get the whole thing started again.

In a sense we are a victim of this long development time for these complex technologies.

I think the question that bothers you is one of saying that we will cut this out. It just about means that to cut it out today and then in 2 or 3 years get it going again it will be 10 to 15 years beyond that before we produce the desired results.

Mr. KLEIN. And spend a lot of extra money in the process.

Mr. ROBISON. I understand your problem. But if William McChesney Martin, Jr. is right, we face the most serious fiscal problem we have encountered since 1931, and are you now saying you are at the lowest level you can go with your portion of the space program and still maintain that minimum amount of momentum or togetherness or whatever the proper word is to keep it alive? I don't want to kill the program either, but is it now possible we could come down with your help to a lower floor if, in the judgment of the subcommittee, it thinks we have to?

Dr. TAPE. Each of these has to be looked at in that way, whether it is just keeping the thing going so we have a faster option to elect in the future, in which case we will be glad to look at it in those terms.

On the other hand, if this is a persistent problem we are up against then we may find ourselves in the position of the Joint Committee where they said, when we reduced the level to $2.5 million on the liquid metals system, that that is not sufficiently viable to keep it going so let us stop it today. That is the problem.

REDUCTION IN ROVER STAFF

Mr. KLEIN. What we have tried to do is to come to grips with exactly that question in proposing this level. For example, I should point out that we have reduced the staff engaged in the Rover portion of the program since last year by 25 to 30 percent. It has been a very marked

reduction. We are at a level where we are having a difficult time keeping together the various disciplines it takes to develop a system. Many different kinds of talents are needed to develop this type of system. We have cut them very markedly.

Mr. ROBISON. I have nothing further.

VARIOUS ENDEAVORS IN SPACE ELECTRIC POWER DEVELOPMENT

Mr. RHODES. One of the things that bothers the gentleman from New York and bothers me, too, is the various areas of endeavor we have in the field of space electric power equipment. Apparently we are still traveling many roads which might lead us in the same direction. I am wondering whether the time has come to abandon some of these roads and concentrate on some of the more promising ones.

Mr. KLEIN. I would like to try to help clarify that, Mr. Rhodes, because that is indeed what we have done.

There are a lot of numbers on this piece of paper which may mask that situation and perhaps I can help you in this respect.

First of all, there is one item here, which shows up as a line, that is ending in fiscal 1969. In the isotope area, then, there are really only two long-life generator programs very active in fiscal 1969. One is the navigation satellite being developed in response to a direct request from the Department of Defense. The other is the high temperature work that is essential to doing anything in the higher power. They are not parallel paths. In one case we are going to develop and deliver a specific piece of hardware for a specific DOD need in the low power range in the near future. In the other we have the only effort now going for paving the way for higher powers which also are of interest to the Department of Defense.

I should emphasize that our space electric power work serves the needs of both the Department of Defense and NASA. The Department of Defense space activities have been increasing. This work is of great interest to them and this work is being conducted partly in response to a letter from them and an expression of interest to work in that area.

Therefore in the isotope generators for long-life use there are these two main efforts, which are quite different in character.

There is a third, the short-lived generator, the SNAP–29, which is a system of several hundred watts, also conducted in response to a request from the Department of Defense to provide the technology of a short-lived generator of this size. The long-life generators involve much more expensive fuels.

Mr. RHODES. I understand this as far as the isotopic situation is concerned.

TECHNIQUES FOR BUILDING REACTORS

Looking at the reactor power development at page RD–69, you have zirconium-hydride reactor technology, advanced reactor technology, supporting technology, and below that you have a subhead on the zirconium-hydride reactor technology.

Are these various techniques for building reactors really required? Aren't they duplicatory of experimentations being performed in other parts of the AEC?

Mr. KLEIN. They are not duplicatory, Mr. Rhodes. There are two programs in the reactor power area. The zirconium-hydride is a near term effort. It is one that will supply power levels up into the tens of kilowatt range. There is an interest in this in both NASA and DOD for space stations. The SATURN I workshop which NASA expects to launch in the 1970 time period will require about 10 kilowatts of power. Looking down to the 1973–74 time period, they expect 20 kilowatts and more to be needed. This is the only way that power can be practically supplied. This is the way to do it. This is the near term part of the reactor program.

To complement that we have one long term effort. We had two, and the Joint Committee, again for the reasons we described earlier, eliminated one of those two, so there is one long term effort remaining. This is a very long development, a very promising one, and one which commands a great deal of interest. We are carrying this out on a relatively fundamental and paced basis. All these programs have been stretched out.

There are only these two reactor programs remaining. The supporting technology portion is just that. It supports these reactor programs and covers shielding work being done to get a better understanding of the shielding problems in space. That is really the entire effort in the reactor area.

Dr. TAPE. If you look at page RD–71, advanced technology line, the $2.5 million for the liquid metal cooled reactor has been deleted by the authorization legislation. That leaves the $5.5 million of the thermionic development.

Mr. RHODES. So the only advanced reactor technology effort now is the thermionic development?

Mr. KLEIN. Yes, and that page, if you look to the left, shows that in 1967 there were four programs in existence in that area. You can see what we have done. We are now down to one. Some of this has not been done voluntarily, I should note.

Mr. RHODES. Thank you, Mr. Chairman.

Mr. MORRIS. Thank you, Mr. Klein, for your presentation.

CIVILIAN POWER REACTOR PROGRAM

Mr. MORRIS. We will next hear from Mr. Shaw, the Director, Division of Reactor Development and Technology.

Mr. Shaw, one of the things I would like you to cover in your general statement is urgency for the large additional increase proposed for the civilian power reactor program. It has gone up year after year, from $102.5 million in 1967, to $118.5 million in 1968 and $132 million is proposed in 1969. In your statement, can you address yourself to why we have to have this expansion at this time?

Mr. SHAW. Yes, sir; Mr. Morris. I will try to cover that.

You recognize that in grouping the civilian power reactor program this way, we are really talking about more than just my program.

In addition to my program this grouping includes Admiral Rickover's program on the light water breeder. I think that was covered before.

I will try to be responsive to your question, Mr. Morris.

In my part of the civilian power program we are continuing to take those types of actions that I discussed with the committee last year. That is, we are taking actions to strengthen the management and the execution of our reactor development programs and to adjust and align our resources with the objectives of concentrating on fewer of the higher priority programs. There have been many numbers of adjustments made that may not be evident through the funding levels alone that you referred to. I think I can make a very valid point of this by noting that in a number of examples where we have actually terminated programs, our funding levels at this time are higher than they were when we were carrying the program as an active item.

HALLAM PROGRAM

For example Hallam, which is a program for a liquid metal reactor carried under the cooperative program, actually requires funding levels in 1969 far greater than what they were in 1966 and 1967 because we terminated that program. That is because in so terminating we have an obligation to remove the reactor, deactivate and decommission the plant. Therefore we have to fund for that effort.

PIQUA REACTOR

The same is true of Piqua, an organic cooled reactor. The Commission made the decision during the last year, to terminate that program. As a result we have to fund that program at a level higher this year than what we had in the previous years.

DISCUSSION OF OTHER PROGRAM TERMINATIONS AND REDUCTIONS

I will certainly try to touch upon these things because it is important in looking at our budget to identify that we have made many terminations and program redirections. These do not necessarily show up in the actual funding levels depicted before you.

In addition to this action just noted, we have increased our efforts over the last year, formally and informally, to encourage the principal participants in the civilian power program, particularly the reactor manufacturers as well as the utilities to participate more actively in carrying development work in the civilian power program. Some of these efforts are for cooperative programs. Specifically here I can cite work in the safety program, standards programs, the heavy section steel programs, while other development work is in areas we have phased out or will be phasing out, having declared our intentions in these areas very specifically, such as the plutonium recycle program, where we certainly have been encouraging the industry and the utilities to pick up a significant effort on this type of work.

In other programs, for example the superheat program where we were exploring the potential of superheat for a number of years, we have definitely decided to phase out that program, and we terminated support for a number of facilities. In addition, the Commission right now is considering the early termination of the superheat BONUS project in Puerto Rico.

In addition we terminated some of the post construction R. & D. commitments on the Pathfinder superheat project we had made in order to withdraw from these areas on an accelerated basis.

INCREASED PARTICIPATION BY INDUSTRY

In working with the industrial people, particularly the utility representatives and the reactor manufacturers, we are very pleased we are getting the top level management attention right now from the principal executives, and they are becoming responsive to the obligations we feel they have for picking up more and more of this type of development work.

The net result of this we think is very important to carrying out our own program. It permits us to concentrate our resources on our priority objectives and at the same time carries very important programs through more ably than if they were not participating in this measure.

In citing their participation, I must refer to three areas. They are putting up dollars in these programs themselves; I am talking about actually contributing dollars.

Secondly, they are building facilities to do some of this work.

PERSONNEL

The third thing, which is probably as important as the other two, they are giving us good people. This has taken a lot of attention from the top management of the Commission and from top management of the reactor manufacturers. We have spent more time in the last year on this very subject than in any previous year in order to get this means to strengthen our program.

BREEDER PROGRAM

I believe the most important single matter I should discuss with you is the breeder program. I know Dr. Seaborg and others have discussed with you the national and international implications of this program and of the overwhelming endorsement of its high priority. I thought I could briefly discuss how this breeder program couples into what you see happening around you in the electrical power generating industry. This correction is a very essential factor in terms of the priority we put on the breeder program and the emphasis we are continuing to place on it at every opportunity.

ELECTRIC POWER DEMANDS

The electric power growth in this country continues to be greater than previously experienced or predicted. For example, in 1967 there was a total of 52 million kilowatts of electric generating capacity procured. This compares to 44 million in 1966, 24 million in 1965, and 17 million in 1964. This unprecedented increase, of course, places a tremendous burden on the electric generating manufacturing capabilities of this country. This demand applies to both fossil fuel as well as nuclear powered generating capabilities.

We believe this rate of growth as just indicated must be taken seriously and the implications of it should be also. Not only is it a rate of growth which imposes manufacturing implications but more importantly this country is becoming increasingly dependent on electric power itself. The blackout and brown-out situations have brought this out vividly. When electric power fails us we realize how extremely dependent on it we are.

Those people worrying about the implications know this concern well. Again the Commission has increased its efforts heavily in working with organizations such as the Federal Power Commission and others in order to try to let people know that nuclear power is not the only type of generating capability that must have reliability associated with it.

NUCLEAR POWER PROBLEMS

We have certainly attracted a lot of attention because we talk openly about our problems in nuclear power. We have emphasized the importance of safety and reliability, but I think it is becoming clearer than ever before that this type of open talk and related actions have to be factored into the overall electric generating capabilities of this country.

Mr. Ramey and I were in Chicago just yesterday where Mr. Ramey spoke during noon on the impact of reliability and quality assurance on the overall economics of the power industry. This speech was well received by some 1,400 people there.

The request for active participation of this industrial group in stressing this important item and their carrying and providing more leadership on it certainly went over well. Mr. Ramey really threw the gauntlet down at them in saying it is high time they assumed the leadership in carrying forward this objective. I commend each of you, if you have the time, to review that speech. It does carry a message in it.

I have one chart (Fig. 1) that I think summarizes the electric growth pattern and the potential impact of it.

(The chart referred to follows:)

U.S. POWER STATISTICS RELATING TO POPULATION AND CONSUMPTION

	1950	1967	Estimate for 1980	Predicted for 2000
Population (millions)	152	200	235	320
Total power capacity (millions of kilowatts)	85	269	600	1,556
Kilowatt capacity per person	0.6	1⅓	2½	~5
Power consumed per person per year (kilowatt-hours)	2,000	6,000	11,500	~25,000
Total consumption (kilowatt-hours)	[1] 325	[2] 1.2	[2] 2.7	[2] ~8
Savings of 1 mill per kilowatt-hour would equal (billions per year)	$⅓	>$1	$2.7	~$8
Nuclear power capacity (millions of kilowatts)	0	2	150	734
Nuclear power capacity (percent of total)	0	<1	25	~50

[1] Billion.
[2] Trillion.

This chart shows the projection of population and electric power generating capability as well as consumption. I invite your attention to the 1967 column which shows we have roughly 200 million people. The electric power consumed per person is roughly 6,000 kilowatt-hours per year. Projecting this out to 1980 it shows 11,500 kilowatt-hours, and in the year 2000 it is 25,000 killowatt-hours.

In registering this point I must note that in the TVA area alone that estimate of 6,000 kilowatts is up around 12,000 today. This does, to some degree, indicate that the numbers projected here are not at all unreasonable in areas of our country which are highly electrified. It is apparent that the 1980 average number is within the actual usage factors of today in certain areas.

Equally important I note the fact that the saving of 1 mill per kilowatt-hour, which we believe the breeder is capable of doing once it becomes commercially available in the 1980's, would mean a saving in this country of about $2.7 billion a year based upon projected electric generating capabilities.

I think this chart in a sense does summarize the concerns I have expressed previously here and it does bring home the importance of the breeder as well as the dependence this country will have on electric power generating capabilities.

Among other obvious things this power growth pattern places more pressure on those organizations involved in the production of fuel, whether it be fossil fuel or nuclear fuel, and raises questions of how these needs will be met. Obviously the growth will be realized in practically all types of electric generating capability in our projections as well as in those of the Federal Power Commission and others who have looked at this picture. In the future we will be using more oil, coal, and nuclear power, in addition to more hydro.

NATIONAL POLICY ON FUTURE ELECTRIC NEEDS

Mr. ROBISON. Are we any closer to development of a national policy with respect to meeting the future electric needs of the Nation than we were last year? We had a colloquy about this last year. I attempted to see what was being done in the way of interrelation and cooperation for future planning between AEC, the Corps of Engineers, TVA, Bonneville Power, Federal Power Commission, and all the rest of the interested agencies.

Are we coming any closer to a Government-wide power resources council concept in this field?

Mr. SHAW. It is an area we have been working hard in. Since I say "we" I think Commissioner Ramey could elaborate on that.

Mr. RAMEY. One development in the last year has been the appointment in the Office of Science and Technology of a staff member for coordination of energy studies. Dave Freeman, who was an assistant to the Chairman of the Federal Power Commission, is now sort of a coordinator of energy studies, not just nuclear but coal, oil, and any other source. He was appointed last November or December and has been getting organized and is beginning to look into this matter which you raise.

He has begun to get active in several areas of interest in the whole energy field.

For example, he has gotten interested in this problem of thermal effects of powerplants, both nuclear and fossil. He also has gotten interested in the siting problems. I gave a speech last fall on the role of atomic power in national electric policy in which I suggested there should be an interim interdepartmental committee on the siting of powerplants, both nuclear and fossil, with all the agencies you men-

tioned participating. There has been considerable interest in this proposal in various parts of Congress and various associations, both publicly owned and the Edison Institute.

Dave Freeman, in the Office of Science and Technology, has taken the lead in trying to get something started on this siting policy.

Whether we will end up with that kind of commitee or not I do not know.

Mr. ROBISON. I hope it does.

Mr. RAMEY. So do I. I think it makes sense.

A couple years ago we participated in the study of the role of research in relation to energy resources, both nuclear and oil, coal, and so on. There was a rather large report put out by an interdepartmental committee.

Now they are doing a followup so as not to repeat on the research side so much but to cover some of the other areas that were not covered. Again the leadership will be taken by Dave Freeman who represents not nuclear and not fossil but more of a neutral standpoint.

I do believe, therefore, some progress is being made.

UTILITY OUTLOOK TASK FORCE

Mr. SHAW. We also have representatives from many of the organizations you indicated working with us on our Utility Outlook Task Force which is reviewing each of our civilian power reactor programs and our projections. They are quite active.

Mr. RHODES. Did you have any representative from private sources?

Mr. SHAW. Both private and public.

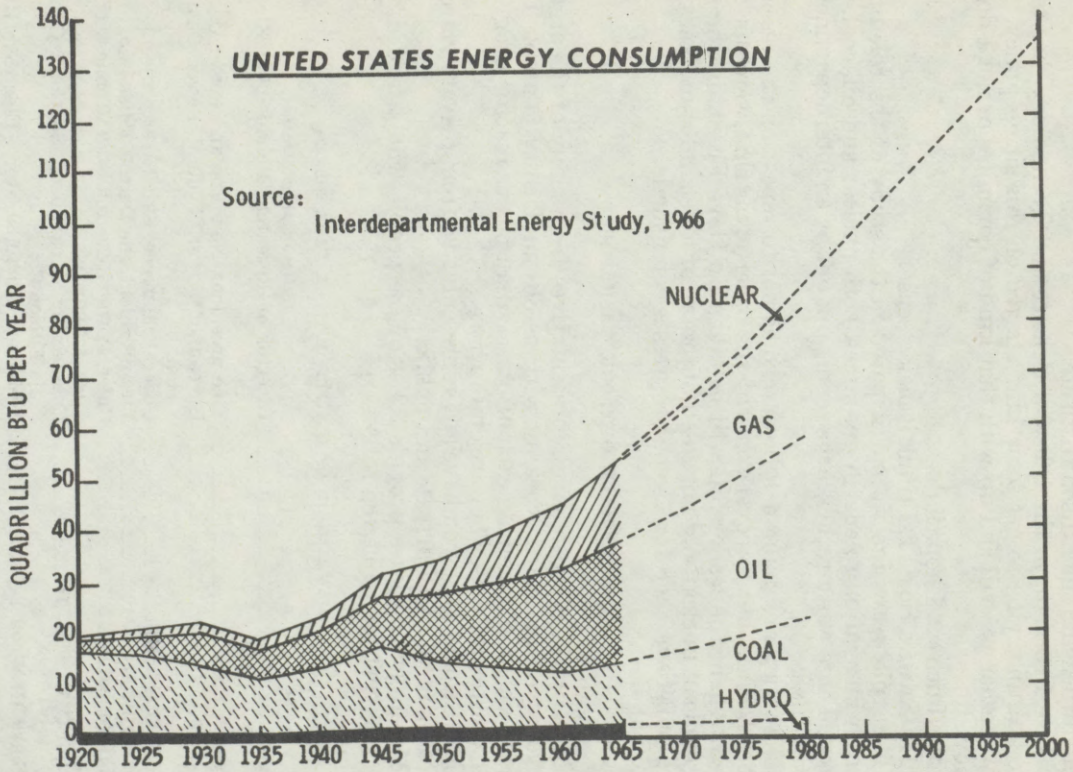
Mr. MORRIS. Please provide a list of the people who attended.

(Information requested follows:)

MEMBERSHIP OF UTILITY OUTLOOK TASK FORCE

Name	*Title and organization*
Wayne C. Astley	Director of Research, Philadelphia Electric Co.
Roger J. Coe	Vice president, New England Power Co.
Norman C. Nelson	Bureau of Power, Federal Power Commission.
Rod J. McMullin	General manager, Salt River project.
Harvey A. Wagner	Vice president, the Detroit Edison Co.
C. H. Wangaman	Chief, Power Research Staff, Tennessee Valley Authority.
Arthur C. Werden, Jr	Engineering Department, Southern California Edison Co.
Richard H. Wood	Assistant Administrator, Electric, Rural Electrification Administration.
Marshall K. Ray, Chairman	U.S. Atomic Energy Commission.

(Chart to be referred to follows:)


UNITED STATES ENERGY CONSUMPTION
Source:
Interdepartmental Energy Study, 1966
QUADRILLION BTU PER YEAR
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
NUCLEAR
GAS
OIL
COAL
HYDRO

INTERDEPARTMENTAL ENERGY STUDY

Mr. SHAW. This chart in front of you (fig. 2) is an amplification of Commissioner Ramey's remarks regarding the energy study. This type of projection is being picked up actively now and there will be a new projection developed. This really portrays my point made previously. In looking to the future there is a place for gas, oil, coal, and hydro, but we recognize the need to keep such projections quite active and updated.

The utilities still are making rather tremendous commitments to light water reactors. I know about a year ago a number of people thought it would taper off.

On the commitments to the light water reactor plants, already in 1968 there are 11 plants announced. There were an additional 32 plants announced last year. In the previous year there were 24. The 32 announced in 1967 brings the total up to about 60,000 megawatts of nuclear power. This is quite a sizable commitment. Roughly 60 million people can be "electrified" from that capability.

What does this mean? Many significant changes have been made in the civilian power program and they can be traced directly and indirectly to this situation I have referred to; that is, the rapid demand over the last 3 years for nuclear power in this country and abroad and the ever-growing commitment of the utility industry to the light water reactors both in number and size.

This recognizes that the uranium fuel will be consumed and plutonium will be thereby produced, and we must bring in a breeder. We have no choice now with respect to bringing the breeder into being.

There is little question that in looking at the power demands in the future that this country, as well as any other highly industrialized country, will be dependent upon a breeder in the future to be assured of adequate amounts of economic electric power and process heat.

PRIORITY OF LIQUID METAL BREEDER

The high priority assigned to the liquid metal breeder program, and as noted in the budget before you, for $82 million, is based on its potential economics, industrial and worldwide interests, the experience we have, and its capability to conserve uranium resources as a result of being able to utilize plutonium very effectively.

Sodium has been chosen as the coolant because of its good cooling characteristics, excellent heat transfer capabilities, large heat capacity, low vapor pressure; that is, the fact it can operate under very low pressures, and its relative freedom from corrosion in the absence of air. It has a good technological base, it uses plutonium fuel, and it provides for a doubling time that will be, in essence, about the same doubling time we see in the electric power generating industry; that is, about every 10 years.

Our program is based on treating the liquid metal breeder key problem areas as well as providing for the facilities to enable us to carry this effort forward.

My next chart, figure 3, brings this out in a little different light from what you have on page RD–23 in your budget book. On this chart, over to the right, I have fiscal year 1969.

Mr. Morris, this is a partial answer in response to your question of why we have increased our budget. You will see in the grand total line, $42.6 million in 1967, $66 million in 1968, and $82 million in 1969.

Up above we have the technology, and down below we have the facilities. I have tried to break it down also in terms of laboratory work and industrial involvement.

INDUSTRY PARTICIPATION

Very important, to our way of thinking, of course, is the fact that until industry gets really involved with the program, no matter how good the concept is, it will not be an effective product in the utility arena. Somebody has to market the product, produce it, and stand behind it.

Of course, a principal part of our present objective is to get the industrial capability, that is, the reactor manufacturers as well as equipment producers, heavily involved in the program. At the same time, we recognize the essentiality of radiation facilities and physics facilities. For example, EBR–2 and the FFTF, you will note, have almost doubled between 1967 and 1969.

The EBR–2 is important since it is the only fast breeder reactor facility operating in this country, and only one of two operating right now, in the free world.

FFTF, which we are committed to, is the only fast flux test reactor with a closed loop capability, and therefore, is a very essential facility as well.

In the SRE–FARET lines you will note both efforts have been terminated in order to enable us to support the other two facilities adequately. In the ZPR's, which include physics facilities at Idaho as well as at ANL–Chicago, you see a significant increase in dollars from roughly a total of $3.3 million in 1967 up to $11.6 million in 1969. The reason that this line item has increased significantly is that we have to have about 3,000 kilograms of plutonium fuel in order to utilize fully these facilities.

Again, in order to take advantage of that expenditure as such, and have that fuel produced in an industrial environment, you will see at the bottom of the chart that $7.7 million of the 1969 funds is actually being done in industry. We are buying this ZPPR fuel from industry rather than having this fuel fabricated in our own facilities.

In this manner, we have planned our program to make maximum use of the industrial capabilities or help develop them as building blocks for the future.

I think, in substance, you will note of the $82 million, about $48 million is devoted to facilities, and about $34 million is devoted to the R. & D. effort.

Of the $34 million, $19.7 million, an increase of only about $3.5 million, is going out to industry. We think it is quite a tight program in terms of what we would like to do in such an important effort.

FAST FLUX BREEDER REACTOR

Mr. RHODES. Is the fast flux a breeder-type reactor?

Mr. SHAW. Yes, sir. But, it is a test reactor. We will operate it with a mixed plutonium oxide fuel. We will not attempt to breed in it because in order to breed, you have to optimize the fuel arrangement such as by the use of a blanket of fertile material. You would go after certain physics characteristics in the fuel arrangement.

It could very well breed. This is correct, sir. But the fuel type is really crucial.

Mr. RHODES. It is crucial because you are testing to develop plutonium as a fuel, are you not?

Mr. SHAW. Yes, sir, we are working with breeder type fuel and other materials in a fast flux, and, for example, in the hot liquid metal environment.

Mr. RAMEY. In the water reactor program we have had very extensive test facilities for the Navy and for civilian purposes, starting out with the MTR and then the ETR, and now the ATR, so-called. It has been a very important thing. If you can have adequate testing facilities, you do not have to have quite so much prototyping and other things. You can test them with fuel pins, and so on.

Mr. MORRIS. Have you completed your statement?

Mr. SHAW. Not completely, sir. In addressing myself to the need of applying the priority to the fast sodium reactor, as well as to the severe restriction we are living under in overall funding, we have curtailed many other efforts, some of which I have refered to.

OTHER PROGRAM REDUCTIONS

I noted, too, in the liquid metal program category alone, we have terminated the SRE, the sodium reactor experiment, and the Hallam program. We have also reduced previously planned efforts on our 1,000 megawatt electrical studies with reactor manufacturers. We are able to cut those back somewhat because principally we have the utility and electrical manufacturers funding their own demonstration plant studies. We think they will do much of that type of work.

In addition, we have had to phaseout other programs because of this difficult budgetary trend. Last year I spoke of the termination of the heavy water organic program, which we have phased out completely in fiscal year 1968. We have announced the termination of the Piqua facility. We have shut down the experimental boiling water reactor which was running at the Argonne National Laboratory. We have backed off quite significantly on the thorium utilization program at Oak Ridge National Laboratory. Because of the tight fiscal situation we just have to back off on some things. We selected this program among others.

SAFETY PROGRAM

Mr. Chairman, there is another program I would like to mention briefly because it, too, feels the impact of the tremendous commitments to the light water reactor. I refer to our safety program. Here again, we are caught in a somewhat awkward position. As the light water industry is building up, there are more and more sophisticated types of questions being raised with respect to reactor plant safety, such as those arising from the size factor, and the location factor. Many, many additional questions are being raised.

At the same time, we would like to be building up in our safety program on the fast breeder reactor (FBR) and other breeders.

So, the increases we have recommended in our budget right now are considered to be quite essential in order to be able to operate the safety facilities we have programed, as well as to permit a minimal start on those program areas related to safety of the fast breeder reactor.

I shall be glad to elaborate on any of these points, Mr. Chairman, or to answer any of your questions.

Mr. MORRIS. Thank you, Mr. Shaw.

We will insert pages RD–1 through RD–41, covering the reactor development program.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

REACTOR DEVELOPMENT PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$509,520,000
Estimate FY 1968	482,103,000
Increase	$ 27,417,000

The Reactor Development Program includes all work related to the development, demonstration, improvement, and safe operation of nuclear reactors and nuclear devices which may be used to generate electricity in power plants; to produce heat for process heat applications such as desalting sea water; to propel submarines or surface vessels; to propel space vehicles; to furnish thermal and electrical power for attended and unattended space, terrestrial, and undersea applications; and to provide energy for use on lunar or planetary bodies. Briefly stated, the objectives by activity are:

Civilian Power Reactors

1. To continue to explore, develop and advance the technology of central station nuclear power plants to achieve their practical application throughout the United States.

2. To continue to provide cooperative assistance to industry to insure the construction and operation of demonstration nuclear power plants incorporating converter and breeder reactors of advanced types which make more efficient use of nuclear fuel and promise lower power costs.

3. To intensify research and development on, and later demonstrate, high gain breeder reactors which will make possible the use of the full potential energy available in nuclear fuels and thus open up vast energy reserves and which will also be economically attractive.

4. To insure the timely development and use of nuclear energy for desalting sea water and other processes by special attention to the needs for the application in the power reactor development program and by continued cooperation with other federal agencies and with industry.

5. To continue to maintain a position of world leadership in reactor technology, and to assist friendly nations with the development and use of nuclear power.

REACTOR DEVELOPMENT PROGRAM - continued

Merchant Ship Reactors

To develop economically acceptable nuclear power plants for marine applications and to cooperate with the Maritime Administration in fostering the use of these plants in the merchant marine.

Naval Propulsion Reactors

To develop nuclear propulsion plants in a wide range of power ratings for installation in Naval ships ranging in size from small submarines to large aircraft carriers.

Rocket, Satellite and Compact Power Sources

To develop nuclear rocket propulsion plants, nuclear auxiliary heat and power systems, and related technology for space, terrestrial, and undersea applications.

General Reactor Technology

To continue to support broadly based research, development and design efforts aimed at the systematic development of new and advanced technology which will lead to the understanding of the technology and to improvements in existing reactors and the development of new reactor concepts and processes.

Advanced Systems

To investigate by initial systems technology demonstrations those advanced reactor concepts which offer promise of extending or improving the application of nuclear power.

Nuclear Safety

To carry out investigations of nuclear safety problems which are of general applicability as well as to conduct tests which establish the safety of a specific reactor system or establish the validity of safety criteria used in reactor analysis, design and operation.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.		Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
RD-4	1.	Civilian Power Reactors	$102,460,222	$118,475,000	$132,000,000
RD-42	2.	Cooperative Power Reactor Demonstration Program	11,611,295	27,183,000	27,658,000
RD-53	3.	Euratom Program	2,746,334	2,440,000	2,500,000
RD-55	4.	Merchant Ship Reactors	49,066	100,000	100,000
RD-56	5.	Naval Propulsion Reactors	91,900,158	106,700,000	115,300,000
RD-57	6.	Space Propulsion Systems	78,591,794	70,500,000	72,000,000
RD-62	7.	Space Electric Power Development	68,962,214	55,540,000	52,650,000
RD-85	8.	Terrestrial Electric Power Development	4,598,554	7,325,000	6,830,000
RD-91	9.	General Reactor Technology	49,817,877	49,000,000	50,000,000
RD-102	10.	Advanced Systems Research and Development	10,467,730	8,535,000	7,980,000
RD-108	11.	Nuclear Safety	28,631,442	33,305,000	40,400,000
RD-121	12.	Operational Services	5,182,782	3,000,000	2,102,000
		Total Reactor Development Program	$455,019,468	$482,103,000	$509,520,000

REACTOR DEVELOPMENT PROGRAM - continued

1. Civilian Power Reactors			$ 132,000,000
a. Converter Reactors			
(1) Water Reactors	FY 1967: $ 9,020,401	FY 1968: $ 6,500,000	FY 1969: $ 5,040,000
(2) Superheat Reactors	2,219,477	1,375,000	1,760,000
(3) Plutonium Utilization	5,147,934	5,000,000	4,000,000
Total	$16,387,812	$12,875,000	$10,800,000
b. Advanced Converter and Low Gain Breeder Reactors			
(1) Water Reactors	$11,558,523	$14,700,000	$15,500,000
(2) Heavy Water Moderated Reactors	11,750,529	5,600,000	3,000,000
(3) High Temperature Gas Reactors	6,812,799	6,700,000	6,000,000
(4) Thorium Utilization	2,420,191	1,400,000	1,100,000
Total	$32,542,042	$28,400,000	$25,600,000
c. High Gain Breeder Reactors			
(1) Liquid Metal Cooled Fast Breeders	$42,591,777	$66,050,000	$82,000,000
(2) Other Fast Breeder Reactor Systems	1,543,902	1,000,000	1,900,000
(3) Molten Salt Breeder Reactor	4,128,430	4,200,000	6,700,000
Total	$48,264,109	$71,250,000	$90,600,000
d. Desalting Program and Other Processes	$ 2,662,822	$ 2,650,000	$ 2,500,000
e. General Research and Development	$ 2,603,437	$ 3,300,000	$ 2,500,000
Total Civilian Power Reactors	$102,460,222	$118,475,000	$132,000,000

1. Civilian Power Reactors - continued

The Civilian Power Reactor Program budget estimates are based on the following principal objectives and assumptions.

The Commission's research and development emphasis in Civilian Nuclear Power is directed to the technology, safety, engineering and the demonstration of high gain breeder reactors. Research and development will also continue on advanced converters-low gain breeder reactors and toward timely development of nuclear energy applicable to the desalting program and other process applications. These efforts will receive assistance from industrial contractors in evaluations of various technical and economic aspects of advanced concepts. The three principal technical objectives of the advanced converter and breeder programs are to: (1) introduce advanced technology on a timely basis into the growing nuclear industry with attendant cost reductions in producing energy; (2) reduce the requirement of fissile materials mined from the ground, thereby extending the availability of nuclear resources; and (3) permit the use of high cost nuclear fuel resources while still producing low cost energy, thereby expanding the resource base.

a. Converter Reactors

The Shippingport Facility will continue to be operated in order to advance technology of light water plants. The Commission will continue to support a minimal program of plant and fuel analysis of Commission-owned and privately-owned light water plants.

b. Advanced Converter and Low Gain Breeder Reactors

Primary emphasis in the program for advanced converter and low gain breeder reactors will be directed toward the following: The continued research and development of the seed-blanket concept, which is the only known approach for increasing the efficiency of using nuclear fuel in light water thermal reactors significantly beyond the present 1 to 2 per cent of the energy obtainable from uranium ore resources now possible with light water thermal reactors. Efforts in support of the Heavy Water Moderated Reactor Program will be to continue a heavy water reactor base research and development program to retain the option, in the future, to exploit heavy water reactors for power production and for the extremely large size needed for dual purpose and desalting applications. Development work in support of the High Temperature Gas Reactor beyond the cooperative prototype will be principally directed to the development of key components and advancement of fuel utilization and

1. Civilian Power Reactors - continued

economics in support of the development of an advanced 1000 MWe plant. The HTGR program is the only advanced converter program with a high thermal cycle efficiency and capability for utilizing modern steam conditions and thereby extending fuel resources by more efficient plant performance.

c. High Gain Breeder Reactors

The Commission will support a comprehensive research and development effort necessary to reach the objectives of the fast breeder reactor program. This effort is focused in the areas of fuel, physics, component, systems and plant developments for the liquid metal cooled fast breeder reactor (LMFBR). The Commission will provide support for design studies of alternate fast breeder concepts and for related work in physics, components, and fuel principally directed to the Gas and Steam Cooled Fast Breeder concepts in FY 1969.

Procurement of equipment for the Fast Flux Test Facility will start in FY 1968 and on-site construction will start in FY 1969. Concurrently, a comprehensive development program on driver fuel development, physics development and testing of components and subsystems will be carried out to insure reliable operation upon completion of the facility.

The Commission will support a research and development program designed to demonstrate the technological feasibility and to provide a basis for a realistic assessment of the engineering and economic potential of the Molten Salt Breeder Reactor System.

d. Desalting Program and Other Processes

Cooperative work with the Department of Interior will be continued to insure the timely development of nuclear energy applicable to the desalting programs. Research and development work will be continued on large HWR plants, and other reactor concepts will be studied. Under the overall program, cooperative efforts are either under way or planned for: 1) studies of other process applications and research and development, and 2) demonstration of nuclear desalting plants on a national and international level directed at the economic production of fresh water by utilizing nuclear energy for desalting.

1. Civilian Power Reactors - continued

The following table provides details of the estimates for the various reactor projects:

a. Converter Reactors			
(1) Water Reactors			
(a) Shippingport Atomic Power Station	FY 1967: $ 8,716,931	FY 1968: $ 6,400,000	FY 1969: $ 4,940,000
(b) Operation Analysis - Private Reactors	274,330	100,000	100,000
(c) Technical Support Services	29,140	0	0
Total	$ 9,020,401	$ 6,500,000	$ 5,040,000
(2) Superheat Reactors - BONUS	$ 2,219,477	$ 1,375,000	$ 1,760,000
(3) Plutonium Utilization			
(a) Plutonium Utilization	$ 4,429,555	$ 4,865,000	$ 3,950,000
(b) Experimental Boiling Water Reactor	718,379	135,000	50,000
Total	$ 5,147,934	$ 5,000,000	$ 4,000,000
Total Converter Reactors	$16,387,812	$12,875,000	$10,800,000
b. Advanced Converter and Low Gain Breeder Reactors			
(1) Water Reactors - Light Water Breeder Reactor (LWBR)	FY 1967: $11,558,523	FY 1968: $14,700,000	$15,500,000
(2) Heavy Water Moderated Reactors			
(a) Heavy Water Organic Cooled Reactor	10,590,804	2,700,000	0
(b) Operation Analysis - Piqua	583,605	350,000	0
(c) Canadian Cooperative Program	576,120	1,000,000	1,000,000
(d) Heavy Water Reactor General	0	1,550,000	2,000,000
Total	$11,750,529	$ 5,600,000	$ 3,000,000

REACTOR DEVELOPMENT PROGRAM - continued

1. Civilian Power Reactors - continued

	FY 1967	FY 1968	FY 1969
(3) High Temperature Gas Reactors Advanced Development Program			
(a) Fuel Development	$ 4,627,098	$ 3,628,000	$ 2,650,000
(b) Physics Development	780,179	545,000	600,000
(c) Component Development	911,050	1,612,000	1,700,000
(d) Systems and Plant Development Program	494,472	915,000	1,050,000
Total	$ 6,812,799	$ 6,700,000	$ 6,000,000
(4) Thorium Utilization	$ 2,420,191	$ 1,400,000	$ 1,100,000
Total Advanced Converter and Low Gain Breeder Reactors	$32,542,042	$28,400,000	$25,600,000
c. High Gain Breeder Reactors			
(1) Liquid Metal Fast Breeder Reactors			
(a) Fuel Development - FBR	$ 9,879,441	$12,300,000	$14,850,000
(b) Physics Development - FBR	7,035,789	14,402,000	17,500,000
(c) Component Development - FBR	6,730,603	12,300,000	18,140,000
(d) Systems and Plant Development FBR	2,269,711	5,118,000	3,760,000
(e) Experimental Breeder Reactor No. 2	7,875,656	10,380,000	13,700,000
(f) Fast Flux Test Facility	7,676,813	11,120,000	14,000,000
(g) Sodium Reactor Experiment	1,123,764	430,000	50,000
Total Liquid Metal Fast Breeder Reactors	$42,591,777	$66,050,000	$82,000,000
(2) Other Fast Breeder Reactors Systems	$ 1,543,902	$ 1,000,000	$ 1,900,000

1. Civilian Power Reactors - continued

(3) Molten Salt Breeder Reactor			
(a) Fuel Development	FY 1967: $ 845,484	FY 1968: $ 850,000	FY 1969: $ 1,400,000
(b) Component Development	838,567	930,000	2,600,000
(c) Systems and Plant Dev.	297,258	350,000	800,000
(d) MSRE Operations	2,147,121	2,070,000	1,900,000
Total Molten Salt Breeder Reactors	$ 4,128,430	$ 4,200,000	$ 6,700,000
Total High Gain Breeder Reactors	$48,264,109	$71,250,000	$90,600,000
d. Desalting Program and Other Processes			
(1) Studies and Evaluations	$ 1,116,639	$ 1,230,000	$ 1,200,000
(2) Research and Development	1,546,183	1,420,000	1,300,000
Total Desalting Program and Other Processes	$ 2,662,822	$ 2,650,000	$ 2,500,000
e. General Research and Development	$ 2,603,437	$ 3,300,000	$ 2,500,000
Total Civilian Power Reactors	$102,460,222	$118,475,000	$132,000,000
a. Converter Reactors			
(1) Water Reactors	$ 9,020,401	$ 6,500,000	$ 5,040,000
(2) Superheat Reactors - BONUS	2,219,477	1,375,000	1,760,000
(3) Plutonium Utilization	5,147,934	5,000,000	4,000,000
Total Converter Reactors	$16,387,812	$12,875,000	$10,800,000

The Converter Reactor Program provides for the continuing operation support of the Shippingport Atomic Power Station, the BONUS Superheat Power Plant; and analysis of high burnup or defective fuel from private reactors.

1. Civilian Power Reactors - continued

(1) Water Reactors

	FY 1967	FY 1968	FY 1969
(a) Shippingport Atomic Power Station	$ 8,716,931	$ 6,400,000	$ 4,940,000
(b) Operation Analysis - Private Reactors	274,330	100,000	100,000
(c) Technical Support Services	29,140	0	0
Total Water Reactors	$ 9,020,401	$ 6,500,000	$ 5,040,000

(a) Shippingport Atomic Power Station

Research and Development	$ 2,827,720	$ 2,425,000	$ 1,620,000
Fuel Fabrication	3,968,267	1,325,000	0
Test Operations	1,577,344	1,975,000	2,100,000
Test Irradiations	137,223	500,000	940,000
Test Reactor Experiments	206,377	175,000	280,000
Total Shippingport	$ 8,716,931	$ 6,400,000	$ 4,940,000

The primary objective of the Shippingport Atomic Power Station (PWR) project continues to be advancement of the basic reactor technology of large pressurized water reactors by actual operation of the reactor for long periods of time. Numerous tests have been conducted in the heavily instrumented reactor plant and core to evaluate its design and performance. Data obtained from these tests have been made available in over 1,900 reports and have played a major role in proceeding to new concepts in the commercial generation of nuclear power. PWR Core 2, which began operation in May 1965, represents a major effort to develop and test an advanced reactor core which includes new types of high performance fuel elements. This core is of the seed-blanket design as was Core 1.

PWR Core 2 has a design power rating of 150,000 gross electrical kilowatts, and a core design lifetime of 20,000 equivalent full power hours (EFPH). PWR Core 1 produced 67,000 gross electrical kilowatts. In addition to being an advanced nuclear design, PWR Core 2 also has a new refueling arrangement, which is expected to result in shorter refueling times. The core utilizes fuel elements consisting of oxide fuel plates clad with Zircaloy-4, an improved alloy, in both the seed and blanket. Core 2 is more heavily instrumented than was Core 1 and requires only 20 control rods and rod drive mechanisms compared to 32 in PWR Core 1.

1. Civilian Power Reactors - continued

The first highly enriched seed (PWR Core 1) installed in the Shippingport plant reactor operated from December 1957, to October 1959, achieving 5,806 equivalent full power hours (EFPH) of operation. During the period 1960-1962, operation of PWR continued with Seed 2 (7,900 EFPH) and Seed 3 (7,329 EFPH) installed with the original natural uranium blanket. The fourth seed used in Core 1 was depleted on February 9, 1964, having achieved 6,745 EFPH. Total hours of operation of PWR Core 1 were 27,780 EFPH compared to the original design objective of 8,000 EFPH. During Seed 4 operation, the Shippingport Atomic Power Station was used for testing, training, and power generation more than 97% of the time; the reactor plant was shutdown for maintenance less than 3% of the time. The first PWR core operated for more than 6 years, and generated a total of 1,798,000,000 kilowatt hours of electricity, more than half of this energy being obtained from the blanket. The average and peak depletion of the natural uranium oxide fuel in the blanket reached 11,000 and 37,000 megawatt days per metric ton of uranium, respectively. Several of the most depleted blanket fuel bundles have been re-installed in the reactor for continued operation with PWR Core 2. These assemblies had already operated for 6 years in Core 1, and achieved higher burnup than any other natural uranium oxide fuel in power reactors.

The first experimental decontamination of an entire commercial reactor plant was completed at Shippingport in March 1964. It will be particularly important to observe the buildup of after-shutdown radiation levels due to deposited radioactivity during Core 2 operation to observe its effect. Emphasis in the PWR project is now on operation and testing of PWR Core 2 and development and fabrication of a second seed. PWR Core 2 Seed 2 is scheduled to be completed during FY 1968 and installation in the Shippingport reactor completed during FY 1969.

During FY 1968 the thermal and hydraulic performance of PWR Core 2 Seed 1 will continue to be evaluated and compared with predictions through the remainder of Seed 1 lifetime. Physics effort will include monitoring and evaluating tests to further determine the range of validity of design methods. A mode of operating Core 2 Seed 1 for extended power operations will be identified. Fluid system and power plant modification packages will be prepared as required. The manufacture of Seed 2 will be completed and delivered to the Shippingport site for refueling. Design and procurement of handling tools and fixtures needed for use during the refueling will be continued. Preparations for Core 2 Seed 2 refueling will be made including preparation of refueling contingency procedures and the end-of-life core test program carried out. Safety analysis for Seed 2 operation will be completed. Plant testing

94-075 O-68-pt. 3—17

1. Civilian Power Reactors - continued

will be initiated for Core 2 Seed 2 initial startup and beginning of life program. Residual disposition of PWR Core 1 components will be accomplished at the Expended Core Facility. Irradiation test work will be conducted in the areas of fuel elements, poison elements, and structural materials, concentrating on proof testing of final Seed 2 component designs, as needed, to establish operating limits for Seed 2.

During FY 1969 the removal of Seed 1 and the installation of Seed 2 will be completed, the reactor restored to operating condition, and the Core 2 test program resumed. Operation of Seed 2 will be followed to assure performance is consistent with predictions. Test data will be obtained and evaluated. Thermal analysis will be conducted in support of spent fuel (Seed 1) and shipment to the Expended Core Facility for metallurgical examination and analysis will be initiated. Initial physics testing, operational follow of reactivity, and thermal and fuel element performance of Seed 2 will be evaluated throughout the year. Evaluation will be completed of Seed 2 initial startup and beginning-of-life tests. Planning for end-of-life removal, inspections, and disposal of Core 2 will be initiated. Irradiation experiments will be continued to "proof test" the Core 2 design to confirm allowable fuel element operating limits established for the balance of Core 2 life.

Revenues from the sale of steam in FY 1969 are estimated at $1,370,000 and are included in the Revenues portion of the budget.

(b) Operation Analysis - Private Reactors ..... FY 1967: $ 274,330 FY 1968: $ 100,000 FY 1969: $ 100,000

This project provides for examination and evaluation of high burnup fuel from the Yankee Nuclear Power Plant.

(c) Technical Support Services..... FY 1967: $ 29,140 FY 1968: $ 0 FY 1969: $ 0

The estimates for this activity are included as engineering support services under the BONUS, LACBWR and Elk River projects.

1. Civilian Power Reactors - continued

(2) Superheat Reactors

BONUS	FY 1967:	FY 1968:	FY 1969:
Research and Development.....	$ 630,520	$ 300,000	$ 300,000
Fuel Fabrication	592,138	125,000	0
Operations	996,819	950,000	1,460,000
Total Superheat Reactors	$ 2,219,477	$ 1,375,000	$ 1,760,000

The BONUS project is a cooperative arrangement between the Atomic Energy Commission and the Puerto Rico Water Resources Authority for the development, construction, and operation of a nuclear superheat power plant in Puerto Rico. When the BONUS project was initiated in January 1960, it was anticipated that the plant would be completed and turned over to the PRWRA for operation by January 1963. Problems during construction and startup delayed plant turnover to PRWRA until July 8, 1966.

The Commission is currently considering whether phase out of the BONUS project is desirable prior to the contract termination date of July 1971, and, if so, the method and timing of accomplishments. The costs projected in FY 1969 are based on procuring no new fuel or making any sizable investment in the plant pending determination of the phase out program. The increase in operation in FY 1969 reflects the planning for the decommissioning of the facility.

(3) Plutonium Utilization

(a) Plutonium Utilization

	FY 1967:	FY 1968:	FY 1969:
Research and Development....	$ 2,247,720	$ 2,370,000	$ 1,660,000
Operations	2,181,835	2,428,000	2,228,000
Irradiations	0	67,000	62,000
Total	$ 4,429,555	$ 4,865,000	$ 3,950,000

(b) Experimental Boiling Water Reactor

	FY 1967:	FY 1968:	FY 1969:
Research and Development....	$ 309,727	$ 35,000	$ 0
Operations	402,206	100,000	50,000
Irradiations	6,446	0	0
Total	$ 718,379	$ 135,000	$ 50,000
Total Plutonium Utilization	$ 5,147,934	$ 5,000,000	$ 4,000,000

1. Civilian Power Reactors - continued

The objective of this program is to develop, in cooperation with industrial efforts, a sound technological base for the safe, reliable and economical recycle of plutonium as a fuel. Recycle of plutonium fuel from light water reactors can significantly increase the efficiency of using nuclear fuels in the near-term pending completion of the development and large scale application use by the utilities of advanced reactor concepts currently under development. Although not as efficient as the advanced converter in terms of fuel utilization, plutonium recycle can reduce the requirements for fissile materials mined from the ground thereby extending the availability of nuclear resources through minimum investment.

Significant quantities of plutonium will become available by the end of this decade as a result of the operation of power reactors in existence and under construction. Private ownership of fuel materials, including plutonium, and the end of guaranteed government buyback of bred material contemplated in the early 1970's require the technology of recycling to be developed on a timely basis so that a realistic market price may be established for plutonium. Hence, the primary objective of this program is the development of technology to permit substitution of "high exposure" plutonium for uranium-235 in power reactors of existing designs. This program includes: (1) operation of the PRTR and associated facilities; (2) conducting studies of theoretical, analytical, and experimental nature on essential aspects of the plutonium fuel cycle for power reactor systems. Conceptual design studies and evaluations are under way to identify and take advantage of those nuclear properties of the plutonium isotope.

It should be noted that the industry requirements for thermal recycle of plutonium bearing fuel will develop prior to the time when there will be widespread demand for plutonium fuels for commercial fast breeder reactors. It should also be noted that there is a direct coupling between the plutonium recycle program and the high priority fast breeder program. Technical and industrial experience acquired in design, development, safety evaluations, fabrication, test and operation of plutonium recycle fuel, utilizing high exposure plutonium discharged from light water reactors, will in many instances contribute directly to the success of the fast breeder program and to establish its industrial base.

The estimates for EBWR represent closeout experiments in FY 1968 and analysis of the data in FY 1968-1969.

1. Civilian Power Reactors - continued

b. Advanced Converter and Low Gain Breeder Reactors

(1) Water Reactors.....	FY 1967: $11,558,523	FY 1968: $14,700,000	FY 1969: $15,500,000
(2) Heavy Water Moderated Reactors..	11,750,529	5,600,000	3,000,000
(3) High Temperature Gas Reactors...	6,812,799	6,700,000	6,000,000
(4) Thorium Utilization	2,420,191	1,400,000	1,100,000
Total Advanced Converter and Low Gain Breeder Reactors	$32,542,042	$28,400,000	$25,600,000

The Commission plans support of the following advanced converter-low gain breeder concepts: (1) Light Water Breeder Reactor; (2) Heavy Water Moderated Reactors; and (3) High Temperature Gas Reactor. The advanced thermal-near breeders potential of substantial economic saving is a principal incentive for the development of advanced converter-low gain breeder reactor technology. The continued research and development in the LWB program is directed toward the technology of breeding using the seed-blanket concept in a light water thermal reactor. Successful demonstration of breeding in light water reactors would provide the basic technology which could make available for power production about 50% of the energy in the thorium reserves, a source of energy many times greater than known fossil fuel reserves. The objectives of work to date have been to develop technology in the areas of fuel element, physics and core engineering in order to proceed with the demonstration of breeding technology. The Heavy Water Moderated Reactor program is being conducted as a base technical program in cooperation with the Canadian effort with the objective of development and demonstration of advanced converter technology offering improved economics of power production and more efficient utilization of fissionable and fertile material; in addition, the HWR has potential for application in the desalting program in large size plants up to 10,000 MWT. Concurrent with this development objective, development of extremely large size plants are being supported under the desalting program. The High Temperature Gas Reactor Development program is directed to the objective of a 1000 MWE advanced converter which is capable of high conversion ratios (about .8), high cycle efficiency (about 40%) and low fuel cycle costs. The technology for realization of the HTGR potential is being developed and demonstrated by research and development on the fuel element physics, components, and the current operation of the Peach Bottom plant and planned operation of Public Service of Colorado (PSC) prototype. Peach Bottom will provide information on HTGR type fuel elements as well as components. The 330 MWE PSC plant will demonstrate fuel elements, prestressed concrete pressure vessel, and other key components of the HTGR plant. The HTGR advanced development program will provide the necessary technology which is beyond the state of technology of the PSC plant and is needed for development of a 1000 MWE economic advanced converter plant.

1. Civilian Power Reactors - continued

(1) Water Reactors -

Light Water Breeder Reactor (LWBR)

	FY 1967	FY 1968	FY 1969
Research and Development	$ 8,361,563	$11,050,000	$ 9,900,000
Fuel Fabrication	0	0	2,100,000
Test Irradiations	1,705,296	1,950,000	2,000,000
Test Reactor Experiments	1,491,664	1,700,000	1,500,000
Total LWBR	$11,558,523	$14,700,000	$15,500,000

During FY 1966 work under this project was reoriented to research and development directed toward demonstrating the technology of breeding using the seed-blanket concept in a light water thermal reactor. From work done to date, it appears feasible to design a reactor core which could demonstrate breeding using the thorium seed-blanket concept in an existing pressurized water reactor. No major changes would be required in the plant except those changes associated with the core design. Successful completion of this breeding demonstration would show that it is feasible to install breeder cores in existing and future pressurized water reactor plants and would be a major advance in power reactor technology.

The LWBR concept is the only known approach for increasing the fuel utilization of light water thermal reactors significantly beyond the 1 to 2% achievable with present types of light water reactors. Successful demonstration of breeding in light water reactors would provide the basic technology which could make available for power production about 50% of the energy in the thorium reserves, a source of energy many times greater than known fossil fuel reserves. Since this concept is based on the proved technology of the pressurized light water system, it is devoid of many of the technical problems that must be solved to obtain high fuel utilization using other systems.

During FY 1968 the LWBR reference design will be completed and a bid package for core fabrication prepared so that a contract could be placed in mid FY 1969. Studies to identify the detailed manufacturing process and the associated facilities required for manufacturing of the core (using radioactive fuel) will be commenced. Test programs in support of the reference design will be initiated. A refined nuclear design analysis model will be developed. Breeder mock-up fuel deliveries will be completed and cold and hot critical experiments will be conducted. The procurement of the detailed cell critical will be initiated and experiments with the cell will be designed. Full size module proof testing will be initiated. In-pile and out-of-pile proof testing of reference design components will be initiated to confirm the final core design structural, hydraulic and thermal characteristics. The variable geometry control balance piston concept test will be completed and an in-pile blanket rod test initiated. Bid packages will be prepared for design and fabrication of a mechanism lead unit and design studies and development of the pressure vessel head. Work will be in progress to design and initiate procurement of bearings and roller nuts for performance test and design evaluation. A mockup mechanism motor will be designed and procured for performance test and design evaluation.

1. Civilian Power Reactors - continued

A shield design adequacy report will be prepared and necessary modifications to the Shippingport plant will be identified. Application and evaluation of corrosion product behavior on rod bundle heat transfer surfaces will be continued by analysis and experiment. An evaluation of the effects of fuel rod bowing on thermal capability will be continued as will development of the required analytical and empirical heat transfer, pressure drop and departure from nucleate boiling correlations to quantitatively assess bundle thermal and hydraulic performance. Detailed analysis of the movable fuel ejection accident will continue. Conceptual design of major refueling equipment will be completed and specifications prepared. Irradiation experiments and analytical effort will be continued as required to permit development of a breeder type fuel capable of performing over core design lifetime.

During FY 1969 contracts will be placed for fabrication of portions of the LWBR breeding demonstration core, reactor vessel closure, mechanisms, instrumentation, and power supplies and fabrication will be initiated. Thermal and hydraulic test programs will be continued to provide necessary design type information. Design calculations will be continued to support the final reference design. Studies will be initiated to develop the reactor protection analysis. Heat transfer tests on electrically heated rod assemblies will be continued as will thermal design work on an LWBR proof test module. The reactor scale flow model will be completed. Full scale module mechanical design proof testing will continue as will tests of fuel rod support systems. Relaxation levels, previously extrapolated from early results, will be confirmed and the adequacy of the structural support system confirmed. Detail design and procurement of core installation and refueling equipment and tools will be continued. Mechanism and motor mock-up tests will be continued.

The fuel loading for the demonstration core will be established using experimental physics critical results and a newly refined detailed core nuclear design model. Detailed core safeguards analysis will continue as will mock-up and detailed cell critical experiments required to set the fuel loading. A shield design analysis will be prepared. Plant auxiliary systems and arrangement studies will continue in support of the detailed core design. A test program for the demonstration core installed in the Shippingport plant will be defined and preparation of test resumes initiated. Operating procedures and system descriptions will be prepared.

Irradiation experiments will continue as required to permit confirmation of fuel elements capable of performing satisfactorily over core design lifetime. These irradiation tests will include proof tests of prototype seed and blanket rod assemblies using $U\text{-}233O_2$ and ThO_2 fuels as planned for the demonstration core. Additional test hardware procurement required for these irradiation tests will be accomplished.

1. Civilian Power Reactors - continued

(2) Heavy Water Moderated Reactors

(a) Heavy Water Organic Cooled Reactors	FY 1967: $10,590,804	FY 1968: $ 2,700,000	FY 1969: $ 0
(b) Operation Analysis - Piqua	583,605	350,000	0
(c) Canadian Cooperative Program	576,120	1,000,000	1,000,000
(d) Heavy Water Reactor General	0	1,550,000	2,000,000
Total Heavy Water Moderated Reactor	$11,750,529	$ 5,600,000	$ 3,000,000

In FY 1968 the program is being aligned to support a base heavy water program to maintain the option, in the future, to exploit heavy water reactors for power production and for the extremely large size needed for dual purpose and desalting applications. This base program will take advantage of heavy and light water experiments in the U. S. A. and foreign countries. In this regard, the United States is closely allied with Canada with their established heavy water moderated reactor program. Through existing agreements the United States has access to the technology and will continue a strong cooperative effort.

(a) Heavy Water Organic Cooled Reactors ..... FY 1967: $10,590,804 FY 1968: $ 2,700,000 FY 1969: $ 0

The FY 1968 estimate represents the close-out costs for this activity.

(b) Operation Analysis - Piqua
Research and Development....FY 1967: $ 583,605 FY 1968: $ 350,000 FY 1969: $ 0

Concurrent with the termination of the Piqua Power Demonstration reactor project, Commission support for this research and development effort will be phased out in FY 1968.

(c) Canadian Cooperative Program
Research and Development....FY 1967: $ 576,120 FY 1968: $ 1,000,000 FY 1969: $ 1,000,000

1. Civilian Power Reactors - continued

This program is a cooperative effort between the U. S. Atomic Energy Commission and the Atomic Energy of Canada, Ltd., for the joint development and exchange of information in technology for advancement of the heavy water reactor concept. The development work is carried out by U. S. industrial contractors, Commission Laboratories, and U. S. universities under the direction of the U.S. - Canadian joint technical board, consistent with the terms of the Memorandum of Understanding, to help insure that the development work is closely related to furtherance of heavy water reactors technology both in the U.S. and Canada.

(d) Heavy Water Reactor General....FY 1967: $ 0 FY 1968: $ 1,550,000 FY 1969: $ 2,000,000

In March 1967, the decision was made to phase out further work on the heavy water moderated, organic cooled reactor concept but to maintain a heavy water reactor program in the U. S. until the role of the advanced converters is further clarified. Over the next few years a research and development program will be conducted to enable the U. S. to maintain the option to exploit heavy water reactors in the future for power production and for the extremely large sizes needed for dual purpose and desalting applications taking maximum advantage of the large Light Water Reactor industrial and utility base in this country.

Early in FY 1968 a Program Office was established at Pacific Northwest Laboratory to conduct the technical planning of the program, R&D activities, and the integration of heavy water activities in the U. S. with similar activities in Canada and other countries. During FY 1968-FY 1969 economic and design evaluation studies will be continued on various types of heavy water moderated, light or heavy water cooled systems. Since the pressure tube is a basic component in most heavy water reactor concepts, a program will be initiated to establish the technical basis for a suitable, long-life pressure tube. Trade-off studies will be conducted of a general nature directed toward determining whether the modularization of the calandria-shields-pressure tube assembly is an attractive option and to determine development, economic and technical advantages of various aspects of on-line refueling. The investigation of techniques to control extremely large reactors will be initiated.

1. Civilian Power Reactors - continued

(3) High Temperature Gas Reactors

Advanced Development Program

(a) Fuel Development	FY 1967: $ 4,627,098	FY 1968: $ 3,628,000	FY 1969: $ 2,650,000
(b) Physics Development	780,179	545,000	600,000
(c) Component Development	911,050	1,612,000	1,700,000
(d) Systems and Plant Development	494,472	915,000	1,050,000
Total Advanced Development	$ 6,812,799	$ 6,700,000	$ 6,000,000

(a) Fuel Development

In-Pile Capsule and Loop Experiments	FY 1967: $ 2,256,070	FY 1968: $ 1,615,000	FY 1969: $ 1,100,000
Fission Product Studies	616,345	544,000	500,000
Recycle Fuel	1,151,270	838,000	850,000
Graphite Experiments	603,413	631,000	200,000
Total Fuel Development	$ 4,627,098	$ 3,628,000	$ 2,650,000

The fuel element work in FY 1969 will continue to concentrate on in-pile capsule tests, out-of-pile fission product chemistry studies, recycle fuel elements, and graphite studies. The in-pile capsule tests will continue in the Oak Ridge Research Reactor and the Engineering Test Reactor. Fuel irradiation test conditions will be extended to higher temperatures, high burnup, and higher fast neutron doses to determine operating limits on fuel performance and performance under abnormal and emergency conditions. Matrix type fuel will be irradiated in long term tests to evaluate effects of high burnup and to provide source materials for reprocessing studies. Loop irradiations will be conducted to evaluate the performance of integral fuel elements under realistic operating conditions particularly when fuel-coolant interactions are involved such as possible corrosion, mass transfer, and fission product transport effects. In conjunction with the loop experiments, out-of-pile tests will be conducted to determine the mass transport characteristics for the metallic fission products, particularly Strontium, Barium, and Cesium in helium temperatures up to 1400°F. Fission product desposition data from the Peach Bottom reactor, the UHTREX, and possibly others will be evaluated and coordinated with the analytical model previously developed.

The fuel recycle effort will be directed toward the needs of this particular reactor design, including suitability for reprocessing, integrity for high burnup and long-term service, and improvements in economics of coating the fuel particles.

1. Civilian Power Reactors - continued

In-pile irradiation tests will be conducted on graphites to obtain data on the effects of irradiation damage particularly in the range of 650° - 1500°C. Various assemblies of pyrolytic-carbon coated fuel particles and graphite will be fabricated, and reaction rates of these composites with steam will be measured at temperatures and partial pressures of interest.

(b) Physics Development

Experimental Reactor Physics....	FY 1967: $ 360,058	FY 1968: $ 250,000	FY 1969: $ 250,000
Nuclear Data	420,121	295,000	350,000
Total Physics Development	$ 780,179	$ 545,000	$ 600,000

The emphasis in physics development will continue to be on studies and experiments of 1000 MWE HTGR cores that contain U-233 recycle fuel. The critical experiments measurements of the flux and power distribution in the vicinity of fuel discontinuities appropriate to the fuel zoning in large HTGR's will be conducted and an analysis of the initial experimental results will be made and compared to values for the same conditions to determine the calculational uncertainties.

The methods development and cross section data will include diffusion model analysis and studies of such areas as the establishment of cross-sections for the conceptual design conditions, yearly loading requirements and nuclide concentrations, and the excess and shutdown reactivities during the approach to equilibrium and at equilibrium.

(c) Component Development

Prestressed Concrete Reactor Vessel	FY 1967: $ 911,050	FY 1968: $ 1,250,000	FY 1969: $ 1,350,000
Equipment and Instrumentation ..	0	362,000	350,000
Total Component Development ..	$ 911,050	$ 1,612,000	$ 1,700,000

A component development program covering the design, construction, and safety aspects of the prestressed concrete reactor vessels (PCRV) and related components and systems penetrations will be continued. Data will be developed on the thermal behavior of concrete, analytical methods, quality control, design modification, and transient and failure characteristics. The thermal problem includes the influence of temperature on concrete properties at currently proposed operating conditions for a number of reactor concepts, other than the HTGR. Improved analytical methods are of particular importance in the development of techniques to handle particular design and the inelastic behavior of the concrete. Quality control, testing, and inspectibility are highly

1. Civilian Power Reactors - continued

important in the construction of devices for nuclear application, and analytical methods and codes used for more familiar types of construction should be augmented. Failure modes must be investigated so that a realistic basis for the safety and design of the vessels can be established for temperature and pressure ranges of interest to the entire reactor development program.

(d) Systems and Plant Development

Advanced Eng. Development.....FY 1967:	$ 68,151	FY 1968: $ 128,000	FY 1969: $ 150,000
HTGR Analysis	426,321	787,000	900,000
Total Systems and Plant Development	$ 494,472	$ 915,000	$1,050,000

The systems and plant development will include such tasks as updating 1000 MWE) design including those examinations of concepts, components and systems that have been demonstrated to be potentially technically superior, and the investigation of an advanced design of the helium circulator and steam generator for use with advanced steam cycles or increased primary coolant pressure.

(4) Thorium Utilization

(a) Research and Development....FY 1967:	$ 2,308,021	FY 1968: $ 1,322,000	FY 1969: $ 1,100,000
(b) Irradiations	112,170	78,000	0
Total Thorium Utilization .	$ 2,420,191	$ 1,400,000	$ 1,100,000

Private ownership of fuel materials, including U-233, and the end of guaranteed government buy-back of bred U-233 will require technology for recycling U-233 for use as fuel material. The refabrication technology should be developed on a timely basis so that realistic market price, without Government support, may be established for U-233. Hence, the primary objective of this program is the development of technology to permit commercial recycling of U-233 in thorium using advanced converters such as the HTGR and the LWBR. Because of the use of the sol-gel process this program may also have value to the plutonium fuel recycle for the fast breeders.

REACTOR DEVELOPMENT PROGRAM - continued

1. Civilian Power Reactors - continued

c. High Gain Breeder Reactors

	FY 1967	FY 1968	FY 1969
(1) Liquid Metal Fast Breeder Reactors			
(a) Fuel Development - FBR	$ 9,879,441	$12,300,000	$14,850,000
(b) Physics Development-FBR	7,035,789	14,402,000	17,500,000
(c) Component Development - FBR	6,730,603	12,300,000	18,140,000
(d) Systems & Plant Development - FBR	2,269,711	5,118,000	3,760,000
(e) Experimental Breeder Reactor No. 2	7,875,656	10,380,000	13,700,000
(f) Fast Flux Test Facility	7,676,813	11,120,000	14,000,000
(g) Sodium Reactor Experiment ..	1,123,764	430,000	50,000
Total Liquid Metal Fast Breeder Reactors	$42,591,777	$66,050,000	$82,000,000
(2) Other Fast Breeder Reactor Systems	$ 1,543,902	$ 1,000,000	$ 1,900,000
(3) Molten Salt Breeder Reactor			
(a) Fuel Development	$ 845,484	$ 850,000	$ 1,400,000
(b) Component Development	838,567	930,000	2,600,000
(c) Systems and Plant Development	297,258	350,000	800,000
(d) MSRE Operations	2,147,121	2,070,000	1,900,000
Total Molten Salt Breeder Reactors	$ 4,128,430	$ 4,200,000	$ 6,700,000
Total High Gain Breeder Reactors	$48,264,109	$71,250,000	$90,600,000

1. Civilian Power Reactors - continued

The Liquid Metal Fast Breeder Reactor program is the Commission's highest priority civilian nuclear reactor program with the objective of the development and demonstration of safe, reliable, and economical fast breeder reactor power plants for the utility environment. A most important element of this objective is to foster the development of a competitive and self-sustaining LMFBR industry.

Liquid Metal (Sodium) Cooled Fast Breeder Reactors have inherent potential advantages: (1) low-pressure reactor system, (2) high temperature operation and efficiency, (3) short doubling time, (4) excellent neutron economy with high breeding ratios, and (5) a hard neutron spectrum resulting in the most favorable utilization of uranium-238 and plutonium. It is acknowledged, however, that the development of the necessary base technology, with a sound engineering approach and minimal risks, will require substantial expenditures and extensive engineering effort.

Major development problem areas are in fuels and materials, physics, coolant technology, instrumentation and controls, component engineering and proof testing, nuclear safety, fuel reprocessing and recycling, core design, and plant design and related studies. The Commission is directing the LMFBR program to obtain the maximum industrial contribution toward solving the problems, to broaden the industrial capability, to strengthen industrial technical management and to develop coordinated long-range planning. The advice of utilities, the final customer, has and will continue to be sought and has been helpful in establishing the national objectives. Extensive effort has been and will continue to be devoted to detail program evaluations and planning, and detailed technical and management assessments and follow through.

The budget estimates for FY 1969 provide for continued support of fast breeder fuels and materials development to insure the development of its technology and industrial capability to manufacture fuel elements meeting necessary standards, criteria and specifications for safe and reliable performance, utilization and economy. Although primarily oriented to the LMFBR concept, this effort will have significant applicability to other FBR concepts.

A substantial cost increase in physics is required in FY 1969 for delivery of ZPPR fuel being manufactured by NUMEC and AEC's Rocky Flats plant. Industrial assistance in physics evaluation of ZPR data must be obtained to complement in-house capability and future industrial growth in this specialized discipline. In addition, component development will significantly increase due to: (1) procurement of large valves, piping, pumps, and steam generators; and (2) extensive use of the engineering resources and facilities of the Liquid Metal Engineering Center.

1. Civilian Power Reactors - continued

Other cost increases in FY 1969 are expected for EBR-II and FFTF. Fuel will be procured for EBR-II from Aerojet General and produced in the "cold" fuel fabrication line at the EBR-II site. Higher power operation of EBR-II to improve its efficiency as an irradiation facility is planned.

A general buildup of the FFTF program will be in progress in FY 1969 resulting in higher costs than FY 1968. Design of the FFTF will be in full progress and a general construction contractor will have started work in FY 1969.

(a) Fuel Development - FBR

	FY 1967:	FY 1968:	FY 1969:
(1) Metallic Fuel	$ 777,929	$ 450,000	$ 600,000
(2) Oxide Fuel	3,737,462	6,100,000	7,800,000
(3) Carbide Fuel	2,266,010	2,700,000	2,900,000
(4) Fuel Cladding and Structures	3,098,040	3,050,000	3,550,000
Total	$ 9,879,441	$12,300,000	$14,850,000

The fuel and related cladding development program for fast breeder reactors is one of the most critical problems which must be solved in order to meet the program objective of developing safe, technically sound, economic, large size Fast Breeder central station power plants. The fuel development program is aimed at producing a safe and reliable plutonium fuel, with an ultimate burnup potential of 100,000 MWD/ton. A longer range objective is that the burnup may eventually be increased. Such improvement will be based on data obtained from statistical tests under thermal and fast neutron irradiation and by other methods for fuel improvement. The nation's qualified technical resources are being focused on this major problem area.

The fuel program is being redirected by assigning the highest priority to the development of the plutonium bearing oxide type fuel because of the advanced state of its technology which makes it the leading contender for the first cores of the FFTF and early demonstration plants. A lower priority has been assigned to the development of plutonium bearing carbide fuels. A secondary effort is under way on ternary metal alloys. Other fuels which have potential advantages for significant performance and economics are being investigated at a lower level of effort under the general reactor technology program. Such fuels are generally of the mixed ceramic type, such as nitrides, sulphides, phosphides, and/or combinations thereof.

1. Civilian Power Reactors - continued

The specific objectives of the fuels and cladding materials program are:

a. To develop a fuel whose characteristics up to target burnups of 100,000 MWD/ton are such that it will have a minimum of interaction with the clad, a minimum of swelling, and fission gas release consistent with safety, operational and maintenance standards.

b. To develop a cladding material whose characteristics up to target irradiation and environment exposures are such that the material will have a minimum of interaction with the fuel or its residuals or with the coolant environment, and whose integrity is maintained under those conditions.

c. To develop a fuel element, with geometry and dimensions in accordance with prescribed subassembly and core design requirements, whose behavior will be such as to maintain a stable configuration under the thermal, hydraulic, and mechanical forces exerted by the reactor environment or by the fuel element itself.

d. To utilize the data obtained from the above activities for the preparation of detailed specifications and procedures for establishment of meaningful fuel process and fabrication standards.

The general criteria of each fuel investigation will include, but not be limited to, such items as fuel burnup, fuel temperatures, temperature gradients, fission gas release, fuel particle size and distribution, thermal conductivity, thermal expansion, density changes, stoichiometry, fuel slumping, fuel ratcheting, location of fission gas collection plenum, redistribution of fuel and its resultant fission products, oxidation or reduction; clad temperature, clad strength-ductility-integrity, clad-coolant interaction, clad thermal conductivity, clad-fuel interaction fuel element geometry, venting, and stability. Much of this work on the mixed oxide and carbide fuels program, will be applicable to other fast breeder concepts.

1. Civilian Power Reactors - continued

The Commission has recognized that a substantial augmentation of each fuel investigation must be initiated as rapidly as practical, in accordance with the current detailed Fuels and Materials Cladding Program Plan, to strengthen fast reactor fuel development by using the combined talents of Commission laboratories and U.S. industrial capability. Estimates for FY 1968-1969 support this goal.

There will be an increase in costs in FY 1969 as more effort is applied to study the creep characteristics of mixed oxide fuels during irradiation. Additional increased costs for cladding development are primarily due to two factors: (1) an increase in the number of irradiation specimens removed from the test reactors will require an increase in post-irradiation examinations, and (2) an increase in the purchase and evaluation of commercial and specialty alloys will be required as development commitments are met.

This effort is expected to furnish important data for use in the FFTF and Demonstration plants.

(b) Physics Development - FBR

	FY 1967	FY 1968	FY 1969
(1) Theoretical Reactor Physics...	$ 1,135,544	$ 1,580,000	$ 1,441,000
(2) Experimental Reactor Physics .	1,270,838	1,150,000	1,790,000
(3) Zero Power Reactors (ZPR's) ..	1,864,578	2,511,000	3,463,000
(4) Zero Power Reactors Fuel	1,461,010	6,652,000	8,156,000
(5) SEFOR	1,303,819	2,509,000	2,650,000
Total	$ 7,035,789	$14,402,000	$17,500,000

The neutron environment and safety problems of fast breeder reactors require extensive analytical and critical experiment work to determine the magnitude of the Doppler coefficient, systems and materials reactivity effects, and sodium void coefficients of reactivity; and to determine and predict the effects of the system and neutronic environment more precisely on system safety and performance in order to advance the technology necessary to proceed with design and construction of safe demonstration facilities. The Southwest Experimental Fast Oxide Reactor (SEFOR) and the ZPR facilities will be utilized in carrying out the experimental program.

94-075 O-68-pt. 3—18

1. Civilian Power Reactors - continued

A coordinated program of theoretical and experimental reactor physics involving both industry and laboratory is being conducted. Computer programs and analytical methods will be developed and used for studies of fast reactor neutronics, thermal hydraulics, and safety characteristics. A program will be pursued to define fast reactor experiments and develop experimental techniques to support the critical experiment program. Shielding studies and experiments will be performed to establish a sound basis for predicting design parameters for fast reactor shielding. The measurement of reactivity effects of high burnup fuel and isotopic determination of fissile and fission product yields will be investigated. Increase in FY 1969 experimental reactor physics provides for expanding experimental support for the ZPR's and ZPPR concurrent with the start of extended shift operation of these facilities. Although principally oriented at this time to the LMFBR program, much of this effort should be applicable to alternate fast breeder concepts.

The Zero Power Reactor effort provides for the operation and analysis of four zero power reactor experiments. ZPR-III, is a flexible, fast, zero power critical reactor of up to 1,500 liters in size and is the only U. S. facility available at this time to investigate cores containing large amounts of plutonium. During FY 1968-1969 a closely related series of dilute plutonium fueled critical experiments will be completed in addition to extensive experimental work on engineering models of test reactor cores including that of the high priority FFTF. The ZPR-VI and IX, two 3,000 liter split-table criticals, will conduct experiments on cores of simple geometry and composition for the verification of computational techniques, measurement of reactivity effects, and cross sections for the design of large fast power breeder reactors. Modification of these facilities for the use of up to 1,000 kgs of plutonium each is under way. Increase in FY 1969 provides for extended shift operation of ZPR-VI and IX to strengthen the support of the fast breeder program. The Zero Power Plutonium Reactor (ZPPR), currently under construction is designed to handle much larger plutonium critical assemblies containing up to 3,000 kgs of Pu and engineering mockups of large 1,000 MWe fast reactor cores up to 6,000 liters. Increase in FY 1969 provides for increasing staff support for two shift operation of ZPPR to investigate simulation of an oxide-fueled reactor of approximately 2,000 liters. Additional cores of about 3,500 and 5,000 liter sizes to be determined by the fuel delivery schedule, will be investigated subject to requirements for ZPPR to perform mockup criticals for fast breeder demonstration designs.

1. Civilian Power Reactors - continued

A large inventory of fuel and nonfissile materials is required for the program of critical experiments and engineering mockups now planned. Approximately 3,100 kgs of plutonium metal fuel are currently required. Increases in FY 1969 will provide principally for 500 kgs of Pu oxides-carbides and 300 kgs of U oxides. It is noted that ZPR III, VI, IX and ZPPR are so designed that the fissile and nonfissile material assemblies are completely interchangeable and will be used freely among the facilities in a way that optimizes the overall program with a minimum of inventory.

SEFOR, located near Fayetteville, Arkansas, is a 20 MWt sodium-cooled fast reactor aimed at measuring the negative reactivity feedback (Doppler effect) as the reactor undergoes a series of transient tests of increasing severity. The experimental reactor is being financed jointly by Southwest Atomic Energy Associates, Karlsruhe Laboratory of the West German Federal Government, Euratom, and General Electric Company. The AEC is providing the support of the research and development program and operation and maintenance of the reactor following completion of construction. The AEC is also providing funds for the fabrication of the core which will be delivered to the SEFOR site beginning in March 1968. Emphasis in FY 1968 will be placed on preoperational checkout and performance testing of the reactor followed by execution of the experimental test program which will start in early FY 1969. The successful operation of the SEFOR and the measurement of the Doppler effect will be a most important milestone in the LMFBR physics program.

(c) Component Development - FBR

	FY 1967	FY 1968	FY 1969
(1) Sodium Component Test Facilities (LMEC).....	$ 3,327,300	$ 4,560,000	$ 6,396,000
(2) Sodium Technology	2,034,427	2,150,000	2,900,000
(3) Heat Exchangers and Steam Generators	1,002,735	1,550,000	2,250,000
(4) Pumps, Valves & Piping..	173,809	661,000	1,850,000
(5) Reactor Mechanisms and Instrumentation	192,332	1,959,000	2,594,000
(6) Fuel Handling , Vessels and Internals	0	1,420,000	2,150,000
Total	$ 6,730,603	$12,300,000	$18,140,000

1. Civilian Power Reactors - continued

The objectives of the Liquid Metal Component Development program are to develop sodium components and technology, to develop criteria, standards, and specifications, to verify design concepts and to proof test components and mechanisms in order to provide safe, reliable, maintainable, and economic components for the liquid metal-cooled fast breeder reactor program. This will require the development and testing of components in large sizes to withstand high irradiation and temperature environments beyond the current state of technology, utilizing the industrial capabilities to the maximum possible degree. Representatives of the industries will participate in the development, design, construction, operation and proof-testing of liquid metal components and will further establish and instill the requirements of the adequate quality assurance programs needed in this area.

The Liquid Metal Engineering Center (LMEC) is comprised of a complex of component test facilities with the necessary supporting chemical, metallurgical and instrumentation laboratories for testing and evaluating components, such as steam generators, valves, pumps, heat exchangers, and instruments for fast breeder reactors. In addition the Center provides technical assistance and consultation services to the AEC. It includes the operation of a Liquid Metal Information Center which compiles, assesses, and disseminates all available information for use by those participating in the overall program.

Current plans call for completion of design, fabrication and replacement of portions of the high pressure steam system for the Sodium Component Test Installation (SCTI) and initiation of steam generator testing in FY 1968. Design of the Sodium Pump Test Facility (SPTF) was undertaken to provide the capability for proof testing large size pumps of up to 120,000 gallons per minute capacity, and 1200°F components and equipment under environmental and operating conditions. In FY 1969 the Title I effort will have been completed and the Title II effort initiated. The procurement of long lead time items will begin in FY 1969. Shop inspection for these items will be accomplished under Title III. Technical assistance and consultation will continue to increase in FY 1969 to meet the requirements in the components area for establishing a strong technological foundation for the LMFBR program. This will include developing standards and specifications, implementing elements of the LMFBR Components Program Plan, initiating an incident reporting plan, conducting special design studies, and making technical recommendations which are vital in planning future LMFBR activities. Emphasis will also be placed on developing LMEC's capability for testing instrumentation and controls. The feasibility of using the Auxiliary Components Test Installation (ACTI) for testing components

1. Civilian Power Reactors - continued

and instrumentation will be determined. In FY 1968 the overall conceptual system design description will have been completed and reviewed to assure that all LMFBR component test requirements that can be accommodated in the ACTI will be met. Also alternate methods of providing required test capabilities will be reviewed to determine optimum design requirements. In FY 1969 the final conceptual design for the ACTI will be completed. The A-E effort, Title I and II, also will be initiated.

Sodium technology development has as its objectives the understanding of sodium corrosion effects on candidate LMFBR materials and the elucidation of the fundamentals of sodium corrosion. Accordingly, the plans for the program are: (1) to study mass transfer in sodium loops; (2) to observe the effects of a sodium environment on the strength and ductility of candidate alloys; (3) to develop and evaluate meaningful processes for the purification of sodium coolants. The technology on effects of high temperature sodium operating in reactor systems requires extensive chemical and engineering study and experimental work in the areas of corrosion and system purification. The principal increases in FY 1969 are in such areas as sodium mass transfer control, hydrodynamic behavior and flow characteristics of model cores, sodium vapor (frosting) removal for equipment and behavior of mechanisms in sodium.

The fast reactor heat removal systems are characterized by the need to remove relatively large quantities of heat from small volumes in order to keep fuel inventory costs down and to improve the rate of production of new fissionable materials. The program plan provides for the development, fabrication, testing and evaluation of heat exchangers and steam generators to meet the stringent reactor system program requirements. The steam generator is considered one of the most critical components requiring development.

Analysis, investigation and development of various elements leading toward the design, fabrication and test of improved heat exchangers and steam generators will be initiated. The increase in FY 1969 is required to support this work and to initiate the fabrication of prototype steam generators and heat exchangers.

The study, design and test of sodium pumps, valves and piping, and the development-testing of bearings, seals and other elements directly related to pumps and valves require extensive engineering development. Procurement will be initiated on the first large sodium pump for testing in the Sodium Pump Test Facility. A companion work program will be continued on

1. Civilian Power Reactors - continued

development and testing of seals and bearings in a sodium test facility. During FY 1968 industrial contractors will be employed to perform research and development on piping and valves. The increase in FY 1969 is required for the design, development, procurement and testing of large sodium pumps, valves and piping. Large costs for hardware will be incurred in FY 1969.

Development and proof testing of operating instruments and controls needed for reliable plant operations require substantial strengthening. In-core instruments are required to operate reliably in high flux fast neutron, intense gamma radiation and elevated temperature environments. It is in this area that the need for development and proof testing of instruments and controls is of great importance. The end objective of the instrumentation and control programs is the development of the detailed specifications and quality control procedures necessary to insure that reliable equipment can be developed and fabricated by industry on a competitive basis. The increases in FY 1969 includes the priority need for the development of an electromagnetic flowmeter for the Sodium Pump Test Facility, development of special purpose instruments and increased engineering review and proof-test programs.

The development and design of a fuel handling machine in support of the fast breeder reactors will be implemented in FY 1968. Specifically, preliminary design for components requiring development test of prototyping will be accomplished and analyses of performance characteristics will be made. During FY 1969, fabrication and testing of components identified for developmental testing by design review will be performed.

(d) Systems and Plant Development - FBR

(1) 1000 MWe Reactor Plant.....	FY 1967: $ 927,425	FY 1968: $ 2,265,000	FY 1969: $ 1,211,000
(2) LMFBR Program Office	1,166,132	2,092,000	2,064,000
(3) Plant Analysis	176,154	761,000	485,000
Total	$ 2,269,711	$ 5,118,000	$ 3,760,000

1. Civilian Power Reactors - continued

Fast Breeder Reactor plant design studies are being conducted utilizing the services of five industrial contractors under the management of the Argonne National Laboratory to perform systems studies and related evaluations leading to identification of research and development programs and related priorities for required Liquid Metal Fast Breeder Reactor plants of 1,000 MWe. This effort, encompassing the nuclear steam supply system and the energy conversion system of a number of concepts, will during FY 1968 and FY 1969: (a) prepare Conceptual System Design Descriptions of the reference systems and subsystems; (b) perform system evaluations, including parametric studies and trade-off analyses where appropriate; (c) determine the incentive for research and development and component test programs which can be of the most benefit in assuring successful development of components and systems.

The Liquid Metal Fast Breeder Reactor Program Office will continue its operation to assist the AEC in detailed planning and technical assessments of various aspects of the LMFBR program. To meet this objective, the Program Office has conducted detailed technical reviews of the program elements, determined the state of the art for each element, identified program requirements and prepared initial drafts of detailed program plans. Efforts in FY 1968-1969 will be the updating of program objectives, preparation and dissemination of the official LMFBR program plan and technical monitoring and assessment of program progress. The Program Office will continually update the program plans as requirements change.

Plant analyses currently includes detailed analyses of components, instruments and controls, and systems performance to enumerate how improvements can be made on future designs. The scope of plant performance effort is to compile selected portions of reactor system experience into reports that are usable in the design of components and systems such as fuel handling systems and steam generators.

(e) Experimental Breeder Reactor No. 2

(1) Research and Development..	FY 1967: $ 2,911,251	FY 1968: $ 4,600,000	FY 1969: $ 4,920,000
(2) Fuel Fabrication	26,188	200,000	3,000,000
(3) Test Operations	4,938,217	5,580,000	5,780,000
Total	$ 7,875,656	$10,380,000	$13,700,000

1. Civilian Power Reactors - continued

The Experimental Breeder Reactor No. 2 (EBR-II) program is being directed to upgrade the capabilities of this facility for the irradiation of fast reactor candidate fuels and materials in a fast flux environment. Reactor operation at 45 MWt was started in March 1965. However, high plant availability as well as operation at the design power level (62.5 MWt) require significant attention and upgrading. At present, the EBR-II is the only available Commission owned liquid metal reactor where fuel and structural materials can be irradiation tested in a fast neutron spectrum. Hence, currently the EBR-II plays the key role in the FBR development programs. The emphasis on irradiation testing places a great importance on efforts to upgrade systems of the reactor and the Fuel Cycle Facility (FCF) which at this time is the principal source for providing EBR-II driver fuel. Further, the FCF will continue to provide services to support examination and testing of driver and experimental fuel removed from EBR-II.

Substantial effort in FY 1968 and 1969 will be directed toward effecting plant improvements to achieve design power rating, increasing plant factor, reducing facility operational complexities, and improving its utility as the fast flux irradiation facility. In addition to the direct engineering improvements, the principal ones planned include: (1) development of an instrumented subassembly, (2) operating with advanced experimental subassemblies and equipment which will allow interim examination of selected test capsules and reinsertion of the subassembly, (3) operating with unencapsulated fuel experiments, (4) incorporation of a radioactive sodium chemistry loop into the primary system and (5) development of an in-core failed fuel subassembly locator system. Further, in 1967 the EBR-II experienced difficulties which impeded operation of the reactor. These difficulties included excessive swelling of the depleted uranium blanket material, reduction in the reactor power coefficient of reactivity, a driver fuel and an experimental fuel fission gas leak, and deposition of about 11 pounds of copper into the primary sodium (from the primary system emergency cooling EM pump electrodes.) Efforts initiated in FY 1967 to resolve these problems will be continued in FY 1968.

1. Civilian Power Reactors - continued

Production of the EBR-II driver fuel by industry will begin in FY 1968. It is planned to use commercial vendor(s) as the principal source for providing an adequate supply of driver fuel. Initial delivery of this fuel is scheduled to begin during the last quarter of FY 1968. and continue through mid FY 1969, with a consequent result of increased cost in FY 1969.

(f) Fast Flux Test Facility

(1) Systems & Plant Dev. .....FY 1967:	$ 2,214,000	FY 1968: $ 3,427,000	FY 1969: $ 3,930,000
(2) Reactor Dev. & Analysis ..	3,617,813	5,435,000	7,300,000
(3) Fuel Handling & Radioactive Maintenance	754,000	848,000	1,335,000
(4) Instrumentation & Control	743,000	805,000	810,000
(5) Fast Reactor Materials ...	348,000	605,000	625,000
Total.....	$ 7,676,813	$11,120,000	$14,000,000

The objectives for the Fast Flux Test Facility are to provide an adequately controlled and instrumented environment in a fast flux for testing instrumented fuel specimens, fuel rods, fuel subassemblies, and clad material with capabilities to test fuel up to and including failure. The reactor must have a high reliable plant performance with means to test fuels for short time periods. Closed and open test loop facilities, interim nondestructive examination facilities and a nuclear proof test facility are included in the overall complex.

The combined laboratory and industrial efforts initiated in FY 1966 directed toward selecting the FFTF concept which best meets the testing capabilities as economically as possible were continued in FY 1967 and 1968. Alternate conceptual reactor core designs were prepared by Atomic Power Development Associates, Inc., Idaho Nuclear Corporation, Pacific Northwest Laboratory, General Electric and Westinghouse. An intensive evaluation of these alternatives was conducted by Pacific Northwest Laboratory resulting in the selection of a split core as the initial reference core for the FFTF with the vertical core as the alternate. Conceptual designs of the core concepts will be completed in FY 1968. Preliminary design is scheduled for completion and detailed design will be initiated in FY 1969.

1. Civilian Power Reactors - continued

Research and development on fuel process development and irradiation of fuel and cladding which was initiated in FY 1967 will be continued in FY 1968 and FY 1969. These efforts will be directed towards establishing product and process specifications for the FFTF fuel which will be utilized in conjunction with the FBR program to assist in developing the industrial capabilities necessary for production of fuel for these programs.

During FY 1967 the overall management and technical basis for the FFTF program were established and steps were taken to strengthen PNL's capability to carry through this program. A project reorganization was accomplished consistent with the program management plan and shift toward the preliminary design phase of the project.

A component proof testing program will be established in FY 1968 in coordination with testing facilities at the LMEC. Design efforts will be initiated in FY 1968 on hydraulic core mockup facilities necessary for establishing those hydraulic and mechanical characteristics of the core and reactor components needed for the design of the reactor. Physics critical experiments initiated in FY 1967 to determine control rod worth will be continued and expanded in FY 1968 and FY 1969 in the ZPR-III facility at Idaho to establish the physics characteristics needed for the core design.

Requests for proposals for Architect-Engineer/Construction Manager and a Reactor Plant Designer were prepared. Evaluation and selection will be made in FY 1968. The Richland, Washington, site was selected as the location for the FFTF.

Costs for FY 1969 reflect the result of a gradual buildup of program with increased effort on development of fuel, design of components, instrumentation and systems as substantial emphasis is being placed on the detailed design of the FFTF. In addition, design and procurement of prototype fuel pins will be accomplished and instrumented subassemblies for irradiation testing in EBR-II will be fabricated. Other items which contribute to the increased costs in FY 1969 are (1) overall increase in management, planning, scheduling and project control as the work progresses into detailed design and procurement phase,

1. Civilian Power Reactors - continued

(2) safeguards analyses and reviews as more detailed information becomes available from the designer, (3) more effort given in transient studies of operational methods using plant simulation, (4) start of qualification of vendors for fuel fabrication, (5) implementation of reliability and quality assurance procedures to support the quality assurance program plan and monitoring of the plan and related procedures and (6) equipment procurement for hydraulic core mockup and other design verification efforts.

(g) Sodium Reactor Experiment .....FY 1967: $ 1,123,764 FY 1968: $ 430,000 FY 1969: $ 50,000

The SRE was phased out in FY 1967. Costs in FY 1968 will be for planning and accomplishing deactiviation of the SRE to the degree required to meet AEC and State authority approvals. In FY 1969 cost will be for continuing deactivation, disposal of excess equipment and maintaining plant surveillance.

(2) Other Fast Breeder Reactor Systems FY 1967: $ 1,543,902 FY1968: $ 1,000,000 FY 1969: $ 1,900,000

Preliminary design studies and evaluations indicate that fast breeder plants employing coolants other than liquid metal such as steam and gas also have potential for high breeding gain and low fuel cycle costs. Emphasis in FY 1968-1969 will be on fuel element in-pile testing at the EBR-II and facilities to test fuel elements and program planning in addition to guidance being fed back from the LMFBR program plan.

Exploratory studies and investigations on large plant core physics, fuel elements, heat transfer and safety will be continued in FY 1968 and FY 1969 to the extent that the core development and program plan requires and the technology developments and analytical work support the future potential of the program.

Assessment studies to evaluate the need for other fast breeder reactor systems will be continued in FY 1968 and FY 1969. This effort will: (1) prepare preliminary design descriptions of appropriate systems and subsystems; (2) perform systems evaluations, including parametric studies where appropriate, to determine the incentives for research and development programs; and (3) identify specific areas where research, development and component test programs can be of the most benefit in reducing power generation costs consistent with safety and the effective use of natural resources. Industrial contractors will conduct much of this study effort.

FY 1969 cost increase results from more effort being placed on FBR fuel development.

1. Civilian Power Reactors - continued

(3) Molten Salt Breeder Reactor

(a) Fuel Development	FY 1967: $ 845,484	FY 1968: $ 850,000	FY 1969: $ 1,400,000
(b) Component Development	838,567	930,000	2,600,000
(c) Systems and Plant Development	297,258	350,000	800,000
(d) MSRE Operations	2,147,121	2,070,000	1,900,000
Total	$ 4,128,430	$ 4,200,000	$ 6,700,000

The project objectives of the Molten Salt Breeder Reactor (MSBR) program are the development of Molten Salt Breeder Reactor Systems to the extent required for realistic evaluation of their industrial potential for producing economic power in large central station plants while operating with low fuel doubling times and high specific power. The Molten Salt concept may be able to operate with fuels and materials at high temperatures with good neutron economy, and, when combined with on site fuel reprocessing plants, has a potential for attractive fuel costs with low fuel doubling time.

Operation of the MSRE will continue through FY 1968 and into FY 1969. It is planned to replace the present U-235 fuel with U-233 in FY 1968 and it is also planned to replace the present coolant salt with a fluoroborate salt in FY 1969.

The research and development program in support of the breeder reactor concept will concentrate on key areas and will include materials work on graphite and hastelloy N., component design and development, fuel chemistry investigations and fuel salt irradiations. Sustained operation of MSRE, engineering evaluations including coverage of plant maintainability and safety concepts, out-of-pile analysis and experimentation are required prior to making any future significant commitments on the molten salt reactor system.

Costs for FY 1969 will be more than FY 1968 as a result of increased development work and studies directed toward the future breeder plant. Increases are expected in: (1) development of equipment and systems which is a requisite to preliminary design, general planning and design criteria; (2) studies of remote welding and other potential maintenance problems; (3) an expansion of the materials development program which will require procurement of much larger quantities of graphite and hastelloy N; and (4) an expansion of the fuel processing development program.

1. Civilian Power Reactors - continued

d. Desalting Program and Other Processes

(1) Studies and Evaluations	FY 1967: $ 1,116,639	FY 1968: $ 1,230,000	FY 1969: $ 1,200,000
(2) Research and Development	1,546,183	1,420,000	1,300,000
Total	$ 2,662,822	$ 2,650,000	$ 2,500,000

Consistent with the program plans submitted to the President, the Commission's desalting program provides for continuing the development and practical application of nuclear energy for water desalting. Also included in this program are investigations of industrial processes such as the production of chemical fertilizers and metals.

The Commission's desalting program has been planned in close coordination with the Department of Interior in view of Interior's responsibility for the development of water desalting technology. Under the overall program, cooperative efforts are either under way or planned for studies, research and development, and demonstration of nuclear desalting plants on a national and international level directed at fostering the economic production of fresh water by utilizing nuclear energy for desalting.

The Commission's program for the development of reactors for the desalting of water and other processes consists of the following efforts:

(a) The assessment and development of promising reactor concepts in plant sizes necessary for industrial processes and regional water needs;

(b) The assessment and development of HWR and other systems for extrapolation to large single unit sizes for use with varied process applications;

(c) The conduct of specific site studies of nuclear desalting plants;

(d) The conduct of systems analyses and resultant hardware development programs to properly and fully utilize the design flexibility made available by the use of reactor system energy in the production of two or more usable products;

1. Civilian Power Reactors - continued

(e) International cooperation in nuclear desalting studies and related activities including participation in the International Water for Peace Program;

(f) Demonstration of nuclear desalting plants on a national and international level.

Specific site studies will be conducted in cooperation with the Department of the Interior, IAEA and the potential users. In FY 1968 funding is provided for the completion and extension of studies initiated in FY 1967 (e.g., Mexico, Greece, Ventura-Santa Barbara Counties) and to provide for the initiation of new foreign and domestic studies in FY 1969. The program of studies and evaluation at ORNL will be continued, and optimization studies and economic analyses will be conducted for those nuclear steam supply systems showing the greatest potential for large nuclear dual purpose and high water-to-power ratio desalting applications. Studies of industrial and agro-industrial complexes using nuclear "energy centers" will be continued. Research and development efforts to design, develop and test dual purpose plant coupling concepts and components (including control and operating flexibility features) will be continued and promising approaches to the solution of these problems identified. Efforts will also be initiated to identify the technology and large components necessary for those concepts showing the greatest potential for large nuclear dual purpose and high water-to-power ratio desalting applications and a means for demonstrating these in plants through cooperative undertakings.

At the present time, no funds are included for possible foreign cooperative undertakings which could occur during this period, should it be determined to participate in an international program such as has been discussed for the mid East or Mexico.

e. General Research and Development..... FY 1967: $ 2,603,437 FY 1968: $ 3,300,000 FY 1969: $ 2,500,000

The responsibility of the Commission for planning and directing the broad and complex Reactor Development Program requires the examination of the progress, quality, and value of continuing work and the evaluation of new ideas, proposals and designs. Substantial reliance is placed on the national laboratories and the Commission's operating contractors to provide assistance in the form of evaluation, review and feasibility studies. In addition, the Commission calls upon industrial contractors and architect-engineers for analysis, evaluation, and design of various technical and economic aspects of concepts which have reached the engineering stage of development.

1. Civilian Power Reactors - continued

Included in this activity are costs involved in the current detailed assessment of the Civilian Nuclear Power Program. Other examples of this program are:

1. comprehensive studies of economics of plant design including fuel cycles for different reactor concepts;

2. studies of power demands and growth factors in various locations of the U.S.;

3. studies and designs associated with reactor plants in locations which may have unique characteristics such as seismology, geology or high population densities;

4. in engineering evaluations of plant designs not unique to a particular reactor concept, or an outgrowth of ideas developed through studies as those in (1) through (3) above.

With more and more emphasis being placed on comparative analysis and detailed technical and economic assessments, and the projection of large energy needs in the U. S. and abroad, it is expected that increased effort will be applied to this activity in the future.

Mr. MORRIS. $132 million is requested for the civilian power reactor program. I have a few questions to ask, and then I will submit to you a list of questions to be answered in writing for the record.

BONUS PROJECT

As outlined on page RD–13, why is the proposed increase of $385,000 essential for the BONUS project in Puerto Rico, considering the possible phaseout of the project?

Mr. SHAW. Mr. Morris, that was our estimate at the time, based on phaseout of the operation of the facility. We recognize if we do phase it out we probably will need additional money in this category.

The Commission has this decision on BONUS before it right now. We have been negotiating with the management of the Puerto Rico Water Resources Authority. I am sure we will be coming up with something definitive very soon.

As I indicated before, if we terminate now it will cost us more money in fiscal year 1969 than anything we have here since we have to decommission that reactor, ship the fuel out.

Pending a decision as to the future of the BONUS project, there has not been developed a detailed plan for decommissioning the plant which would provide a sound basis for estimating the costs involved. However, in order that our financial planning provide for decommissioning, in the event this course of action is decided upon, our budgets include $1.8 million in fiscal year 1969, $5 million in fiscal year 1970, and $2 million in fiscal year 1971. On the basis of your requested assumption, the initiation of decommissioning in fiscal year 1969 would result in a considerable portion, probably at least half, of the $5 million costs budgeted in fiscal year 1970 being incurred in fiscal year 1969. These estimates for budgeting purposes represent our current projection as to the cost of decommissioning the BONUS plant, pending a more definitive cost estimate that would be developed in conjunction with the detailed decommissioning plan referred to above.

Mr. MORRIS. It costs money to stop a program.

Mr. SHAW. Yes, sir. I would point out it takes more effort to stop them, too.

MERCHANT SHIP REACTORS PROGRAM

Mr. MORRIS. We will insert page RD–55 in the record at this point.

(The page follows:)

4. Merchant ship reactors $100,000

	Fiscal year 1967	Fiscal year 1968	Fiscal year 1969
(a) Advanced pressurized water system	$40,423	$100,000	$100,000
(b) General research and development	8,643	0	0
Total, merchant ship reactors	49,066	100,000	100,000

The primary goal of the merchant ship reactors program is to develop nuclear reactor systems for commercial maritime use which, together with other improved and interrelated nonnuclear ship system innovations, can make available the superior service necessary to make and keep the U.S. merchant marine economically competitive. The immediate objective in accomplishing this goal is to resolve the operational requirements and then proceed to develop, fabricate, and demonstrate an automated nuclear powerplant utilizing an advanced pressurized water reactor system. Funds under general research and development in fiscal year 1967 provided for shipment of waste fuel from storage to the reprocessing plant. The waste fuel was generated under the NS *Savannah* prototype fuel element fabrication and irradiation program.

(*a*) Advanced pressurized water system:

Fiscal year 1967	$40,423
Fiscal year 1968	100,000
Fiscal year 1969	100,000

Pending clarification of the national policy on a nuclear merchant fleet (which recommendations are contained in a report requested by Senator Warren Magnuson and prepared by the Commission and the Departments of Defense and Commerce), the fiscal year 1968 and fiscal year 1969 efforts will involve the continuation of work initiated in fiscal year 1967 to study and evaluate nuclear fuel cycle costs, capital costs, cost trends, and specific designs for civilian maritime applications, as well as updating information in the report prepared for Senator Magnuson.

The technical feasibility of the use of pressurized-water reactor for ship propulsion has been sucessfully demonstrated by the NS *Savannah* and Navy programs. The main questions to be resolved relate to whether improved designs of pressurized-water reactors specifically for the operational environment of civilian maritime applications can be achieved to satisfy the required performance, availability, cost, reliability, and safety envelopes; and whether, if attained, these characteristics, along with potential ship system improvements, would be sufficient to assure reasonable economics for widespread merchant marine application.

You have about $100,000 in here for the merchant ship reactors program. Why is that necessary in fiscal year 1969?

Mr. SHAW. I asked for $100,000 for that program since it is quite clear that the pressures are still heavy on the maritime program. We do have a need for analyzing the information being developed.

It is quite clear there is a spinoff from the civilian power program into the maritime program which a number of people still believe can be exploited successfully. I think the effort we propose is just enough to keep current on that program and to make sure we can be responsive to the needs to analyze the information and project costs.

We are working quite closely with the Maritime Administration and the Department of Transportation.

Mr. MORRIS. We will insert pages RD–42 through RD–52 covering the Cooperative Power Reactor Demonstration program, in the record at this point.

(The pages follow:)

2. Cooperative Power Reactor Demonstration Program ..... $ 27,658,000

a. Converter Reactors	FY 1967: $ 3,547,452	FY 1968: $ 8,264,000	FY 1969: $ 5,758,000
b. Advanced Converters and Low Gain Breeders	8,063,843	16,663,000	15,900,000
c. Desalting	0	2,256,000	6,000,000
Total	$ 11,611,295	$ 27,183,000	$ 27,658,000

The estimates are based on the Commission's plans to continue support of previously authorized reactor projects. As detailed in the following justification, Commission support for certain projects will be completed in the time period covered by these estimates.

a. Converter Reactors

(1) Southern California Edison (San Onofre)	FY 1967: $ 14,996	FY 1968: $ 48,000	FY 1969: $ 0
(2) City of Los Angeles (Malibu)	140,981	200,000	2,000,000
(3) ECNG-FWCNG	5,585	20,000	0
(4) RCPA (Elk River)	1,051,832	1,544,000	1,743,000
(5) Northern States Power (Pathfinder)	213,476	0	0
(6) Consumers of Michigan (Big Rock Point)	65,297	10,000	0
(7) LaCrosse Boiling Water Reactor	330,692	1,948,000	747,000
(8) Consumers Public Power District (Hallam)	1,724,593	4,494,000	1,268,000
Total	$ 3,547,452	$ 8,264,000	$ 5,758,000

2. Cooperative Power Reactor Demonstration Program - continued

b. Advanced Converters and Low Gain Breeder Reactors

(1) Public Service Company of Colorado	FY 1967: $ 4,379,371	FY 1968: $ 14,808,000	FY 1969: $ 13,000,000
(2) Carolinas-Virginia Nuclear Power Plant	423,512	100,000	0
(3) Philadelphia Electric (Peach Bottom)	291,748	250,000	250,000
(4) City of Piqua	2,969,212	1,505,000	2,650,000
Total	$ 8,063,843	$ 16,663,000	$ 15,900,000

c. Desalting

(1) Metropolitan Water District.	$ 0	$ 2,256,000	$ 6,000,000
Total	$ 11,611,295	$ 27,183,000	$ 27,658,000

Summary of Obligations for Cooperative Power Program

Public Service Co. of Colorado	FY 1967: $ 12,000	FY 1968: $ 0	FY 1969: $ 0
Metropolitan Water District	0	15,000,000	0
Hallam	2,717,000	4,922,000	0
Piqua	3,040,000	1,649,000	7,000,000
Elk River	889,000	1,684,000	0
Other Going Projects	369,000	-1,030,000	0
Total	$ 7,027,000	$ 22,225,000	$ 7,000,000 1/

1/ Unobligated carryover to be obligated in FY 1969.

a. Converter Reactors

(1) Southern California Edison (San Onofre)

Research and Development .	FY 1967: $ 14,996	FY 1968: $ 48,000	FY 1969: $ 0

Provides for research and development assistance of $ 6.4 million in support of the plant. The research and development supported by the AEC will be completed in FY 1968.

2. Cooperative Power Reactor Demonstration Program - continued

(2) City of Los Angeles (Malibu)

Research and Development	FY 1967: $ 140,981	FY 1968: $ 200,000	FY 1969: $ 2,000,000

Provides for Commission financial support of Title I and II design up to a ceiling of $ 8.0 million. A contract between City of Los Angeles and Westinghouse has not been consummated pending approval of site location. Cost reimbursement by the Commission to the City of Los Angeles is contingent upon this contract.

(3) East Central Nuclear Group - Florida West Coast Nuclear Group (ECNG-FWCNG)

Research and Development	FY 1967: $ 5,585	FY 1968: $ 20,000	FY 1969: $ 0

Represents payment in FY 1968 for audit adjustments involving a subcontractor for fuel development.

(4) RCPA (Elk River)

Fuel Fabrication	FY 1967: $ -2,000	FY 1968: $ 0	FY 1969: $ 0
Operations	1,053,832	1,544,000	1,743,000
Total	$ 1,051,832	$ 1,544,000	$ 1,743,000

Provides for a second round type arrangement for the design, construction and operation of a nuclear power plant at Elk River, Minnesota. The total estimated project cost is $ 20.5 million. Modifications were required in the nuclear instrumentation and the radiolytic gas recombination system which delayed the turnover of the facility to the utility company until April 1965. Rated power of 23.0 MWE was achieved on February 10, 1965. Fabrication of Core II, started in FY 1964, was completed in FY 1966 and one-third of the new core is now in the reactor. The Commission executed a contract in FY 1966 with CNEN for the reprocessing and fabrication of material from Core I. The majority of this work will be accomplished in FY 1968-1969. Revenues from sale of steam are estimated at $ 500,000 in FY 1969 and are included in the Revenues portion of the budget.

2. Cooperative Power Reactor Demonstration Program - continued

(5) Northern States Power (Pathfinder)

Research and Development	FY 1967: $ 213,476	FY 1968: $ 0	FY 1969: $ 0

Commission support of this project was completed in FY 1967.

(6) Consumers of Michigan (Big Rock Point)

Research and Development	FY 1967: $ 65,297	FY 1968: $ 10,000	FY 1969: $ 0

This project provides for pre- and post-construction research and development in support of a high power density boiling water reactor at Big Rock Point, Michigan, for a total project cost of $ 4,026,000. The work in FY 1968 is for completion of the post-construction R&D program.

(7) LaCrosse Boiling Water Reactor

Fuel Fabrication	FY 1967: $ 0	FY 1968: $ 675,000	FY 1969: $ 0
Operations	330,692	1,273,000	747,000
Total	$ 330,692	$ 1,948,000	$ 747,000

This cooperative project provides for a second round type arrangement for the design, construction and operation of a 50 MWE boiling water plant in cooperation with the Dairyland Power Cooperative. The total estimated project net cost to the Commission is $ 13,314,000. This estimate does not provide for (1) possible monetary claims from Allis-Chalmers, penalty payments to Dairyland or (2) offsetting payments to AEC from Allis-Chalmers. The fuel loading was completed in July 1967 and turnover of the plant to Dairyland is planned for the first half of CY 1968. Fabrication of Core II will be completed in FY 1968. Based on a plant factor of 80%, revenues from sale of steam are estimated at $ 912,000 in FY 1969 and are included in revenues portion of the budget.

(8) Consumers Public Power District (Hallam)

Operations	FY 1967: $ 1,724,593	FY 1968: $ 4,494,000	FY 1969: $ 1,268,000

The Hallam project was terminated in FY 1966. The revised total estimated cost is $ 71,262,000, which includes $ 1,690,000 for settlement of CPPD claims and non-fund costs of $ 3,800,000 for fuel reprocessing. Costs for the retirement of the facility are estimated at $ 5,085,000. It should be noted that the 15% limitation in SEC 111 (b) of Public Law 85-162 does not include the above cost of retirement of the facility.

2. Cooperative Power Reactor Demonstration Program - continued

b. Advanced Converters and Low Gain Breeder Reactors

(1) Public Service Co. of Colorado

Research and Development .... FY 1967: $ 4,379,371 FY 1968: $ 14,808,000 FY 1969: $ 13,000,000

This project provides for the research and development, design, construction and operation of an advanced high-temperature gas-cooled power reactor having a capacity of 330 MWE. The Public Service Co. of Colorado will provide the major portion of the funds for the construction and operation of the nuclear electric plant and the Commission will provide assistance toward research and development, design and engineering, and the other features mentioned below.

		Not to Exceed
Research and Development	$ 12,178,000	
Design and Engineering Assistance	15,700,000	$ 27,878,000
Training		85,000
Construction (First-of-a-kind or specialized equipment including prestressed concrete reactor structure)		7,900,000
Fuel Fabrication		5,000,000
Total Funded Program		$ 40,863,000
Fuel Cycle Use (Inventory) Charge Waiver		6,443,000
Total		$ 47,306,000

Additionally, the Commission will make certain commitments with respect to the purchase of uranium containing the isotope 233 produced in and discharged from the reactor during the term of the arrangement and with respect to reprocessing or making settlement for the cost of reprocessing fuel elements discharged from the reactor during the term of the arrangement. Any costs in excess of the ceiling amounts to be provided by AEC will be borne by one or both of the contractors.

The AEC supported work in FY 1968 will be R&D on fuel and components; nuclear analysis, overall plant design, and procurement of first-of-a-kind equipment will be initiated. In FY 1969, these activities will continue and training and fuel fabrication will be initiated.

2. Cooperative Power Reactor Demonstration Program - continued

It is expected that the proposed demonstration plant will make a significant contribution to the advancement of the Civilian Power Reactor Program. This reactor will demonstrate key technical features which can be incorporated in a 1000 MWE power plant with a thermal efficiency of about 40% and conversion ratios of about .8 using a recycle fuel. The high thermal efficiencies and high conversion ratios combine to provide a major improvement in fuel utilization, which is a major objective of the advanced converter program.

(2) Carolinas-Virginia Nuclear Power Plant

Research and Development	FY 1967: $ 423,512	FY 1968: $ 100,000	FY 1969: $ 0

This project provided for research and development support of the heavy water plant at Parr, South Carolina. The research and development supported by the Commission was completed in FY 1967. The estimate for FY 1968 provides for final termination costs and possible audit adjustments.

(3) Philadelphia Electric (Peach Bottom)

Research and Development	FY 1967: $ 291,748	FY 1968: $ 250,000	FY 1969: $ 250,000

Provides for Commission support of pre- and post-construction research and development in support of the Peach Bottom gas-cooled nuclear plant at a total estimated cost of $ 14.5 million. The post-construction research and development will be continued in the period FY 1968 through FY 1969 and is principally directed to work on materials behavior and the operation analysis of systems and components including analysis of the effectiveness of the helium purification system. This reactor reached criticality in FY 1966 and full power in FY 1967.

(4) City of Piqua

Research and Development	FY 1967: $ 2,206,506	FY 1968: $ 775,000	FY 1969: $ 150,000
Operations	762,706	730,000	2,500,000
Total	$ 2,969,212	$ 1,505,000	$ 2,650,000

2. Cooperative Power Reactor Demonstration Program - continued

The Commission is in the process of terminating the operating contract for the Piqua reactor project. Several factors entered into this decision including: an increasing need for available resources (manpower and funding) by higher priority programs; little programmatic interest since support for organic cooled and moderated reactors and the HWOCR concept have been phased out; the technical problems which continue to delay reoperation of the plant and the unlikelihood of the City purchase of the plant. The present contract would have expired in February 1969.

FY 1968 funding provides for work on the recovery program prior to the decision to terminate the project and initial planning for retirement of the Piqua facility. Retirement of the facility is planned to begin in FY 1969. A detailed plan outlining procedures and related costs for dismantling and decontamination of the Piqua facility is being prepared.

c. Desalting

(1) Metropolitan Water District

Research and Development ... FY 1967: 0 FY 1968: $ 2,256,000 FY 1969: $ 6,000,000

This cooperative project with the Department of Interior and the Metropolitan Water District of Southern California is expected to provide the first large scale demonstration of nuclear desalting. The project involves the construction of two light water reactors of approximately 3,000 thermal megawatts each, two large condensing turbine generators, a back pressure turbine, and a water desalting plant having an initial capacity of 50 million gallons of fresh water per day. Subsequent additions could increase this capacity to 150 million gallons of fresh water per day. The AEC/Department of Interior contract with the Metropolitan Water District was signed November 20, 1967.

AEC assistance, which will not exceed $ 15.0 million, will pertain to many unique aspects of the first large scale dual-purpose project, including the siting and related structural and functional design of the plants, and the coupling of the desalting plants with the back pressure turbine and the nuclear power plants and possibly to other aspects of the projects pertinent to the interrelationship of nuclear power and desalting. In regard to the latter possible assistance to other aspects of the project, AEC does not intend to provide assistance to the development, design, construction, operation or maintenance of the nuclear power plants themselves. Also, AEC expects that its assistance will pertain to analysis; to research and development, to design; to testing; or to first-of-a-kind or specialized features or components of the site, the structures, or components of the project.

2. Cooperative Power Reactor Demonstration Program - continued

During FY 1969, it is expected that design of the man-made island will be completed and that research and development and design work on the plants and the interconnection of the plant systems will be under way.

The electric utilities participating in the project have proceeded with the ordering of long lead time equipment for the nuclear power plants. Contracts have been awarded to English Electric for the condensing turbines, and bids have been received, and are undergoing evaluation, on the nuclear steam supply systems. The Metropolitan Water District has selected Bechtel as its architect engineer for the design of the desalting plant, the back pressure turbine, the island, and the causeway which connects the island to the mainland. On August 28, 1967, the Governor of California signed a bill granting Metropolitan the necessary beach, tide, and submerged land required for the project. The electric utilities submitted formal applications to AEC Regulatory for construction permits for the two nuclear power plants on August 31, 1967.

2. Cooperative Power Reactor Demonstration Program - continued

The following table shows the prior year and planned funding pattern for the various reactors which comprise the Cooperative Power Reactor Demonstration Program.

(In Thousands)

	Total Authorization		Obligations			
	Previous Estimate	Revised Estimate	Through FY 1966	FY 1967	FY 1968	FY 1969
Consumers Public Power District (Hallam)						
Pre-Construction R&D	$ 16,511	$ 16,511	$ 16,511	$ 0	$ 0	$ 0
Unusual Main.& Fuel Cycle Costs	15,245	15,743	9,005	2,034	520	0
Construction	38,425	38,500	38,422	75	0	0
Equipment	508	508	508	0	0	0
Subtotal Project Costs	$ 70,689	$ 71,262	$ 64,446	$ 2,109	$ 520	$ 0
Facility Retirement	N.A.	5,085	0	683	4,402	0
Total	$ 70,689	$ 76,347	$ 64,446	$ 2,792	$ 4,922	$ 0
Fast Breeder Reactor Systems						
Operating	$ 4,309	$ 4,309	$ 2,524	$ 0	$ 0	$ 0
Elk River						
Construction	$ 11,252	$ 12,664	$ 10,057	$ 0	$ 1,430	$ 1,177 1/
Post-Construction Operating Expenses	5,162	7,278	4,567	889	1,684	0
Equipment	601	548	470	-77	45	110
Total	$ 17,015	$ 20,490	$ 15,094	$ 812	$ 3,159	$ 1,287
Piqua						
Pre-Construction R&D	$ 3,566	$ 3,566	$ 3,566	$ 0	$ 0	$ 0
Construction	9,986	9,986	8,951	515	101	417 1/
Post-Construction	12,171	12,171	7,408	3,040	1,649	0
Equipment	320	350	220	50	10	70
Subtotal Piqua	$ 26,043	$ 26,073	$ 20,145	$ 3,605	$ 1,760	$ 487
Facility Retirement	0	7,000	0	0	0	7,000 1/
Total	$ 26,043	$ 33,073	$ 20,145	$ 3,605	$ 1,760	$ 7,487
Chugach						
Pre-Construction R&D	$ 2,300	$ 2,300	$ 2,300	$ 0	$ 0	$ 0

2. Cooperative Power Reactor Demonstration Program - continued

(In Thousands)

	Total Authorization		Obligations			
	Previous Estimate	Revised Estimate	Through FY 1966	FY 1967	FY 1968	FY 1969
Northern States						
Pre-Construction R&D	$ 7,233	$ 7,003	$ 7,062	$ 0	$ - 59	$ 0
Post-Construction R&D	1,209	1,027	1,192	1	-170	0
Equipment	58	70	71	-1	0	0
Total	$ 8,500	$ 8,100	$ 8,325	$ 0	$ -229	$ 0
Carolinas-Virginia						
Pre-Construction R&D	$ 8,550	$ 8,550	$ 8,550	$ 0	$ 0	$ 0
Post-Construction R&D	3,758	2,695	3,147	61	- 547	0
Total	$ 12,308	$ 11,245	$ 11,697	$ 61	$ - 547	$ 0
East Central-Florida West Coast NPG						
Pre-Construction R&D	$ 1,728	$ 1,728	$ 1,728	$ 0	$ 0	$ 0
Intermediate Size Organic Reactor	$ 2,456	$ 2,456	$ 2,456	$ 0	$ 0	$ 0
Consumers of Michigan						
Pre-Construction R&D	$ 2,496	$ 2,496	$ 2,496	$ 0	$ 0	$ 0
Post-Construction R&D	2,054	1,530	1,753	29	- 254	0
Total	$ 4,550	$ 4,026	$ 4,249	$ 29	$ - 254	$ 0
Philadelphia Electric						
Pre-Construction R&D	$ 12,500	$ 12,500	$ 12,500	$ 0	$ 0	$ 0
Post-Construction R&D	2,000	2,000	2,000	0	0	0
Total	$ 14,500	$ 14,500	$ 14,500	$ 0	$ 0	$ 0
Small Size Nuclear Prototype Water Reactor						
Pre-Construction Operating Expenses	$ 361	$ 361	$ 361	$ 0	$ 0	$ 0
Construction	81	81	81	0	0	0
Total	$ 442	$ 442	$ 442	$ 0	$ 0	$ 0

2. Cooperative Power Reactor Demonstration Program - continued

(In Thousands)

	Total Authorizations		Obligations			
	Previous Estimate	Revised Estimate	Through FY 1966	FY 1967	FY 1968	FY 1969
LaCrosse Boiling Water Reactor (Dairyland)						
Pre-Construction Operating Expenses...	$ 1,116	$ 1,415	$ 1,116	$ 278	$ 21	$ 0
Construction	11,288	11,308	11,099	16	2	191 1/
Post-Construction Operating Expenses..	9,541	12,158	2,039	0	346	912
Equipment	410	490	150	0	40	0
Revenues	- 11,800	- 12,057	0	0	- 367	- 912
Total Dairyland	$ 10,555	$ 13,314	$ 14,404	$ 294	$ 42	$ 191
City of Los Angeles	$ 8,000	$ 8,000	$ 8,000	$ 0	$ 0	$ 0
Southern California Edison	$ 6,437	$ 6,437	$ 6,355	$ 0	$ 0	$ 0
Connecticut Yankee	$ 6,050	$ 6,050	$ 6,050	$ 0	$ 0	$ 0
Public Service Co. of Colorado						
Operating Expenses	$ 40,863	$ 40,863	$ 40,851	$ 12	$ 0	$ 0
Metropolitan Water District	$ 15,000	$ 15,000	$ 0	$ 0	$15,000	$ 0
Unallocated Authorization	$ 44,731	$ 27,796	$ 0	$ 0	$ 0	$ 0
Summary						
Operating Expenses	$223,547	$221,971	$153,537	$7,027	$22,225	$ 7,000 1/
Construction	71,032	72,539	68,610	606	1,533	1,785
Equipment	1,897	1,966	1,419	- 28	95	180
Total Cooperative Power Reactor Demonstration Program	$296,476	$296,476	$223,566	$7,605	$23,853	$ 8,965

1/ Unobligated carryover to be obligated in FY 1969.

Mr. MORRIS. Mr. Rhodes.

Mr. RHODES. I have no further questions.

Mr. MORRIS. Mr. Davis.

NUCLEAR DESALTING PLANTS

Mr. DAVIS. Briefly, what does your desalting work consist of? Is this merely the development of heating units for the basic condensing system? Is that what you are tackling?

Mr. SHAW. No, sir. It is principally along the following lines:

One is to make studies related to the combination of nuclear powerplants and desalting and other processes. That is, how would you use most efficiently a reactor plant with various assumptions as to its characteristics? For example, a high-temperature gas reactor, a heavy water type reactor, a light water reactor, a high-temperature metal reactor.

These require different approaches, because the distribution of temperatures is entirely different. Of course, we have programatic interests in pursuing each of these.

In addition, we have a number of cooperative studies which are underway. For example, we are working with the people in the Great Salt Lake area. We are working with chemical processing organizations in order to investigate processes for other purposes besides desalting.

In addition, we are analyzing the optimum arrangement, that is, configuration of reactor plant. For example, if one had, say, 80 percent desalting load or process load, compared to 20 percent electric load, one may design the fuel and heat transport system entirely different. Much of the effort is devoted to that type of studies.

Mr. RAMEY. The basic principle in the desalting plants using nuclear power is to pass the steam through a back-pressure turbine-generator, and thence to a brine heater as the source of heat for the brine in an evaporator desalting facility. There is some savings in terms of costs by reason of utilizing the steam initially for your electric power purposes, and then using the so-called waste heat in the desalting facility. You also have to steal a little of the steam that would go to electric power.

Mr. ABBADESSA. In addition to R. & D. and evaluation studies, we also have a co-op program and are a partner in MWD, which is a very large actual demonstration. Our share is $15 million.

The Chairman referred to this yesterday. That is in California on Bolsa Island.

Mr. SHAW. We work closely with the Department of Interior in all this desalting program effort.

Mr. DAVIS. Basically, then, in common parlance, your work deals entirely with the fuel part of it. There is no departure from the basic concept of the evaporator as the means of doing the desalting.

Mr. SHAW. Interior carries various means of doing the desalting. We are carrying the various means of generating the heat. We combine these efforts.

Some of our longer range studies do look at a number of different ways of producing water, that is, reverse osmosis, for example, on making the water by vapor compression methods as well as the more conventional evaporation techniques. Interior really pays for most of that effort.

A lot of this does reflect back into the reactor technology. For example, we could use a metal fuel in a breeder compared to an oxide or carbide fuel if one were able to operate the reactor plant on a low temperature basis compared to, say, what one would normally do, operate at as high a temperature as possible to get the most efficient operation.

STUDY OF PLANT SITE IN GULF OF CALIFORNIA

Mr. RAMEY. We have been engaged in a study with the Mexicans under the auspices of the International Atomic Energy Agency, looking to plants in the Gulf of California that would serve Arizona, California, and that area in Sonora and Baja California in Mexico. This is a very large plant that we would be looking at for that area. We hope to have a report on that project some time this summer.

Mr. SHAW. Mr. Morris, I owe you one other note in response to your first question. In our cooperative power program—the fiscal year 1967 costs were $11.6 million, and in 1969, $27.7 million is being requested. This increase is due principally to two programs. One is the Public Service Co. of Colorado project, which is the 330-megawatt high temperature gas, cooperative undertaking in the advanced converter category. The other is for the Bolsa Island desalting project, with the metropolitan water district (MWD). These two projects have caused this category to increase compared to the frame of reference you cited.

Mr. MORRIS. Are those previously funded programs?

Mr. SHAW. Yes, sir.

Mr. MORRIS. They are not new moneys?

Mr. SHAW. They are not new money, but they do reflect into those cost numbers you cited, sir.

Mr. MORRIS. They are not in your request for new appropriations.

Mr. CORSO. The figures we cited were increases in costs or expenditures, and they do affect those totals, although there is not one dime of new appropriations involved.

Dr. TAPE. The fiscal people have offsetting figures.

Mr. MORRIS. The money was carried over; it was not all spent in the year it was appropriated.

That is one of the problems. We all know that.

ATOMIC ENERGY OF CANADA, LTD.

Mr. DAVIS. What sort of entity is Atomic Energy of Canada, Ltd.? Is that a government agency, like the Atomic Energy Commission, or is it a wholly government-sponsored corporation, or what kind of entity is it?

Mr. RAMEY. I think it is a government corporation.

Dr. TAPE. In Britain, I think it would be called a Crown company. It is called that in Canada, too, I believe.

Mr. ABBADESSA. It is difficult, and I am sure I do not understand it, but where I come out on it is that it is a kind of combination, consortium type organization that has very heavy Government involvement.

Mr. SHAW. I think the recent AECL announcement with respect to encompassing the nuclear power system design and engineering groups of Canadian General Electric with AECL is one further step

in combining the industrial resources that exist there with the Government cooperation, in order to concentrate on getting their job done.

Of course, that is like they are doing in Great Britain, and that is like they are doing in a number of other countries, in order to carry their program.

Dr. TAPE. Oversimplified, I believe it is a company of which the Government is the stockholder.

Mr. DAVIS. Something like the TVA?

Dr. TAPE. I am not sure.

Mr. RHODES. Please provide a statement for the record concerning this company.

The following is an excerpt from the AECL annual report.

Atomic Energy of Canada, Ltd. is a Crown company incorporated in February 1952 under the Companies Act pursuant to the Atomic Energy Control Act. It is an agent for all purposes of the Crown and the shares of the company (with the exception of the qualifying shares of the directors) are held by a Minister of the Crown in trust for Her Majesty.

The company has an 11 man board of directors. The directors come from various parts of Canada and are mainly from industry, public power companies and the universities. Following normal company practice, the directors are responsible to the shareholders for the operation of the company.

Mr. DAVIS. Did you refer to that as a merger of General Electric of Canada with Atomic Energy of Canada?

Mr. SHAW. A combination of resources was announced 2 weeks ago, saying for the next year they have agreed that one will work for the other in order ot help market the heavy water reactor.

Mr. RAMEY. The Canadian AECL sort of took over the design organization of the General Electric group in Canada. That is what we have gathered. They have a board of directors for their organization, and we, the U.S. Atomic Energy Commission, have met with them each year. We either go up there to meet with them or they come down here to meet with us, usually at a laboratory site. We exchange data and information and ideas on how our programs can be coordinated, and the status of activities, and so on.

Mr. DAVIS. Maybe the Panama Canal Company would be a good analogy. We shall get some further information on that for the record. (See insert above.)

That is all, Mr. Chairman.

Mr. MORRIS. The gentleman from New York.

Mr. ROBISON. Mr. Shaw, the civilian power reactor program has shown a steady gain, as has already been remarked upon here. It is up to $132 million now.

INCREASE IN HIGH-GAIN BREEDER REACTOR PROGRAM

The largest component of this increase is the high-gain breeder reactor program; is that correct?

Mr. SHAW. That is correct, sir; the high-gain breeder and, within that, the liquid metal cooled fast reactor program.

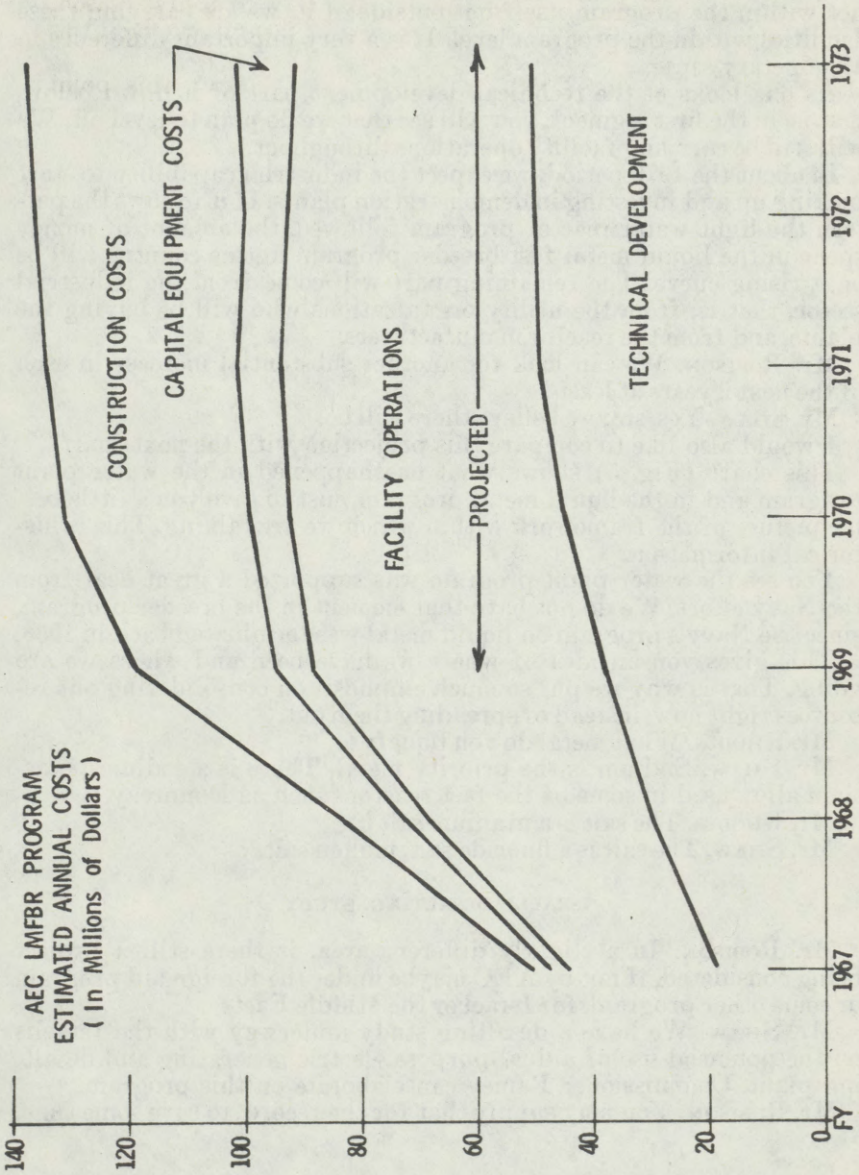
Mr. ROBISON. This particular subprogram will be almost twice what it was in 1967. It was $48 million in fiscal 1967, and $90 million is requested for fiscal 1969. Would you say this is going to level off pretty soon?

Mr. SHAW. Yes, sir; I think it will level off pretty soon. I think the emphasis in the program will shift somewhat, too.

I have a projection here which may explain why. The first reason, as I indicated before, is because we are investing heavily in facilities now.

Mr. Robison, I think this chart figure 4, will convey this point to you.

(Chart referred to follows:)



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In 1968 you will see we are investing quite heavily in facilities. Unlike what was done in the light water program where the facilities were not within the program itself but outside of it, we are carrying these facilities within the program level. It is a very important difference in a budgetary sense.

As one looks at the technical development part of it down below, that is, in the first segment, you will see that we do plan to level off. We will still be carrying facility operations throughout.

In about the 1970 period, we expect the industrial capability to start picking up and investing in demonstration plants. If it follows the pattern the light water reactor program followed, the amount of money spent in the liquid metal fast breeder program in this country will be on a rising curve. The remaining part will come from the industrial sector, that is, from the utility organizations who will be buying the plants, and from the reactor manufacturers.

Mr. ROBISON. We can look for another substantial increase in each of the next 2 years at least?

Mr. SHAW. Yes, sir; we believe there will be.

I would also like to compare this projection with the next chart.

This chart (Fig. 5) shows what has happened in the water plant program and in the liquid metal program, just to give you a little better picture of the framework within which we are talking. This is historical information.

You see the water plant program was supported a great deal from the Navy effort. We do not have that element in the breeder program, since the Navy's program on liquid metal was terminated back in 1958.

This gives you an idea of where we have been and where we are going. That is why we put so much emphasis on consolidating our resources right now, instead of spreading them out.

Mr. RHODES. What metal do you liquefy?

Mr. SHAW. Sodium is the priority metal. There is a sodium-potassium alloy used in some of the fast reactors such as Dounreay.

Mr. RHODES. The salt is a uranium salt?

Mr. SHAW. The salt is a fluoride salt, molten salt.

ISRAELI DESALTING STUDY

Mr. ROBISON. In a slightly different area, is there still a project being considered, if not by AEC maybe under the foreign aid program or some other program, for Israel or the Middle East?

Mr. SHAW. We have a desalting study underway with the Israelis on the potential use of a dual-purpose electric generating and desalting plant. Commissioner Ramey can elaborate on this program.

Mr. ROBISON. You may supply that for the record, to save some time.

(The information follows:)

For a number of years the Government of Israel, in cooperation with the United States, has been investigating the potential of a nuclear desalting plant to provide water and power for Israel. A joint United States-Israel team made a preliminary study of the power and water needs of Israel during August–October 1964. Based on the results of this team investigation, a detailed engineering study was conducted by Kaiser Engineers, in association with the Catalytic Construction Co., of a dual-purpose plant. The report of the study in January 1966 recommended proceeding with a plant which would produce approximately 200 megawatts electrical and 100 million gallons per day of fresh water. The project was estimated to cost approximately $200 million (exclusive of escalation) and if pursued promptly could have been operational by 1972.

Following review and evaluation of the engineering study, the Israeli Government indicated that a more appropriate date for plant operation might be 1975 since by that time a larger electrical generating capacity could be accommodated in Israel's power system. Accordingly, an updating of the study was conducted for a project having a 300-megawatts electrical capacity and a 100-million gallons per day output. The larger plant, for 1975 operation, was estimated (without escalation) to cost approximately $225 million. The results of this updating study are under review by the Israeli Government and indications are that Israel is desirous of considering a project of the general type studied to provide a solution to its increasing need for power and water.

During 1967, the U.S. Senate adopted a resolution (S. 155) endorsing the construction and operation of large nuclear desalting plants in the Middle East as a means of providing useful work for many of the refugees and at the same time providing the power and water which would assist in the economic and industrial development of the area. The executive branch is currently looking at ways and means in which this concept might be implemented, including the use of nuclear "energy centers" for large industrial and agro-industrial complexes.

(Off the record.)

Mr. MORRIS. We will insert pages RD–53, RD–54, and RD–85 through RD–175, the remainder of the reactor development program justification.

(The pages follow:)

3. Euratom Program ..... $ 2,500,000

Total Euratom Program ..... FY 1967: $ 2,746,334 FY 1968: $ 2,440,000 FY 1969: $ 2,500,000

Under the terms of the Agreement for Cooperation between the United States and the European Atomic Energy Community, a ten-year Joint R&D Program was established consisting of two 5-year periods, from FY 1959 through FY 1963 and from FY 1964 through FY 1969. The program being conducted both in the United States and in Europe is aimed primarily at improving performance and lowering fuel cycle costs of the type of reactors being constructed under the Joint Reactor Program. The reactors under the Joint Reactor Program have reached operational status and are as follows:

Euratom Reactors	MWE	Type	Country
SENN	150	BWR	Italy
SENA	210-266	PWR	France
KRB	237	BWR	Germany

The current target level for expenditure by each party under the Joint R&D Program is $37.5 million. Funding for United States participation in the Program has been authorized in annual increments for a cumulative total through FY 1966 of $28.1 million. Additional authorization beyond this $28.1 million is not being requested in view of the Commission's desire to apply its reactor development resources to other higher priority requirements. AEC is accordingly negotiating with Euratom looking toward arrangements whereby (1) the target level of participation by each party for the entirety of the Joint R&D Program is reduced from $37.5 to $33 million, which is the amount for which Euratom now had budgetary authorization; and (2) domestic projects otherwise being carried out by the Commission (involving approximately $5 million funded under the Commission's other reactor development programs) will be accepted by Euratom beyond the approximately $28.1 million which AEC estimates it will expend on already authorized Joint Program projects as fulfilling the Commission's commitment to being its total participation to the aforementioned $33.0 million level. It is expected that these negotiations will be concluded during the third quarter of FY 1968.

The program for the first five years of the joint program consisted of research and development activities covering: (1) advanced development of UO_2 technology; (2) basic studies on the use of plutonium and uranium compounds as reactor fuels; (3) environmental behavior of reactor materials such as zirconium, zirconium

3. Euratom Program - continued

alloys, and pressure vessel steels; and (4) heat transfer (H_2O). The estimated costs for FY 1968 and FY 1969 are required for: (1) the continuation of work initiated during the first five years of the Joint Program; and (2) the work authorized during the second five-year program which falls primarily within the following general categories: (1) development and demonstration of improved reliable fuel clad materials; (2) investigation of plutonium recycle in water reactors; (3) evaluation of performance characteristics and performance improvements in existing joint program reactors; (4) studies on heat transfer and fluid flow; (5) nuclear safety; (6) waste disposal; and (7) chemical reprocessing.

The estimated costs of $2.5 million for FY 1969 will be offset by a reduction of the same amount in the Selected Resources portion of the budget, resulting in no requirement for additional obligation authority in FY 1969.

8. Terrestrial Electric Power Development ..... $ 6,830,000

a. Radioisotope Power Development						
(1) Surface Generator Development	FY 1967:	$ 1,841,943	FY 1968:	$ 2,800,000	FY 1969:	$ 4,125,000
(2) Deepsea Generator Development		1,281,319		1,950,000		1,200,000
(3) Supporting Technology		787,303		1,175,000		1,475,000
Total		$ 3,910,565		$ 5,925,000		$ 6,800,000
b. Terrestrial Power Reactors						
(1) Terrestrial Low Power Development.	FY 1967:	$ 273,725	FY 1968:	$ 400,000	FY 1969:	$ 0
(2) Portable Medium Power Reactors ...		414,264		1,000,000		30,000
Total		$ 687,989		$ 1,400,000		$ 30,000
Total Terrestrial Electric Power Development		$ 4,598,554		$ 7,325,000		$ 6,830,000

a. Radioisotope Power Development

This program provides for the development of a series of advanced terrestrial generators to satisfy an increasing demand for reliable, long-lived power systems for use in military, oceanographic, and commercial applications. The design, verification and proof testing program for these generators consists of individual component testing, followed by system testing leading to final long-term environmental testing to confirm complete performance characteristics including reliability and lifetime considerations.

(1) Surface Generator Development						
(a) SNAP-23 Sr-90	FY 1967:	$ 958,782	FY 1968:	$ 2,000,000	FY 1969:	$ 2,800,000
(b) Milliwatt Generator		735,249		750,000		1,275,000
(c) SNAP-19C Pu-238		147,912		50,000		50,000
Total		$ 1,841,943		$ 2,800,000		$ 4,125,000
(a) SNAP-23 Sr-90	FY 1967:	$ 958,782	FY 1968:	$ 2,000,000	FY 1969:	$ 2,800,000

In FY 1966, a program was initiated to develop a series of generators in the 25- to 100-watt range for use in a wide variety of surface applications. This program is based on improved

8. Terrestrial Electric Power Development - continued

thermal-insulation, thermoelectric converters, and generator design and is directed toward the achievement of economically competitive, highly reliable, power systems with reductions in size and weight, where required.

Detailed design, preparation of standards, specifications, test criteria and the component development for a 60-watt generator were initiated during FY 1967. In FY 1968, materials, component and subsystem development will be conducted. The fabrication and testing of a 60-watt experimental generator will commence in FY 1969. The fabrication of fueled demonstration systems will begin in FY 1969 directed at environmental testing in FY 1970. This effort will provide the basis for adaptation, in FY 1969, of the 60-watt technology to other power systems maintaining a commonality of components, materials and design concept.

The systems are being developed for potential applications such as shore-based navigation lights (Coast Guard), weather buoys (Navy), and seismic stations (ARPA), microwave repeater stations, aircraft instrument landing systems, and communications systems.

(b) Milliwatt Generator ..... FY 1967: $ 735,249 FY 1968: $ 750,000 FY 1969: $ 1,275,000

This program provides for the development of generators in the microwatt to the 1000 milliwatt range. The program for these generators consists of engineering, design and analysis, including preparation of specifications and standards; individual component development and testing; and system testing leading to the final long-term environmental testing to confirm complete performance characteristics including reliability and lifetime capability.

There is increasing evidence that milliwatt generators will have application in the microelectric area, particularly in solid-state communications systems for remote locations, underwater Navy weapons, and deep moored oceanographic instrument stations. To be prepared to meet this need, the preliminary study of systems in the 100 to 1000 milliwatt range began in the latter half of FY 1966 and was completed in FY 1967.

8. Terrestrial Electric Power Development - continued

The expressed interest of the medical profession in the development of a radioisotope thermoelectric generator for use as a cardiac pacemaker has resulted in the decision to develop such a system in cooperation with the National Institutes of Health, Bethesda, Maryland, and the Beth Israel Hospital, Newark, New Jersey. Contractor proposals were evaluated in FY 1966, and a contractor selected for the first phase involving the design and component development of the radioisotope heat source and its integration into a developmental pacemaker unit. This effort, including appropriate testing, will continue through most of FY 1968. It is planned to initiate the fabrication and testing in vivo of the first prototype units in FY 1969.

Effort continued in FY 1967 on the design and development of an upgraded one milliwatt Pu-238 fueled generator (SNAP-15A) for potential use in the control of nuclear weapons. Fabrication and assembly of fueled prototypes was started in late FY 1967 and will continue into early FY 1968. Upon completion of this fabrication effort, an extensive laboratory test program will be initiated to demonstrate critical lifetime and reliability characteristics. This effort, which is planned to continue into FY 1969, will include delivery of prototype units to weapons laboratories for simulated environmental testing. Consideration is being given to the adaptation of the SNAP-15A power supply to other electronic control applications. The SNAP-15C Pu-238 fueled generator (100 milliwatt range) was placed on environmental testing in June 1965. Additional R&D effort to improve the performance and stability of this generator system in a specific component area was initiated in FY 1966 and completed in FY 1967. Electrically heated and fueled prototypes will be fabricated in early FY 1968 for long-term testing pruposes.

(c) SNAP-19C Pu-238 ..... FY 1967: $ 147,912 FY 1968: $ 50,000 FY 1969: $ 50,000

In FY 1967, two 30-watt Pu-238 power systems based upon the SNAP-19/NIMBUS space application were designed and fabricated for terrestrial application. The first of these units was fueled and successfully installed in late FY 1967. The second unit is undergoing long-term laboratory life testing and will be made available in FY 1968 for Navy application. The FY 1969 request will provide for possible analysis, test and modification as a result of these field test efforts.

8. Terrestrial Electric Power Development - continued

(2) Deepsea Generator Development

(a) SNAP-21 Sr-90	FY 1967: $ 1,281,319	FY 1968: $ 1,850,000	FY 1969: $ 1,200,000
(b) KW Generator	0	100,000	0
Total	$ 1,281,319	$ 1,950,000	$ 1,200,000

(a) SNAP-21 Sr-90 ..... FY 1967: $ 1,281,319 FY 1968: $ 1,850,000 FY 1969: $ 1,200,000

Based on more advanced technology than that utilized in the completed SNAP-7E program, the design and development of components for a 10-watt Sr-90 fueled deepsea system was conducted in FY 1965 and the fabrication of developmental systems was initiated. Further design, development, fabrication and test effort began in FY 1967 to produce several fueled prototypes for subsequent environmental testing. Developmental generators will be fabricated and extensive life, performance and environmental testing will be conducted through 1970. The SNAP-21 advanced technology is expected to permit the fabrication of highly reliable, more compact, more efficient, and more economical systems. The application of the basic technology to higher power systems, to be initiated late in FY 1968, will be continued and expanded in FY 1969. It is expected that the fabrication and testing of the higher power systems will begin in FY 1970.

(b) KW Generator ..... FY 1967: $ 0 FY 1968: $ 100,000 FY 1969: $ 0

Design studies of a kilowatt range deepsea system are planned for FY 1968. These design studies will identify the technology areas that require additional development effort in advance of system development. Based on the results of these studies in the future a program will be defined for materials investigations and component development followed by systems evaluation, design, development, testing and demonstration. This isotopic power system in the low kilowatt range would support manned arctic stations and ocean-bottom mining and exploration activities.

8. Terrestrial Electric Power Development - continued

(3) Supporting Technology

(a) Fuel Development	FY 1967: $ 148,021	FY 1968: $ 575,000	FY 1969: $ 725,000
(b) Conversion Technology ...	571,582	525,000	700,000
(c) Other Research	67,700	75,000	50,000
Total	787,303	1,175,000	1,475,000

This activity supports those unique terrestrial generator development areas previously described by providing the basic technology required to improve concepts, establish preliminary parameters of advanced concepts, and to develop advanced conversion materials and fabrication technology. The study of new thermoelectric materials (Lead - Germanium - Tellurium), the study of gas-pressure bonding, Sr-90 materials technology and environmental safety activities will continue through FY 1969.

Studies and investigations will be continued to evaluate the most useful, economical and desirable applications (both surface and oceanographic) for radioisotope generators in conjunction with various using agencies. These studies will also assist in defining the specific development areas that require greater emphasis in the future to assure that the AEC will be in a position to respond to the specific agency requirements in a reasonable time period and at a reasonable cost.

(b) Terrestrial Power Reactors

(1) Terrestrial Low Power Development	FY 1967: $ 273,725	FY 1968: $ 400,000	FY 1969: $ 0
(2) Portable Medium Power Reactors ..	414,264	1,000,000	30,000
Total	$ 687,989	$ 1,400,000	$ 30,000

(1) Terrestrial Low Power Development FY 1967: 273,725 FY 1968: $ 400,000 FY 1969: $ 0

This program covers the development of technology for nuclear reactor systems in the 100 KWe to 2 MWe range usable in a variety of applications. In FY 1967 design studies assessed the state-of-the-art of pressurized and boiling water reactor power-plant technology. A conceptual design for a PWR-type 1.5 MWe plant will be completed in FY 1968 and the program will be closed out pending the decision to proceed with further development.

8. Terrestrial Electric Power Development - continued

(2) Portable Medium Power Reactors ... FY 1967: $ 414,264 FY 1968: $ 1,000,000 FY 1969: $ 30,000

The AEC's part of the Portable Medium Power Reactors program will be closed out. Continued development and testing of improved systems and components for portable medium powered, water-cooled nuclear power plants will be subject to the interest, requirements and support of the Department of Defense.

REACTOR DEVELOPMENT PROGRAM - continued

9. General Reactor Technology ..... $ 50,000,000

a. Applied and Reactor Physics	FY 1967: $ 8,424,455	FY 1968: $ 8,550,000	FY 1969: $ 8,300,000
b. Reactor Fuels and Materials Development	27,927,778	27,600,000	28,800,000
c. Engineering Development	4,117,550	4,950,000	5,100,000
d. Chemistry and Chemical Separations ...	9,348,094	7,900,000	7,800,000
Total General Reactor Technology ...	$49,817,877	$49,000,000	$50,000,000

The General Reactor Technology Program generates the data and base technology required for the entire reactor program. Work is undertaken on reactor fuels and materials, reactor engineering, reactor physics, chemical process development for salvaging fissionable material from used reactor fuels and reactor instrumentation. General Reactor Technology programs take basic data from the fundamental research areas and apply such knowledge to establishment of engineering feasibility of untested systems. This program is required to strengthen our highest priority objectives by providing the basic technology for all areas of the Commission's reactor development program, bringing to bear the technology and resources necessary to resolve many critical problems, and to establish sound technical bases before proceeding with major projects requiring large scale technical commitments and considerable financial outlays.

The FY 1969 estimate provides support of those areas of technology underlying the major problems of all advanced types of reactor development. The estimate includes (1) operating cost for the High Temperature Lattice Test Reactor which will provide integral reactor physics data for solid moderator reactors over a wide temperature range, (2) operating support of the Oak Ridge Electron Linear Accelerator and the Argonne National Laboratory Fast Neutron Generator which will provide cross section measurements on the fast neutron spectrum, (3) operating support of the General Reactor Technology pressurized water loop in the Advanced Test Reactor which will significantly reduce the time required to obtain radiation damage data on fuels and materials applicable to all reactor systems and (4) increased emphasis on fast reactor fuels and cladding, and instrumentation development.

REACTOR DEVELOPMENT PROGRAM - continued

9. General Reactor Technology - continued

a. Applied and Reactor Physics

(1) Theoretical Reactor Physics	FY 1967: $ 780,916	FY 1968: $ 667,000	FY 1969: $ 660,000
(2) Experimental Reactor Physics	3,871,554	3,850,000	3,800,000
(3) Nuclear Data	3,771,985	4,033,000	3,840,000
Total Applied and Reactor Physics	$ 8,424,455	$ 8,550,000	$ 8,300,000

This program contributes to the development and optimization of many reactor systems. It includes research in neutron thermalization, measurements of cross sections needed for reactor calculations, basic shielding studies, the development and testing of better reactor calculational methods, and the development of better neutron and gamma ray spectroscopy techniques. Data are obtained on neutron thermalization in moderators such as H_2O, D_2O, C, BeO and ZrH_x. Detailed investigations of reactor lattices (with increased emphasis on fast reactor lattices) are carried out using pulsed neutron source techniques, substitution techniques and "clean" (consisting principally of fuel and moderator materials) exponential and critical facilities.

(1) Theoretical Reactor Physics FY 1967: $ 780,916 FY 1968: $ 667,000 FY 1969: $ 660,000

This subactivity includes development of reactor calculational methods, development of computer codes for nuclear application, research in basic reactor theory, the analysis of critical and subcritical experimental results, and the investigation of many problems in reactor physics such as fuel burnup predications, neutron flux distribution, neutron thermalization, and reactor kinetics. This program also covers the development of shielding calculational methods and the analysis of shielding experiments.

REACTOR DEVELOPMENT PROGRAM - continued

9. General Reactor Technology - continued

(2) Experimental Reactor Physics

Research and Development	FY 1967: $ 3,801,340	FY 1968: $ 3,755,000	FY 1969: $ 3,740,000
Irradiation Units	70,214	95,000	60,000
Total Experimental Reactor Physics	$ 3,871,554	$ 3,850,000	$ 3,800,000

This subactivity includes carrying out critical and subcritical experiments, pulsed source experiments on moderating systems, and continuing nuclear criticality safety measurements on ex-reactor materials. The experimental programs cover lattice substitution measurements, resonance integral measurements, burnup measurements, neutron spectra measurements, and sodium void, doppler and reactivity measurements.

(3) Nuclear Data

Research and Development	FY 1967: $ 3,316,596	FY 1968: $ 3,278,000	FY 1969: $ 3,245,000
Irradiation Units	455,389	755,000	595,000
Total Nuclear Data	$ 3,771,985	$ 4,033,000	$ 3,840,000

Basic nuclear data measurements will continue including neutron cross section measurements, neutron scattering law measurements and measurements of other nuclear data needed in reactor design. This subactivity also includes reactor cross section evaluations and calculations, as well as information center activities on reactor codes, radiation shielding and nuclear criticality safety.

9. General Reactor Technology - continued

b. Reactor Fuels and Materials Development

	FY 1967	FY 1968	FY 1969
(1) Fuels and Claddings	$11,826,888	$12,767,000	$11,434,000
(2) Coolants, Moderators, and Control Materials	2,732,591	1,645,000	1,650,000
(3) Radiation Damage on Structural Materials	6,605,447	6,644,000	6,925,000
(4) Techniques of Fabrication and Testing	2,496,066	2,434,000	2,576,000
(5) Engineering Properties of Reactor Materials	4,266,786	4,110,000	6,215,000
Total	$27,927,778	$27,600,000	$28,800,000

The objective of the fuels and materials development program is to broaden and improve the technical base supporting the selection and utilization of materials in nuclear applications in terms of new materials and processes, improved theories, and identification and solution of longer range materials problems limiting the nuclear industry. The research program provides information necessary for establishing the capabilities and limitations of reactor materials and the related theory. It includes the synthesis, fabrication, and testing of fuels and fuel clad combinations aimed specifically at understanding the mechanisms associated with improving nuclear reactor power output and life. Data are obtained on physical and mechanical properties of metals, alloys, and materials required by reactor designers. Where testing criteria are inadequate, more meaningful testing procedures are developed to provide data for use in the design of nuclear systems.

The fuels and materials program leads to the development of materials for use in current and advanced nuclear power systems. For the former application, studies define the use limitations of materials presently employed. This includes temperature capability and burnup limitations. For the advanced systems, the research concentrates on improvement of currently used fuels and materials and on development of new material forms capable of operating under more extreme and abnormal environmental conditions. Research in the various areas of the program is described below.

9. General Reactor Technology - continued

(1) Fuels and Claddings

Research and Development	FY 1967: $10,757,943	FY 1968: $11,368,000	FY 1969: $10,427,000
Irradiation Units	1,020,550	1,399,000	1,007,000
Test Reactor Experiments	48,395	0	0
Total	$11,826,888	$12,767,000	$11,434,000

Fuels research includes study of heat transfer characteristics (thermal conductivity) and mechanical properties, before and after irradiation. Corrosion resistance is studied under deliberate defect conditions to determine potential loss of fuel from ruptured cladding. Irradiation of various fuel forms is conducted to determine changes in fuel dimension, fission gas release, and distribution of fission products in the irradiated fuel. Fuel interaction with cladding is studied under conditions simulating core meltdown in order to permit prediction of the consequences of the meltdown.

Particular emphasis is being placed on developing data leading to the use of plutonium bearing fuels in fast breeder reactor systems; major fuel systems are UO_2-PuO_2, UC-PuC, UN-PuN, and U-Pu alloyed with other metals. For advanced reactor systems, uranium-plutonium compounds, alloyed or dispersed, are being prepared and studied.

Cladding research is concerned with compatibility; the fuel with the cladding, and the cladding with the coolant. The former is determined through out-of-reactor testing and through in-reactor capsule irradiations. The latter is primarily determined by means of circulating coolant loops, in-reactor and ex-reactor. The nuclear radiation effects program on cladding is covered in the radiation damage discussion below.

9. General Reactor Technology - continued

(2) Coolants, Moderators and Control Materials

	FY 1967	FY 1968	FY 1969
Research and Development	$ 2,683,933	$ 1,645,000	$ 1,650,000
Irradiation Units	48,658	0	0
Total	$ 2,732,591	$ 1,645,000	$ 1,650,000

Coolant studies are devoted to determination of interaction with cladding (see above) and with other potential containment materials. The work includes study of the effects of selected impurities on accelerating or retarding corrosion, the influence of temperature and coolant flow rate, and the effect of dissimilar metals in a system.

Moderator studies include evaluation of radiation stability of graphite, as well as certain classified hydride moderators. In the studies, the effect of such variables as grain size, porosity, orientation (as a function of fabrication technique), and transmutation is considered. For the hydrided moderator forms, high temperature stability is evaluated in detail, including retention of hydrogen as a function of temperature and time.

Control materials are studied primarily to determine property changes as a function of burnup including interaction with materials of construction. In the case of burnable poisons, this includes study of migration of the poison through the fuel form.

(3) Radiation Damage on Structural Materials

	FY 1967	FY 1968	FY 1969
Research and Development	$ 4,671,137	$ 4,729,000	$ 4,748,000
Irradiation Units	1,934,310	1,915,000	2,177,000
Total	$ 6,605,447	$ 6,644,000	$ 6,925,000

This phase of the materials program provides detailed information on the effects of thermal and fast neutrons on cladding, structural, and pressure vessel materials. The coordinated effort considers all aspects of nuclear radiation effects, from basic studies of very pure metals (such as iron or columbium) to changes in engineering properties of commercial alloys. Properties studied include tensile strength, tensile ductility fracture toughness, and change in nilductility transition temperature (NDTT) as measured by Charpy V-notch impact testing.

94-075 O-68-pt. 3—21

9. General Reactor Technology - continued

Metallurgical variables studied include composition (chemistry), grain size, degree of cold work, and fabrication history. Particular emphasis is placed on study of the effects of small impurities, such as boron, on changes in mechanical properties. Spectrum effects are studied in detail, to permit formulation of a consistent basis for reporting radiation exposure regardless of the reactor spectrum.

The FY 1969 increase reflects a substantial expansion of the irradiation damage program of clad and structural materials including increased irradiation services in support of this effort.

(4) Techniques of Fabrication and Testing

	FY 1967	FY 1968	FY 1969
Research and Development	$ 2,429,039	$ 2,262,000	$ 2,421,000
Irradiation Units	67,027	172,000	155,000
Total	$ 2,496,066	$ 2,434,000	$ 2,576,000

Fabrication of nuclear fuels and materials is studied to meet two principal objectives. The first is to define techniques that will permit fabrication of the material into the desired configuration. An example of this is the detailed study of fabrication techniques for tungsten and tungsten-rhenium alloys. The second objective is to develop materials that are reproducible from lot to lot, with predictable characteristics for each lot used. An example would be definition of power properties for mixed urania-plutonia fuel that will permit fabrication of pellets having predictable properties.

Testing of materials also covers two principal objectives. The first is development of destructive testing techniques that allow reliable prediction of material property changes during irradiation or environmental exposure. An example of this is the effort under way for development of a double cantilever beam specimen for measuring fracture toughness of reactor pressure vessel steels. The second objective is development of nondestructive testing techniques that permit assessment of materials' integrity before and during exposure to the nuclear environment. Such work includes evaluation of fuel cladding, determination of dimensional changes in irradiated fuel rods, and evaluation of pressure vessels for flaws induced by fabrication.

9. General Reactor Technology - continued

(5) Engineering Properties of Reactor Materials

	FY 1967:	FY 1968:	FY 1969:
Research and Development	$ 3,572,137	$ 3,312,000	$ 3,318,000
Irradiation Units	694,649	798,000	2,897,000
Total	$ 4,266,786	$ 4,110,000	$ 6,215,000

This portion of the program is intended to provide detailed information on properties of reactor materials to permit reliable design of reactor components. It includes such efforts as the study of in-reactor creep of fuel cladding, stress-rupture lifetime of refractory alloys (Tungsten-Rhenium, etc.), and plastic fatigue of steels under creep conditions. Study of reactor fuel forms includes fission gas release from single crystals, mechanical properties of unirradiated fuel, and thermal conductivity of unirradiated fuel. Such studies are aimed at obtaining data which may be used for reactor systems. Research to determine the use of high strength alloys as candidate materials for reactor pressure vessels is being continued. Data on reactor materials, in the intermediate temperature ranges of 1100° - 1400°F, are to be obtained, as such data are now sparse and not too reliable.

All of the FY 1969 increase covers the cost of irradiation services for the ATR water loop operation.

c. Engineering Development

	FY 1967:	FY 1968:	FY 1969:
Research and Development	$ 4,115,899	$ 4,881,000	$ 5,056,000
Irradiation Units	1,651	69,000	44,000
Total	$ 4,117,550	$ 4,950,000	$ 5,100,000

The objectives of this program are: (1) to provide state-of-art information and technology complementary to existing reactor development programs to assist in achieving the goal of obtaining safe, reliable and economic breeder, converter, and special reactor systems; (2) to provide information, techniques and equipment which will permit the development of advanced reactor systems having higher power density, improved thermal efficiencies and power conversion, more effective means of operation and control, greater reliability and safety and (3) to provide ancillary equipment and techniques associated with reactor operation, such as remote control mechanical equipment for fuel handling, remote inspection and decontamination of reactor systems, nondestructive fuel assay and process instrumentation and control devices.

9. General Reactor Technology - continued

(1) Thermal and Fluid Dynamics Technology

This subactivity includes (a) general investigations of heat transfer phenomena and coolant behavior as applied to reactor engineering and systems development for both subcooled and boiling regimes for liquid metals and water, and high temperature gas coolants, and (b) studies relating to the development of new coolants for reactor and thermal transport systems. These efforts are aimed at developing state-of-art technology for present reactor development programs and at achieving greater performance (higher power densities, thermal efficiencies, etc.) in reactor systems through improved utilization of generated heat and/or through improvements in ability to operate systems at temperatures and heat fluxes which are considerably higher than those in use at the present time.

Work will be initiated in FY 1969 to investigate basic core dynamics in a forced convection sodium system related to design of FBR reactor cores and critical flow phenomenon through various reactor nozzle geometries.

(2) Energy Transport and Conversion System Engineering

This program provides for an orderly, systematic study and development of the various components in energy conversion systems projected for advanced reactor systems employing high temperature liquid metals, gases, and other fluids. The objective of this activity is to utilize all the related advances in materials research, engineering mechanics and mechanical designs for the development of components and systems capable of performing under the projected elevated temperature and adverse environments where existing technology is inadequate or not defined. To accomplish these objectives various analytical and experimental studies are undertaken to advance engineering mechanics and dynamics technology for design application. Specific hardware concepts are carried through the demonstration state to the point where reactor projects can utilize results in sufficient time to integrate such component improvements into the reactor system design.

The FY 1969 request includes work on specific advanced components for breeder and compact reactor systems and the development of technology necessary for the design of high temperature components as required by the breeder reactor programs.

9. General Reactor Technology - continued

(3) Instrumentation and Control

This area of investigation includes: (a) development of improved and more reliable instrumentation and control systems utilizing the latest developments in electronics, solid-state devices, fluid amplifiers, and computer techniques, with emphasis on basically improved and new instruments for whole classes of reactors rather than engineering modifications suitable only for a single reactor class; (b) investigation of new non-destructive fuel burnup measurement methods for optimizing fuel cycles in reactor cores; (c) measurement of reactor shutdown reactivity and operating stability; (d) development of techniques and equipment for remotely inspecting and testing radioactive reactor system components; (e) development of techniques and equipment for detecting degradation of reactor control systems and components; and (f) the development of special manipulators and remotely-operated machines for handling, storing and processing of radioactive materials and fuel elements.

The FY 1969 request includes a program on instrumentation technology to provide new methods for detecting and measuring impurities and for fast fuel development instrumentation for capsule and loop experiments.

d. Chemistry and Chemical Separations

(1) Aqueous and Volatility Process ..	FY 1967: $ 5,306,844	FY 1968: $ 3,746,000	FY 1969: $ 2,836,000
(2) Closed Cycle Processes	1,356,039	1,255,000	1,255,000
(3) General Chemistry and Chemical Engineering	2,685,211	2,899,000	3,709,000
Total	$ 9,348,094	$ 7,900,000	$ 7,800,000

The Chemistry and Chemical Separations programs include (1) development of modifications to aqueous processing technology to handle new and advanced fuels, (2) development of volatility processing as an alternate to aqueous technology with major efforts associated with fast reactor fuel processing, (3) process work on close coupled pyrochemical-remote refabrication fuel cycles, and (4) the basic investigations in general chemistry and chemical engineering. The latter program includes (a) the development of reactor coolant chemistry, with emphasis on sodium coolant systems, (b) the development of analytical techniques for the accurate determination of burnup in irradiated fuels, (c) investigations on the use of fission fragment energy for the initiation of chemical reactions, and (d) general chemical studies in support of reactor systems.

9. General Reactor Technology - continued

(1) Aqueous and Volatility Processes

	FY 1967	FY 1968	FY 1969
Research and Development	$ 5,226,876	$ 3,690,000	$ 2,771,000
Irradiation Units	79,968	56,000	65,000
Total	$ 5,306,844	$ 3,746,000	$ 2,836,000

Development of methods by which new fuel types can be accommodated in existing aqueous process systems will be continued with major effort on the special problems associated with fast reactor fuels. A lesser effort is being conducted on high temperature gas cooled reactor graphite uranium-thorium carbide fuels. Scouting studies of reprocessing methods for advanced fuels developed in the materials development program are conducted as these materials show increasing promise for application.

A portion of the program is being reoriented toward evaluating the application of volatility technology for fast breeder fuel processing as a backup for aqueous methods and will be continued in FY 1969.

(2) Closed Cycle Processes ..... FY 1967: $ 1,356,039 FY 1968: $ 1,255,000 FY 1969: $ 1,255,000

Both Pu and U-233 recovered from highly irradiated power fuel will contain gamma and/or neutron emitting isotopic contaminants which will increase the biological shielding requirements for refabrication. Partial decontamination methods, applicable when remote refabrication is used, yield cost savings partially offsetting the higher cost of remote refabrication. As the fuel material is recycled and the concentration of contaminants increases, fully remote refabrication becomes more probable.

The effort in this program is concentrated on development of partial decontamination pyrochemical techniques for application to fast breeder reactor fuels.

(3) General Chemistry and Chemical Engineering ..... FY 1967: $ 2,685,211 FY 1968: $ 2,899,000 FY 1969: $ 3,709,000

The successful application of sodium, as a reactor coolant, requires the development of a greater understanding of the behavior and consequences of impurities (metals and non-metals), fission products and materials in sodium. The requested increase reflects additional emphasis that will be placed on analytical chemistry, solubility of materials, behavior of fission products and chemical specie identification.

10. Advanced Systems Research and Development $7,980,000

a. Experimental Beryllium Oxide Reactor ...	FY 1967:	$ 1,134,486	FY 1968:	$ 0	FY 1969:	$ 0
b. Ultra High Temperature Reactor Exp.		2,176,032		2,000,000		2,000,000
c. Advanced Plutonium Fuel Tech. Prog.		3,135,002		2,790,000		3,230,000
d. Direct Conversion		370,663		0		0
e. Research Reactors R&D		2,606,846		2,213,000		1,700,000
f. Test Reactors R&D		287,694		355,000		150,000
g. Other Advanced Systems Research and Development		757,007		1,177,000		900,000
Total Advanced Systems R&D		$10,467,730		$ 8,535,000		$ 7,980,000

a. Experimental Beryllium Oxide Reactor (EBOR)

Research and Development	FY 1967:	$ 564,952	FY 1968:	$ 0	FY 1969:	$ 0
Operations		569,534		0		0
Total EBOR		$ 1,134,486		$ 0		$ 0

The purpose of the EBOR program was to develop the technology of beryllium oxide as a high temperature gas-cooled reactor moderator. Because of serious technical problems with major components, difficulties encountered during pre-nuclear checkout testing of various parts of the system, and the diminishing potential contribution of the project to the high temperature gas-cooled reactor program, this project was terminated in FY 1967.

b. Ultra High Temperature Reactor Experiment (UHTREX)

Research and Development	FY 1967:	$ 1,598,960	FY 1968:	$ 1,050,000	FY 1969:	$ 1,050,000
Operations		0		950,000		950,000
Reactor Fabrication		577,072		0		0
Total UHTREX		$ 2,176,032		$ 2,000,000		$ 2,000,000

The objective of this program is to obtain data on graphite fuels with high fission product retentivity for exceptionally high-temperature gas-cooled reactors. This 3 MWt helium-cooled graphite moderated reactor will be used to conduct experiments at operational temperatures (500-1000°F) higher than those

10. Advanced Systems Research and Development - continued

used and projected in today's high temperature gas reactors (about 1400°F). In the course of operation, some fission products are expected to be released and their behavior in the primary loop and the resulting operational and maintenance problems will be evaluated. The fission product retention of improved ceramic fuels is considered one of the most important technical problems in the further advancement of gas reactors to high temperatures and the use of UHTREX to investigate this area is an important part of the Commission's overall Gas Cooled Reactor Program.

Fuel, consisting of enriched U-235 in the form of pyrolytic, carbon coated microspheres of UC_2, was loaded in the reactor and criticality was achieved in FY 1968. After low power testing, operation at full power and temperature will be approached during the later part of the fiscal year, Testing, checkout, and operation will continue in FY 1969 to provide technical information on components systems and power operations of the reactor as an entity. In addition, consideration is being given to conducting gas reactor transient and heat transfer experiments. Such experiments could provide basic information on high temperature reactor safety characteristics and shut-down mechanisms and could furnish experimental benchmarks for establishing the validity of current analytical prediction methods.

c. Advanced Plutonium Fuel Technology Program

Research and Development ..... FY 1967: $ 3,135,002 FY 1968: $ 2,790,000 FY 1969: $ 3,230,000

This program conducted at the Los Alamos Scientific Laboratory (LASL) is directed toward areas of interest to the long range aspects of the Fast Breeder Program (FBR), with initial emphasis on the compatibility of the fuel for liquid metal cooled systems. In FY 1968-1969, development will be conducted in several areas. There will be a continuing program on the synthesis, fabrication and investigation of the advanced plutonium ceramic fuel materials. The principal goal is to determine high temperature properties of well characterized pure material. Closely related to this effort is the study of the interaction of carbide and nitrides with potential cladding materials to develop the technology required for sodium-bonded elements in which the fuel and cladding materials are compatible. Another area relates to sodium technology and includes the study of mass transfer of materials in contact with sodium, removal of impurities from the sodium coolant, control of fission products released to the sodium, analytical techniques for monitoring impurities and physical chemical studies of sodium impurity interactions.

Because of the Laboratory's experience in preparing and developing plutonium bearing alloys, a program will be initiated to evaluate selected ternary metal alloy systems of plutonium as potential fuel

10. Advanced Systems Research and Development - continued

candidates. Such systems will be studied at a low level in FY 1968 and plans developed for an increased research program on candidate systems in FY 1969.

d. Direct Conversion

Research and Development	FY 1967: $ 370,663	FY 1968: $ 0	FY 1969: $ 0

In the past, a modest development effort has been devoted to non-mechanical advanced type electrical generators for use with a nuclear energy source. No program is planned under this activity in FY 1968-1969.

e. Research Reactors R&D

Research and Development	FY 1967: $ 2,579,269	FY 1968: $ 2,213,000	FY 1969: $ 1,700,000
Irradiations	27,577	0	0
Total	$ 2,606,846	$ 2,213,000	$ 1,700,000

(1) Argonne National Laboratory - Argonne Advanced Research Reactor (AARR)

The construction of the AARR was authorized in FY 1965. This reactor is being designed to produce a flux in excess of 5×10^{15} at a power level of 100 MWt. In addition to the central flux trap in which the maximum flux occurs, the facility would provide six horizontal experimental beam tubes and two horizontal through holes, as well as vertical sample tubes for short and long term irradiation investigations.

A determination was made in FY 1967 to reorient the AARR program to utilize the aluminum core and control system developed for the ORNL High Flux Isotope Reactor in place of the stainless steel core and control system previously planned for the AARR. While this change has resulted in a reduction in development costs, additional development work is still required. Thus research and development effort will be conducted in FY 1968-1969 on tasks such as: design, fabrication and testing of prototype reactor beam tubes and vertical hydraulic and pneumatic irradiation facilities; development of mathematical models and analog computer programs for assessing the kinetic behavior of the reactor and the overall plant and site safety in relation to the experimental programs; determination of source strengths for shielding internal to the pressure vessel; and physics analysis of the operating core with AARR beam tube and irradiation experiments. In addition, thermalhydraulic

10. Advanced Systems Research and Development - continued

analysis for the reactor will be extended beyond what had been done for HFIR to provide a more comprehensive understanding of the system behavior under transient conditions.

(2) Brookhaven National Laboratory

The BNL work in FY 1968-1969 will consist of engineering and physics studies and conceptual design and development work on a high power density, pulsed fast research reactor.

The pulsed fast reactor is a small fast reactor assembly which can be pulsed rapidly and repetitively to very high peak power levels. Successful development could provide a research reactor facility with capabilities for neutron time-of-flight experiment exceeding that of current advanced steady state research reactors. The pulsed fast reactor being studied under this program has an average power of 10-30 MWt. Peak burst power may be from 2,000 to 10,000 MWt with a repetition rate of 20 to 80 bursts per second.

The FY 1968 effort will include assembly and operation of a preliminary critical experiment, evaluation of promising candidate fuel materials including high cycle fatigue testing of unirradiated specimens, and the continuation of design studies of alternate pulsed reactor concepts best suited to meet future research needs. The development effort will continue in FY 1969 with operation of the preliminary critical experiment and analysis of the critical experiment data including development of special analytical methods as necessary to describe the neutronics of repetitively pulsed fast assemblies. Reference designs will be undertaken for both a Pulsed Reactor and an Accelerator Injected Pulsed Reactor and studies to evaluate their comparative advantages and disadvantages will continue. Potential user requirements and typical experiments to be performed at the Pulsed Reactor will be evaluated for the two alternative concepts. Fuel Development work will continue with cyclic fatigue testing of candidate fuel and clad materials and irradiation testing of promising materials.

(3) Oak Ridge National Laboratory

Work at ORNL includes the SORA critical experiment program, development effort in support of the High Flux Isotope Reactor (HFIR), and technical assistance in the procurement of fuel and control elements.

SORA is a 500 KWt average power pulsed research reactor being designed and considered for construction by EURATOM. The program of critical experiments in support of the SORA design being conducted under

10. Advanced Systems Research and Development - continued

an agreement of cooperation with EURATOM will be completed in FY 1968. Work in the other areas will be conducted at a reduced level in FY 1969.

The development work related to the HFIR is directed toward the resolution of problems associated with the core and related structures and the development of improved cores. A major task in FY 1968-1969 will be the design, development and proof testing of cores containing approximately a 25% increase in fuel content which will result in longer core life and lower fuel cycle costs. Improvements will also be sought in the welding procedures for fabrication of the fuel element in order to reduce costs and improve quality.

During FY 1968-1969, ORNL will provide technical assistance related to the procurement of fuel and control elements for AEC test and research reactors. This work embraces review and approval of the fuel element and control rod specifications; inspections during vendor qualification and production, and assistance to the AEC and fuel fabricators in the solution to problems which may arise.

f. Test Reactors R&D

Research and Development ..... FY 1967: $ 287,694 FY 1968: $ 355,000 FY 1969: $ 150,000

During FY 1968, work under this activity will include improvement of test reactor physics calculations, neutron amplifier studies, and studies of an Intermediate Reactivity Measurement Facility (IRMF). It is currently planned to discontinue the neutron amplifier and IRMF studies by the end of FY 1968; however, the work associated with test reactor physics calculations will be continued in FY 1969. This effort will include experimental and theoretical work on the prediction of spatial and energy distributions of neutron flux in the test reactors and reactivity measurement facilities. Emphasis will be given to improvement of calculations of the variations of spatial and energy distributions and reaction rates throughout a test reactor operating cycle. This work is expected to result in improvement in the design and interpretation of test reactor experiments, and in the operation of the test reactors to minimize the variations in test experiment flux from cycle to cycle and throughout an operating cycle.

10. Advanced Systems Research and Development - continued

g. Other Advanced Systems R&D

Research and Development	FY 1967:	$ 757,007	FY 1968:	$ 982,000	FY 1969:	$ 900,000
Irradiations		0		195,000		0
Total		$ 757,007		$ 1,177,000		$ 900,000

This activity covers the study of advanced reactor systems concepts and components and the development of associated technology. Work to be conducted at LASL will include exploratory studies and development of reactor instrumentation. The Phoenix fuel program will continue at the Pacific Northwest Laboratory to develop the technology required for determining the characteristics of plutonium fuels in reactors that yield long reactivity lifetimes. It is planned to demonstrate this concept by designing and fabricating a suitably enriched plutonium-fueled core to be operated in an existing AEC reactor during the latter part of FY 1969.

11. Nuclear Safety $40,400,000

a. Nuclear Safety Research and Development	FY 1967:	$ 9,043,645	FY 1968:	$ 9,654,000	FY 1969:	$12,300,000
b. Effluent Control Research and Development		4,851,482		4,459,000		4,600,000
c. Engineering Field Tests		7,076,177		8,430,000		10,000,000
d. Reactor Safety Analysis and Eval. .		1,404,690		1,792,000		2,500,000
e. Engineered Safety Features		6,255,448		8,970,000		11,000,000
Total Nuclear Safety		$28,631,442		$33,305,000		$40,400,000

The Nuclear Safety Program carries out investigations of safety problems which are of general applicability to research, test and power reactors and related nuclear facilities and conducts tests to establish the safety of a specific reactor system or to establish the validity of safety criteria used in reactor design, construction, operation and related accident analysis. Technical advancements attained under this program in addition to providing technology to assure continuing safety also will contribute significantly to the solution of problems associated with siting reactors and related nuclear facilities. Full recognition has been given to the fact that safety considerations are an inherent part of the effort associated with the design, construction, and operation of each reactor project; and that primary responsibility for assuring the safety of a specific reactor project rests with the management of that project.

These estimates provide for increased effort related to engineering and technology as needed to advance the capability and reliability of safety systems and engineered safety features; in the design and inspection of critical systems; in the practical demonstration of the dependability of performance of such systems; and in increased assistance and technical support to the regulatory process.

The Nuclear Safety Program includes the following activities:

a. Nuclear Safety Research and Development involves both fundamental and applied research in nuclear reactor safety, including studies in reactor kinetics, fuel meltdown phenomena and fuel-coolant interactions resulting in pressure generation.

b. Effluent Control Research and Development is directed toward the development of more efficient and economical means of managing radioactive wastes resulting from nuclear facility operations, and toward determining and assessing the fate and behavior of these residual radioactive effluents in the environment, and with the geophysical aspects of reactor siting, design and construction.

11. Nuclear Safety - continued

c. Engineering Field Tests extend laboratory scale test results on nuclear systems into full engineering-scale tests for proof-test and demonstration purposes.

d. Reactor Safety Analysis and Evaluation provides for safety analysis studies that supplement other program activities; provides assistance in planning and directing the overall Nuclear Safety Program; and provides for nuclear safety-information dissemination.

e. Engineered Safety Features provides a program for investigation and development of effective engineered safety features in the construction and operation of reactors, both to prevent major accidents and to control their consequences in the unlikely event they should occur.

The objectives of the reactor safety program on a system basis are in:

(1) Water Reactor Safety to perform analysis, experiments and tests on the abnormal behavior of reactors and their system components thereby establishing a technical basis for prevention and control and aid in accident analysis through experimentally verified engineered safety systems.

(2) Fast Reactor Safety to develop and implement a program of safety research development and tests in support of the development of fast breeder reactors.

(3) Gas Cooled Reactor Safety to conduct analytical and experimental investigations to assure adequate safety in advanced high temperature gas-cooled reactors.

(4) Other Advanced Reactor Safety to provide the required safety technology support to other unique applications such as MSBR, HWR, and other advanced concepts.

a. Nuclear Safety Research and Development

(1) Reactor Kinetics	FY 1967:	$ 7,152,029	FY 1968:	$ 7,865,000	FY 1969:	$10,600,000
(2) Chemical Reactions		1,891,616		1,789,000		1,700,000
Total		$ 9,043,645		$ 9,654,000		$12,300,000

The objective of the nuclear safety research and development program is to study abnormal behavior including accident effects of reactor systems and related nuclear facilities. A reactor can potentially be destroyed by a nuclear excursion or by a loss of core coolant, resulting in the release of fission products into the

11. Nuclear Safety - continued

containment shell and possibly some release to the outer environment. This research is intended to provide increased knowledge on the accident behavior of various reactor systems and related nuclear facilities to meet the goals of both safety and economic operation.

(1) Reactor Kinetics ..... FY 1967: $ 7,152,029 FY 1968: $ 7,865,000 FY 1969: $10,600,000

The Reactor Kinetics Program investigates the transient behavior of reactors operated under accident conditions of varying severity in the range between normal power operation and large power excursions capable of core destruction. This information is important in the design of future large reactors as well as in the improvement of existing reactors.

Note: Costs shown are for Research and Development unless otherwise indicated.

(a) SPERT

Research and Development ...	FY 1967:	$ 2,493,020	FY 1968:	$ 2,380,000	FY 1969:	$ 1,965,000
Irradiations		0		35,000		35,000
Total SPERT		$ 2,493,020		$ 2,415,000		$ 2,000,000

The SPERT Program includes a series of comprehensive experimental and theoretical studies of the behavior of reactors under temperature transient conditions. The purpose of these studies is to predict the limits of safe reactor operation as well as the consequences of exceeding these limits including information about fuel failure, reactor shutdown mechanisms and heat transfer that occur during reactor excursions.

The specific areas of investigation during the budget period include:

1) The subassembly testing program utilizing the Capsule Driver Core will be continued through FY 1969. During FY 1968 tests of prototype Power Burst Facility (PBF) and SPERT III fuel will be completed. In FY 1969, a testing program will be initiated on irradiated oxide test fuel to determine how fission gas buildup and material property changes created during normal burnup cycles affect the fuel when it is subjected to accident conditions.

11. Nuclear Safety - continued

2) The Oxide Core Kinetics program will be completed in FY 1968. During the first half of FY 1968 the kinetic behavior of the SPERT III E-Core at high initial power will be investigated. The analysis and reporting of the data received from experimental investigations conducted during FY 1967-1968 will be completed by the last quarter of FY 1968.

3) Following completion of tests in the Oxide Core Kinetics Program, a limited damage test program may be initiated in SPERT III to realistically assess the course and consequence of damaging reactivity accidents under typical water cooled power reactor operating conditions.

4) A program plan for a Large Core Dynamics Program to provide experimental data on the dynamic response of large reactor cores to localize perturbations is being prepared.

(b) Power Burst Facility (PBF)

Research and Development ...	FY 1967:	$ 1,521,363	FY 1968:	$ 1,325,000	FY 1969:	$ 1,400,000
Fuel Fabrication		0		75,000		1,200,000
Total		$ 1,521,363		$ 1,400,000		$ 2,600,000

The Power Burst Facility (PBF) is a pulse-type, oxide fueled, epithermal, water moderated reactor presently under construction as part of the SPERT complex. This reactor is designed to generate power bursts with initial asymptotic periods as short as 1 msec, producing energy releases large enough to destroy entire fuel subassemblies placed in a capsule or flow loop mounted in the reactor, all without damage to the reactor itself. The R&D effort in FY 1968 includes: static and kinetic calculations required to establish the performance of both the PBF core and typical experiments within the test space, continued analysis of prototype PBF fuel fods in nuclear environments, the preparation of the PBF Safety Analysis Report, establishment of physical properties of the final PBF fuel, issue all System Design Descriptions (SDDs), thermal-hydraulic analysis of the core and design of in-pile tubes for planned experiments. The FY 1969 estimates provide for the major portion of the fuel for the first PBF core and continuation of most of the R&D effort provided for in FY 1968. Operator training will commence in FY 1969.

11. Nuclear Safety - continued

(c) Other Reactor Kinetics

Research and Development ...	FY 1967:	$ 2,987,233	FY 1968:	$ 3,801,000	FY 1969:	$ 5,702,000
Operations		150,413		175,000		213,000
Irradiations		0		74,000		85,000
Total		$ 3,137,646		$ 4,050,000		$ 6,000,000

The estimates provide for the continuation of the fast reactor safety studies to determine the margin of safety of fast reactor fuel under excursion conditions. The increase in the research and development is due mainly to two new efforts: (1) a study initiated in FY 1968 to define a program of work for fast reactor test facilities and the definition and development of the design criteria and concepts for such facilities to carry out such a program and (2) implementation of fast reactor safety analyses to specific fast breeder designs. These efforts will require substantial increases in FY 1969.

(2) Chemical Reactions

Research and Development	FY 1967:	$ 1,891,616	FY 1968:	$ 1,773,000	FY 1969:	$ 1,685,000
Irradiations		0		16,000		15,000
Total		$ 1,891,616		$ 1,789,000		$ 1,700,000

This program provides for assessing the consequences of postulated nuclear accidents for both fast and thermal reactor systems involving fuel overheating or melting leading to fission product release; destruction of fuel elements; chemical reactions of fuel or cladding with coolant and their resultant energy releases; and retention of released fission products by coolant and on surfaces. This data is needed for the development of adequate engineered safety features and as input for safety analyses used in reactor evaluation and site selection.

b. Effluent Control Research and Development

(1) Environmental Studies.....	FY 1967:	$ 791,601	FY 1968:	$ 664,000	FY 1969:	$ 775,000
(2) Low & Intermediate Level Waste Studies		421,865		400,000		435,000
(3) High Level Waste Studies		2,711,845		2,565,000		2,500,000
(4) Gaseous Effluent Studies		926,171		830,000		890,000
Total		$ 4,851,482		$ 4,459,000		$ 4,600,000

94-075 O-68-pt. 3—22

11. Nuclear Safety - continued

The work being carried out under this activity is directed toward the problems associated with the environmental aspects of nuclear operations including the treatment, handling, and disposal of radioactive effluents and their effects upon the environment. This effort centers around: (1) development of economic waste treatment and disposal methods for the safe management of all types of radioactive waste; (2) development and testing of cleaning systems for the control of gaseous radioactive effluents resulting from reactor accidents; (3) establishment of technical criteria for the controlled disposal of radioactive effluents into the environment; (4) meteorologic, hydrologic, geologic, seismologic aspects of reactor location, design and construction.

(1) Environmental Studies ..... FY 1967: $ 791,601 FY 1968: $ 664,000 FY 1969: $ 775,000

This subactivity involves studies necessary to analyze and evaluate all environmental factors associated with the safe disposal of radioactive effluents. Included are hydrologic and geoseismic analyses to assist in the evaluation of proposed power reactor sites and to determine the fate of radionuclides released to the terrestrial environment; oceanographic and thermal pollution research studies to determine the environmental effects of nuclear systems and waste disposal operations under both routine and accident conditions; and shipping container testing associated with the transportation of fissionable material and radioactive products and wastes.

(2) Low & Intermediate Level Waste Studies ..... FY 1967: $ 421,865 FY 1968: $ 400,000 FY 1969: $ 435,000

This subactivity is concerned with the development, testing and application of improved systems for handling, treatment, and disposal of low and intermediate radioactive waste materials. Engineering-scale pilot plant work will be carried out in FY 1968-1969 to demonstrate an asphalt insolubilization process for solidification of these wastes; development and demonstration of processing methods for side streams generated in the course of high level waste solidification; and development of techniques for determining the applicability of hydrofracturing other than at ORNL.

(3) High Level Waste Studies .....FY 1967: $ 2,711,845 FY 1968: $ 2,565,000 FY 1969: $ 2,500,000

This research and development program involves the development and demonstration, on an engineering scale, of systems for conversion of high level liquid wastes to solids suitable

11. Nuclear Safety - continued

for permanent disposal in a satisfactory environment. The "conversion-to-solids" methods under study involve spray solidification, pot calcination and phosphate glass techniques. Operation of the Waste Solidification Engineering Prototype (WSEP) with actual high-activity wastes at Richland during FY 1968-1969 will allow engineering scale comparisons of these alternate solidification processes in terms of their economics and applicability to the different waste compositions expected to arise from the reprocessing of test and power reactor fuels. Associated with the solidification program is a systematic study of the short-and-long-term physical, chemical and radiological properties of solidified wastes and the internal and external environmental effects on solidified forms and containers. Work previously carried out on ultimate disposal in salt formations is associated with this activity.

(4) Gaseous Effluent Studies ..... FY 1967: $ 926,171 FY 1968: $ 830,000 FY 1969: $ 890,000

The hazards associated with potential airborne radioactivity require development of methods for removing these radioactive fission products from bulk gas streams and for determining the disposition of the radioactivity released to the atmosphere. Therefore, these studies are directed toward the development of new and improved systems for measurement and control of gaseous and particulate effluents with increasing emphasis being given to studies in the areas involving air cleaning of reactor and fuel reprocessing contaminants following an accident. These estimates include research on characterization of energy release and aerosol transport during chemical reactions such as sodium fires to provide data required for nuclear safety analyses and engineered safety features design.

c. Engineering Field Tests

(1) Nuclear Safing and Recovery	FY 1967: $ 45,487	FY 1968: $ 0	FY 1969: $ 0
(2) LOFT	7,030,690	8,430,000	10,000,000
Total	$ 7,076,177	$ 8,430,000	$10,000,000

The principal feature of the Engineering Field Tests Program is engineering scale testing of nuclear power reactors to acquire general safety technology and to demonstrate safety characteristics or techniques on a "proof-of-principle" basis, and to develop and verify calculational techniques suitable for industrial and AEC (regulatory and development) use.

11. Nuclear Safety - continued

(1) Nuclear Safing and Recovery .... FY 1967: $ 45,487 FY 1968: $ 0 FY 1969: $ 0

Until a program plan is developed and approved, no support beyond FY 1967 is presently planned for this activity.

(2) LOFT

Research and Development ..... FY 1967:	$ 5,404,925	FY 1968: $ 6,990,000	FY 1969: $ 6,975,000
Fuel Fabrication	677	50,000	1,050,000
Reactor Experiment Fabrication .	1,624,999	1,390,000	1,975,000
Test Irradiations	89	0	0
Total LOFT	$ 7,030,690	$ 8,430,000	$10,000,000

During FY 1967, the LOFT Testing Program was re-evaluated as a result of the increasing emphasis being placed on actual engineering safety features. The LOFT program priority has been redirected from unperturbed loss-of-coolant tests to the analysis and related testing of emergency core cooling systems and other engineered safety systems.

The current program can be divided into three areas of work:

LOFT Supporting Development .... FY 1968	$ 2,795,000	FY 1969: $ 3,000,000
LOFT Fabrication & Quality Assurance	5,435,000	6,600,000
LOFT Testing Program	200,000	400,000
Total	$ 8,430,000	$10,000,000

Supporting Development

To support the LOFT Testing Program and to make use of the information developed in all phases of the LOFT endeavor, experimental work and analytical studies will be performed to develop calculational techniques and computer codes for predicting performance of the reactor and its safety systems under abnormal accident conditions and for establishing safety criteria. In

11. Nuclear Safety - continued

parallel with and in support of this analytical effort, engineering and development tests are required as exemplified by the quarter-scale non-nuclear LOFT tests. This quarter-scale system is used to evaluate the forces which will be impressed on the LOFT system and core during loss-of-coolant blowdown and the effects created by introducing emergency core cooling water on the core and other system components.

In addition, instrumentation development and testing will continue so that all of the important data generated during LOFT nuclear operation can be fully retrieved. Radiochemistry relating to fission product sampling and post-test cleanup will continue. The objective of the LOFT support effort is to assure that the required data can be obtained during the LOFT tests and that it can then be interpreted and applied to safety and siting questions on many types and sizes of test and power reactors. The increase in FY 1969 reflects the more sophisticated analytical techniques and tests associated with the complex heat transfer and other processes involved when emergency coolant is introduced.

Fabrication and Quality Assurance

The activities covered by this project include all work essential to completing the LOFT plant and providing the reactor and appurtenances to conduct the LOFT emergency core cooling systems testing program. This includes design, analysis, procurement fabrication, quality assurance, quality control and liaison for the LOFT reactor systems.

The increase in FY 1969 reflects the continuing emphasis on quality assurance as well as the design, procurement and installation of the emergency core cooling system (injection, accumulator and deluge). In addition, it reflects dislocations of the FY 1968 procurement pattern to accommodate these adjustments.

Testing Program

This category covers the formulation and planning of the actual LOFT tests. In FY 1969, planning will continue and organization and training of test personnel will begin. This will include trial runs with the sampling systems and with the data analysis system. It will also include assessment of the health and safety aspects of the nuclear tests.

11. Nuclear Safety - continued

d. Reactor Safety Anal. & Eval. ..... FY 1967: $ 1,404,690 FY 1968: $ 1,792,000 FY 1969: $ 2,500,000

Increases in this activity reflect a substantial additional effort aimed largely at assisting in the AEC's tasks of evaluating proposed reactors from a licensing standpoint and insuring proper feedback into the research and development program. The Computer Handling of Reactor Data-Safety (CHORD-S) Project will provide a computerized memory bank of specific reactor safety characteristics, which together with a capability for computation and data manipulation, will enable comparative safety evaluations of reactor designs to be made by regulatory. RDT also will make extensive use of the results of this project for evaluating designs and for program planning purposes. This project is expected to develop in broader scope in FY 1969. The new Technical Assistance project will require substantial new budgetary support for FY 1968 and FY 1969 and is intended to provide the Division of Reactor Licensing with the expert services of Commission laboratory and contractor personnel to augment and assist in the development of DRL's evaluative capabilities by performing model calculations by best current techniques and evaluating data supplied by applicants for licenses. This project will be useful to RDT for its identification of weak areas in the technology and their priority needs. Other new efforts will be undertaken to assist in the establishment of operator standards and the application of reliability analysis to the assessment of reactor safety. Ongoing projects include planning and information dissemination, the development of technology in support of the evaluation and assurance of the integrity of primary systems.

e. Engineered Safety Features

(1) Safety Features Technology ..... FY 1967:	$ 4,028,029	FY 1968: $ 4,355,000	FY 1969: $ 4,500,000
(2) Plant Application & Engineering Tests	790,290	1,800,000	2,400,000
(3) Standards, Codes & Specifications	1,437,129	2,815,000	4,100,000
Total	$ 6,255,448	$ 8,970,000	$11,000,000

The objective of this activity is to (1) develop technology required for the design of engineered safety systems which will prevent reactor accidents or minimize their consequences and (2) demonstrate the effectiveness of such systems in preserving both integrity and public safety of reactors and other nuclear facilities. It will also foster the application of sound engineering principles to design, fabrication, construction, quality control, inspection, and prooftesting of such safety features. This effort was initiated in response to the urgent needs of Regulation for data associated with decisions on the evaluation and siting of large nuclear power plants. The program will utilize

11. Nuclear Safety - continued

the results of other research and development programs in order to develop the requirements for safety systems and the technology (practices, codes, and design standards) of their manufacture applicable to all reactor types.

(1) Safety Features Technology ..... FY 1967: $ 4,028,029 FY 1968: $ 4,355,000 FY 1969: $ 4,500,000

This subactivity is concerned with the development of experimental data to define the effectiveness of engineered safety systems for preventing and/or limiting the consequences of potential reactor accidents and to improve the effectiveness of such systems. It involves expanded effort in defining the characteristics of various reactor accidents which engineered safety systems and countermeasures must overcome and the environment in which the systems must operate. It provides for research and development efforts to obtain information on thermal and hydraulic effects of loss-of-coolant accidents on in-core emergency cooling systems; on development of engineered features capable of resisting mechanical damage from accidents in fast or thermal reactors so as to insure post accident operability and integrity; in evaluation of air cleaning and chemical spray systems under reactor accident conditions; on development and testing of noble gas removal systems under reactor accident conditions and from fast reactor fuel reprocessing effluents; on techniques for the continuous monitoring of primary cooling circuits for detecting and isolating incipient failures; on analysis of advanced containment designs and testing under realistic accident conditions; on development of fission product scavenging techniques; and on the development of analytic techniques for design and safety evaluations.

The FY 1969 estimate includes the pipe rupture program, the Containment Systems Experiment (CSE), and the development of spray and filter system technology. The pipe rupture program investigates the credibility and extent of a pipe failure as a cause of a major loss of coolant that could lead to core destruction and release of radioactivity into the containment. The CSE studies the effect of a simulated loss-of-coolant accident and consequent release of radioactivity upon systems employed to reduce the post-accident pressure and upon the efficiency of engineered safety systems in restricting the movement of radioactivity.

11. Nuclear Safety - continued

A major effort will be applied to tests of emergency core cooling systems under a wide range of accident conditions to counteract the consequence of any potential loss-of-coolant accident. Considerable emphasis will be given to correlating and synthesizing the results of R&D programs and other available data into analytical models of total reactor accident sequences capable of wide application.

(2) Plant Application & Engineering Tests ..... FY 1967: $ 790,290 FY 1968: $ 1,800,000 FY 1969: $ 2,400,000

The Plant Applications and Engineering Test program was initiated in FY 1966 to conduct in-plant and engineering scale tests directly related to safety feature design and engineering of large nuclear power stations. The intent is to be of direct assistance to industry and the Commission on matters of safety assurance and siting. The increase in FY 1968-1969 reflects the implementation of these tests.

Tests of safety systems and safety features planned for FY 1968 in a commercial reactor will be expanded in FY 1969 in cooperation with utilities and industry. Similar tests will be conducted in selected AEC-owned reactors.

In addition, a program of reliability monitoring of power reactors which started in FY 1968 will be continued with a larger scope in FY 1969. The purpose of this in-plant program is to collect failure data in a standardized format on a pilot program basis in large power reactors. In this manner, a system can be established for collecting meaningful, and reliable information for comparative purposes on a long range systematic basis.

Tests of advanced systems to detect and monitor crack initiation and propagation in pressurized systems will continue, and engineering scale tests of major safety systems such as filters will be explored. Testing of emergency core cooling systems on full size electrically heated PWR and BWR fuel assemblies initiated in cooperative effort with industry in FY 1968 will be continued. Also, tests which do not depend on pump operation such as gravity flooding for emergency core cooling will be exploited. This advanced type test was initiated in late FY 1967.

11. Nuclear Safety - continued

(3) Standards, Codes & Specifications ..... FY 1967: $ 1,437,129 FY 1968: $ 2,815,000 FY 1969: $ 4,100,000

This activity supports the development of criteria, standards, codes, specifications, operating limitations, process controls and test and inspection procedures for reactors and other needed test and experimental systems and components under the cognizance of RDT, but taking advantage of accelerated or going efforts in industry. These efforts are expected to contribute to the basis for commercial standards appropriate for the reactor industry. Increases in this budget area are mainly due to the Heavy Section Steel Technology project which is developing the technology to support standards for thick walled vessels typical of large water reactors to provide additional assurance of their safety. Another area of increase is for highly focused programs to collect, modify and implement standards for test and power reactors and for upgrading piping system codes. Substantial increases in these efforts will be needed in FY 1969. Ongoing work includes the assessment of the status of current technology in particular areas for the purpose of planning further development in support of standards and codes.

12. Operational Services $2,102,000

a.	Test Reactors - Net.....	FY 1967: $4,382,315	FY 1968: $2,274,000	FY 1969: $1,150,000
b.	Reactivity Measurement Facility	- 2,042	0	0
c.	Standby Costs	324,800	150,000	200,000
d.	Transportation & Security Shipments .	21,597	101,000	50,000
e.	Operational Services - Other	456,112	475,000	702,000
	Total	$5,182,782	$3,000,000	$2,102,000

a. Test Reactors - Net ..... FY 1967: $4,382,315 FY 1968: $2,274,000 FY 1969: $1,150,000

Estimates under this activity provide for gross costs of operation for MTR-ETR and ATR plus gross costs of irradiation unit charges for certain AEC-sponsored experiments in the General Electric Test Reactor less credits for MTR-ETR-GETR and ATR charges. The residual Test Reactor costs represents ATR pre-operational costs in FY 1967; ATR low power operation for nine months and system checkout in FY 1968; and the effect of decreasing experiments in MTR in FY 1969.

The test reactor estimates are based on the following assumptions:

(1) The ATR will achieve full-scale operation in the fourth quarter of FY 1968. Cost of operation subsequent to that time will be distributed to user activities.

(2) With the utilization of the ATR to accommodate a major portion of the irradiation requirements of the Navy program, all experiments will be withdrawn from the MTR at the end of FY 1969 or early FY 1970 and shifted to either the ETR or ATR. Since the MTR costs during the latter portion of FY 1969 are not equitably distributable over the diminishing MTR experimental load, a portion of the MTR costs ($1,050,000) is budgeted for under this activity in FY 1969.

(3) ETR experimental utilization will increase during the budget period to accommodate the shift of experiments from the MTR. $100,000 for flux stabilization studies in both FY 1968 and FY 1969 is included in the Test Reactors - Net.

12. Operational Services - continued

(4) GETR utilization will increase over the FY 1967 level.

Test reactor gross costs and distributions to users are summarized below:

Gross Costs:

MTR	FY 1967: $ 4,740,270	FY 1968: $ 4,900,000	FY 1969: $ 5,050,000
ETR	6,851,369	6,800,000	7,250,000
GETR	1,895,252	2,800,000	3,084,000
ATR	3,230,886	6,974,000	12,900,000
Subtotal Gross Costs	$16,717,777	$21,474,000	$28,284,000

Distribution Credits:

AEC Users	FY 1967: $10,474,473	FY 1968: $17,400,000	FY 1969: $25,434,000
Other	302,769	0	0
Experiment Services	1,558,220	1,800,000	1,700,000
Subtotal Distribution Credits	$12,335,462	$19,200,000	$27,134,000
Test Reactors - Net	$ 4,382,315	$ 2,274,000	$ 1,150,000

b. Reactivity Measurement Facility .... FY 1967: $ - 2,042 FY 1968: $ 0 $ 0

Gross costs in FY 1967 were $166,146. Distribution of costs amounted to $168,188.

c. Standby Costs ..... FY 1967: $ 324,800 FY 1968: $ 150,000 FY 1969: $ 200,000

The estimates under this activity represent surveillance and necessary maintenance and industrial work for areas such as Army Reactor Area, Experimental Organic Cooled Reactor, and the Organic Moderated Reactor Experiment at the National Reactor Testing Station, the Heavy Water Components Test Reactor at Savannah River, and the Oak Ridge National Laboratory graphite reactor.

REACTOR DEVELOPMENT PROGRAM - continued

12. Operational Services - continued

d. Transportation and Security Shipments ..... FY 1967: $ 21,597 FY 1968: $ 101,000 FY 1969: $ 50,000

The estimates represent courier services and security shipments related to irradiation experiments in the MTR-ETR-ATR at the NRTS and in FY 1968 shipping costs related to Hallam equipment.

e. Operational Services - Other ..... FY 1967: $ 456,112 FY 1968: $ 475,000 FY 1969: $ 702,000

The estimates provide for: (1) advance general site planning, underground water investigations and predatory animal and noxious weed control at the NRTS and (2) the Aerial Radiometric Measurement System (ARMS) at the Nevada Test Site.

NOTE: All net costs of the general site services function and the Reactivity Measurement Facility at the NRTS are distributed to user organizations.

Additional information of a classified

nature is contained in Classified Book I.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

REACTOR DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$185,039,000
A Construction Projects	
A-1 Obligations for new projects	($ 60,925,000)
A-2 Obligations for prior year projects	($ 71,114,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 38,550,000)
B-2 Obligations from prior year appropriations .	($ 14,450,000)
Estimated Obligations FY 1968	$ 46,863,643
Actual Obligations FY 1967	$ 57,296,916

Obligations for the Reactor Development Program for FY 1969 are estimated at $185,039,000, of which:

a. $60,925,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act or were previously authorized and for which a request for appropriation was deferred until FY 1969.

b. $71,114,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $38,550,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $14,450,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back".

SECTION A-1

The projects comprising Section A-1, which are requested for authorization in FY 1969 or which were previously authorized and for which a request for appropriation was deferred until FY 1969, are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-4-a	Hot fuel examination facility, National Reactor Testing Station, Idaho	$ 10,200,000			
	Less Construction Planning and Design	200,000			
	Net	10,000,000	$ 0	$ 10,000,000	$ 0
69-4-b	Modifications to EBR-II and related facilities, National Reactor Testing Station, Idaho	2,000,000	0	2,000,000	0
69-4-c	Research and development test plants, Project Rover, Los Alamos Scientific Laboratory, New Mexico, and Nevada Test Site, Nevada	1,000,000	0	1,000,000	0
69-4-d	Modifications to reactors	1,000,000	0	1,000,000	0
69-5-a	Conversion of heating plant to natural gas, Argonne National Laboratory, Illinois	525,000	0	525,000	0
69-8	General plant projects	11,400,000	0	11,400,000	0
67-3-a	Fast flux test facility	87,500,000	28,500,000 a/	35,000,000	24,000,000
	Total	113,425,000	28,500,000	60,925,000	24,000,000

a/ Of this amount, $4,750,000 will be obligated in FY 1968 and $23,750,000 will be carried over into FY 1969 as shown in Section A-2.

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-4-a Hot fuel examination facility, National Reactor Testing Station, Idaho $10,000,000

The facility will consist of basically a one-story building, with high and low bays, and with a full basement located adjacent to the north wall of the existing Fuel Cycle Facility (FCF) at the EBR-II complex. The building will include an integrated complex of shielded cells, nonshielded support facilities, service floor, and fan lofts with the intent of including capabilities for handling a variety of highly radioactive components principally for the Fast Breeder Reactor Program. The facility will contain an examination cell with an inert gas atmosphere and will incorporate many features that will insure the containment of radioactive particulates. The facility will also include shielded areas for the maintenance, decontamination and storage of in-cell equipment.

The primary purpose of the facility is to provide a shielded, hot cell examination complex and associated facilities initially needed to support, expedite and enable irradiation experiments essential to the development of fuel, fuel cladding and structural materials principally for the FBR program. The facility will contribute importantly to the experimental programs by providing rapid turn-around of irradiation experiments, including interim inspection and prompt and reliable completion of terminal examinations, by enabling examination of irradiated experiments requiring an inert atmosphere, by enabling preparation and post-transient examination of destructive safety-related experiments, and by other important services. Present hot cell facilities are not adequate to support the existing experimental irradiation program now under way at the National Reactor Testing Station (NRTS). The complexity of the project stems from the necessity of handling irradiated plutonium bearing fuel and the requirement of making accurate type measurements and tests on hot fuel. Special and unique precision equipment must be designed and strategically located to make accurate measurements remotely and reliably in an irradiation environment.

Details of Cost Estimate:*

a. Engineering, Design and Inspection Costs @ approx. 20% of Construction Costs, item b		$ 1,400,000
b. Construction Costs:		6,700,000
(1) Improvements to Land	$ 20,000	
(2) Building; (approx. 36,000 sq. ft. @ about $33/sq. ft.)	1,200,000	
(3) Cell Structures:		
(a) Main cell	1,200,000	
(b) Auxiliary cells	800,000	
(4) Utilities, incl. sewer, water, steam, electrical, etc.	180,000	

Section A-1 - continued

1. Project 69-4-a - continued

Details of Cost Estimate:* (Continued)

(5) Special Facilities:		$3,300,000	
(a) Shielding windows	$ 500,000		
(b) Manipulators and special cranes	1,000,000		
(c) Analytical measuring equipment	800,000		
(d) Examination equipment, transfer cars, remote TV, periscopes and laboratory equipment	1,000,000		
c. Standard Equipment (office furniture, etc.)			$ 100,000
Subtotal			8,200,000
d. Contingency @ approx. 25% of above costs			2,000,000
Total Project Cost			$10,200,000**

*Based on preliminary conceptual design

**Includes $200,000 for construction planning and design.

2. Project 69-4-b Modifications to EBR-II and related facilities, National Reactor Testing Station, Idaho ..... $ 2,000,000

This project provides for the following modifications to the Experimental Breeder Reactor II (EBR-II): (a) nuclear core instrumentation test facility, (b) packaged loop, (c) chemistry laboratory addition, (d) cold line addition to the Inspection and Testing Facility, (e) plutonium chemistry cells and (f) failed fuel subassembly locator system.

The primary purpose for these modifications is to insure the reliability and enhance the capability of the EBR-II to fulfill its function as the only available test reactor of the FBR program. Past modifications to the EBR-II have improved the operational potential of the plant but to meet the needs of the FBR program these proposed modifications are required. The primary objectives of these new modifications are to: (1) increase the on-stream factor, (2) increase the power level from 45 MWt toward the design power level of 62.5 MWt, and (3) expand the irradiation utility of EBR-II.

REACTOR DEVELOPMENT PROGRAM - continued

Section A-1 - continued

2. Project 69-4-b - continued

Details of Cost Estimate: *

a. Engineering, Design and Inspection Costs @ approx. 15% of Construction Costs, item "b"				$ 220,000
b. Construction Costs				1,450,000
(1) Improvements to Land			$ 20,000	
(2) Buildings:			470,000	
(a) Chemistry Laboratory Addition (approx. 4200 sq. ft. @ about $38/sq. ft.)	$160,000			
(b) Cold Line Addition to Inspection and Testing Facility (approx. 3000 sq. ft. @ about $44/sq. ft.) 1/	130,000			
(c) Plutonium Chemistry Building Addition (approx. 4000 sq. ft. @ about $45/sq. ft.)	180,000			
(3) Other Structures:				
(a) Plutonium Chemistry Hot Cells 2/			160,000	
(4) Special Facilities:			780,000	
(a) Failed Fuel Subassembly Locator System	330,000			
(b) Nuclear core instrumentation and related equipment	200,000			
(c) Packaged loop piping, pumps and related equipment	250,000			
(5) Utilities			20,000	
Subtotal				$ 1,670,000
c. Contingency @ approx. 20% of above costs				330,000
Total Project Cost				$ 2,000,000

*Based on partial conceptual design

1/ High unit cost is attributable to the extensive mechanical and electrical facilities required for fuels testing and handling.

2/ The two cells (approx. 325 cu. ft. each) are to be thick-walled, heavy concrete construction completely lined with metal, equipped with remote viewing and handling equipment, and provided with inert gas atmosphere.

3. Project 69-4-c Research and development test plants, Project Rover, Los Alamos Scientific Laboratory, New Mexico, and Nevada Test Site, Nevada ..... $ 1,000,000

This project provides for modifications and/or expansion of existing facilities, and construction of additional facilities and systems as appropriate to support research and development of nuclear rocket reactors (Project Rover) at Los Alamos and Nuclear Rocket Development Station.

Examples of types of facilities, additions, and modifications under consideration are: Expansion of fuel fabrication and component testing facilities at Los Alamos Scientific Laboratory; test and support facility improvements and additions at NRDS; and site improvements and additions at NRDS.

The funding for this project provides for additional facility requirements not now identified as specific items, for site improvements, and in general for facility support. Facility modifications are required to accommodate more advanced and improved experiments plus other modifications required by the changing nature of test operation. In a developing experimental program it is not possible to anticipate all requirements since these are dictated by progress in research and development and operating experience.

Details of Cost Estimate:

Details of the cost estimate for design and construction are not available due to the nature of the proposed project.

4. Project 69-4-d Modifications to reactors ..... $ 1,000,000

This project provides for modifications and changes to existing reactors, critical assemblies and major test facilities. A major segment of the reactor development program is dependent upon the effective use of these facilities and funds must be available to effect the modifications and improvements which are dictated by progress in research and development and by operating experience. While it is not possible to accurately forecast specific modifications to some of the many reactors and extensive and complex test facilities that are now in existence or planned, there will be continuing need for modifications to these facilities to accommodate more advanced experiments plus a variety of other plant modifications required by the changing nature of test operations.

Section A-1 - continued

4. Project 69-4-d - continued

Seventeen AEC-owned experimental reactors plus an additional number of critical assemblies are currently being operated in connection with the reactor development program. In addition, several major complexes are being operated to test reactor systems.

The Liquid Metal Engineering Center (LMEC), at Santa Susanna, California, is the key candidate project for funding under this project. The LMEC is considered essential to the Liquid Metal Fast Breeder Reactor (LMFBR) Program as a test facility in connection with the testing of prototypical liquid metal components and sub-components such as heat exchanger, valves, bearings, seals, instrumentation, etc. In order to conduct operations on a reliable basis and in consonance with the LMFBR schedule, plant updating, engineering improvements, vital plant component and system redundancy and provisions for decreasing the down time between tests are required. Examples of some of the urgent modifications to the LMEC include increasing the capability of the LMEC to test steam generators, instruments, small valves, pumps and flow meters, bearings and seals, core mechanisms and control systems.

Details of Cost Estimate:

Not available due to type of project involved.

5. Project 69-5-a Conversion of heating plant to natural gas, Argonne National Laboratory, Illinois ... $ 525,000

This project is required to fulfill the provisions of Executive Order 11282 (Section 3), "Control of Air Pollution Originating from Federal Installations". The remedial measures proposed were developed on the basis of air pollution standards prescribed by the Secretary of Health, Education and Welfare.

The work will involve augmenting the existing coal burning equipment with gas and oil burners and installation of combustion controls, oil pumps, 100,000 gallon oil storage tank, and interconnecting piping. Both coal and oil will be maintained as reserve fuels for use during emergency periods when the gas supply is interrupted.

The Executive Order specifies that the Commission comply with the standards establishing the maximum emission rate of sulfur dioxide from fuels used in combustion units which, in the Chicago, Illinois area, shall not exceed 0.65 pounds per million BTU (gross value) heat input. Presently, the stack effluent contains approximately 4.5 pounds of sulfur dioxide on this basis. It has been determined that the only feasible solution available is to modify the four boilers to permit the burning of natural gas in lieu of coal, which will result in essentially no sulfur dioxide emission. Equipment for the storage, handling and burning of light

5. Project 69-5-a - continued

fuel oil is necessary to maintain an emergency fuel supply in the event of a gas supply failure. Maintaining coal as the only reserve fuel for use during an emergency period when the gas supply is interrupted places the production of steam in jeopardy because of the relatively longer time required to transfer from gas firing to coal firing; therefore oil firing will be utilized until a coal fire is fully established. It is expected that coal firing will be used only for short term emergency periods.

Details of Cost Estimate: *

a. Engineering, Design and Inspection Costs @ approx. 15% of Construction Costs, item b		$ 55,000
b. Construction Costs:		380,000
(1) Installation of gas burners	$ 260,000	
(2) Oil Storage and handling equipment	120,000	
Subtotal		435,000
c. Contingency @ approx. 20% of above costs		90,000
Total Project Cost		$ 525,000

*Based upon partial conceptual design

6. Project 69-8 General plant projects $11,400,000

The work contemplated under this project consists of many miscellaneous improvements, alterations, and additions, including minor new construction. Similar work is performed annually in order to provide for the continuity of operations, improvements to techniques, and reduction in operating costs in the facilities supporting the research and development programs. The project covers (1) all of the general plant requirements of the Argonne National Laboratory, the Oak Ridge National Laboratory, the Pacific Northwest Laboratory at Richland, Washington, the National Reactor Testing Station in Idaho, the Nuclear Rocket Development Station in Nevada, the Pittsburgh Naval Reactors Office and the Schenectady Naval Reactors Office; and (2) general plant support of the reactor development programs under the Chicago, New York, Oak Ridge and San Francisco Operations Offices.

6. Project 69-8 - continued

The estimate is based on the past experience of the various operations offices with individual requirements as follows:

Argonne National Laboratory	$ 2,300,000
Chicago Operations Office	50,000
Idaho Operations Office	2,150,000
New York Operations Office	50,000
Pittsburgh Naval Reactors Office	600,000
Schenectady Naval Reactors Office	600,000
Oak Ridge Operations Office	50,000
Oak Ridge National Laboratory	2,400,000
Pacific Northwest Laboratory	2,200,000
Space Nuclear Propulsion Office - Nevada	500,000
San Francisco Operations Office	500,000
Total	$11,400,000

Details of Cost Estimate:

Details of cost estimates for this project are not available at this time. Detailed cost estimates for General Plant Projects are normally made in connection with the request for directive after the need for the work has been established, the job has been scoped, and preliminary engineering completed.

7. Project 67-3-a Fast flux test facility $87,500,000 1/

The objectives for a fast flux test facility are to provide an adequately controlled and instrumented environment in a fast flux for testing instrumented fuel specimens, fuel rods, fuel sub-assemblies, clad and structural materials with capabilities to test up to and including failure in dynamic sodium. The facility will have a high, reliable plant performance with means to test fuel for short time periods, minutes, or even seconds, and interim non-destructive fuel examination capability.

To meet these objectives the following facility requirements are being considered: four or more instrumented closed loops, up to about 6 inches in diameter for a 3 to 4 foot core; instrumented open loops, and rabbit facilities. Facilities for interim fuel examination including disassembly, reinstrumentation and reassembly of specimens, capsules, or rods will also be provided.

1/ The FY 1969 appropriation request for this project is $35,000,000.

Section A-1 - continued

7. Project 67-3-a - Continued

The fast flux test facility will have a fast flux capability of about 0.7×10^{16}nv to 1.3×10^{16}nv, at neutron energy levels 75%>0.1 Mev, with a specific power in the range of 500 to 2000 or more watts/gm Pu. Maximum reactor core outlet sodium temperature will range from 800 to 1200°F. Provision will be made for sodium purity control capable of maintaining impurities to below the concentrations required to protect the stainless steel, refractories, superalloys and other cladding and structural materials. Specific requirements needed to meet the objectives include a minimum of two reactor primary system loops, two secondary loops, and two heat sinks, designed to permit continued plant operation with one loop in a non-operating status. Closed loops accessible and removable external to the reactor will also be required with adequate provision for coolant control instrumentation and monitoring equipment, including equipment for controlling and/or monitoring fuel test assemblies.

The FFTF reactor will have a heat removal capability of about 400 MW. The reference initial core loading will be mixed Pu U oxide clad in stainless steel. The reactor is presently conceived as a hexagonal lattice split cone core assembly surrounded by a fixed neutron reflector region that is subsequently enclosed in successive barriers of reactor vessel, shroud vessel, neutron shield, primary containment, and, finally, the FFTF structure. However, configuration may change as design becomes more definitive.

Conceptually, the reactor will be cooled by **liquid sodium "primary" circuits and reactor heat will be** extracted from the primary circuit by separate secondary sodium circuits which will discharge the heat to the atmosphere by air-cooled heat exchangers. Provision will be made for maintenance of sodium and cover gas purity at all times.

Development of economic fast breeder fuels is an integral part of the Commission's high priority objective of demonstration of commercial economic large size nuclear breeder power plants to assure the economical utilization of the nation's nuclear resources for energy production. To accomplish this objective, facilities are needed for irradiation testing under fast reactor conditions. In addition, fast flux testing is required for other programs using fast flux reactors.

Fuel and structural materials in future fast breeder reactor cores will be exposed to local maximum sodium temperatures of 1300-1400°F (associated with sodium bulk outlet temperatures up to 1200°F), to neutron flux up to 10^{16}nv, and to flux-time integrals of up to 10^{24}nvt. Fuel exposures in excess of 100,000 MWD/Ton will be required. Thermal reactor environments cannot be reliably substituted for such prototypic fast spectrum environments because of significant differences in conditions imposed on the test specimens.

Section A-1 - continued

7. Project 67-3-a - continued

Several studies have been conducted investigating alternative ways of providing improved irradiation testing facilities. These studies have resulted in the determination that improved facilities are needed, and the conclusion reached is that construction of fast reactor test facilities of special design must be undertaken if national objectives in fast reactor development are to be achieved. The estimated annual cost for operation of the planned fast flux test facility is approximately $7.0 million, exclusive of the research and development program on the fuel to be tested.

Details of Cost Estimate:

The cost estimates are preliminary and indicate the type of facility complex required for a fast flux test facility.

a.	Engineering, Design and Inspection Cost @ approx. 20% of Construction Costs, item b		$11,000,000
b.	Construction Costs:		56,200,000
	(1) Reactor system	$22,500,000	
	(2) Closed test loops	7,700,000	
	(3) Fuel handling and storage	3,200,000	
	(4) Buildings, structures, cranes, electrical and miscellaneous services	11,300,000	
	(5) Interim Fuel Examination Facility	5,200,000	
	(6) Containment	3,200,000	
	(7) Nuclear Proof Test Facility	1,300,000	
	(8) Maintenance Facility	1,800,000	
	Subtotal		67,200,000
c.	Contingency at approx. 30% of above costs		20,300,000
	Total Project Cost		$87,500,000

Funding appropriated for this project through fiscal year 1968 totals $28.5 million although the project was fully authorized at $87.5 million in fiscal year 1968. Appropriation of $35.0 million is required for fiscal year 1969. This funding will be used in support of the following phases of the project:

1. Continuation of procurement of long lead items of equipment for the reactor system and fuel handling system.

2. Authorization and initiation of Title III services for the architect-engineer and reactor plant designer.

3. Initiation of major construction activities.

After fiscal year 1969, funding of $24.0 million will be required to be appropriated.

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-3-a	Research and development test plants, Project Rover, Los Alamos Scientific Laboratory, New Mexico, and Nevada Test Site, Nevada	$ 2,000,000	$ 81,000	$ 1,919,000	$ 0
68-3-b	Isotopic space systems facility, Sandia Base, New Mexico	2,250,000	150,000	2,100,000	0
68-3-c	Modifications to reactors	1,000,000	100,000	900,000	0
68-6	General plant projects	12,000,000	10,800,000	1,200,000	0
67-3-a	Fast flux test facility	a/	4,750,000	23,750,000	a/
67-3-b	Modifications and addition to reactor facilities, West Milton, New York	10,000,000	800,000	9,200,000	0
67-3-c	Research and development test plants, Project Rover, Los Alamos Scientific Laboratory, New Mexico, and Nevada Test Site, Nevada	1,000,000	993,000	7,000	0
67-3-f	Modifications to reactors	3,325,000	2,625,000	700,000	0
67-6-a	Alpha fuels environmental test facility, Mound Laboratory, Miamisburg, Ohio	3,000,000			
	Non-Reimbursable Excess Utilized	500,000			
	Net	2,500,000	198,000	2,302,000	0
66-4-a	Sodium pump test facility	6,800,000	250,000	6,550,000	0

a/ See Section A-1 for details

SECTION A-2 - continued

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
66-4-c	Modifications to reactors	$ 3,500,000	$ 2,850,000	$ 650,000	$ 0
65-4-b	Power burst facility, National Reactor Testing Station, Idaho	13,100,000			
	Non-Reimbursable Excess Utilized	6,000			
	Net	13,094,000	10,094,000	3,000,000	0
64-e-4	Nuclear safety engineering test facilities, National Reactor Testing Station, Idaho	24,000,000			
	Non-Reimbursable Excess Utilized	211,000			
	Net	23,789,000	16,196,000	7,593,000	0
64-e-7	Thorium-uranium fuel cycle development facility, Oak Ridge National Laboratory, Tennessee	7,275,000	6,647,000	628,000	0
63-e-4	Research and development test plants for Project Rover	8,500,000			
	Non-Reimbursable Excess Utilized	16,000			
	Net	8,484,000	8,388,000	96,000	0
61-d-5	Fast reactor core test installation, Los Alamos Scientific Laboratory, New Mexico ...	7,000,000	5,265,000	1,735,000	0
61-d-7	Test installation for Project Rover	30,114,000			
	Non-Reimbursable Excess Utilized	69,000			
	Net	30,045,000	29,660,000	385,000	0
61-d-9	Advanced test reactor	59,000,000			
	Non-Reimbursable Excess Utilized	31,000			
	Net	58,969,000	56,119.000	2,850,000	0

REACTOR DEVELOPMENT PROGRAM - continued

SECTION A-2 - continued

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
60-110	Cooperative power reactor demonstration program	$11,389,000	$11,198,000	$ 191,000	0
58-111	Cooperative power reactor demonstration program				
	Piqua	9,986,000			
	Non-Reimbursable Excess Utilized	2,000			
	Net	9,984,000	9,567,000	417,000	0
	Hallam	38,500,000			
	Non-Reimbursable Excess Utilized	3,000			
	Net	38,497,000	38,497,000	0	0
	Elk River	12,664,000	11,487,000	1,177,000	0
	Subtotal - Net	61,145,000	59,551,000	1,594,000	0
57-xxx	Nuclear-powered merchant ship	29,850,000	28,492,000	1,358,000	0
	Reserve for project overruns	2,406,000	0	2,406,000	0
	Total			71,114,000	0

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Civilian Power Reactors	$ 12,700,000
Cooperative Power Reactor Demonstration Program	180,000
Naval Propulsion Reactors	4,300,000
Space Propulsion Systems	4,000,000
Space Electric Power Development	4,500,000
Terrestrial Electric Power Development	200,000
General Reactor Technology	2,500,000
Advanced Systems Research and Development	530,000
Nuclear Safety	2,300,000
Other Capital Equipment	7,340,000
Total	$ 38,550,000

Section B-1 - continued

JUSTIFICATION

1. Civilian Power Reactors $12,700,000

The FY 1969 equipment requirements are needed for the comprehensive and varied research and development programs, including support of experimental reactor facilities, being carried out at Commission Laboratories and industrial contractors' sites. The principal requirements are for:

The program for the development of high gain breeder fast reactors will require equipment in support of the following development efforts: fuels and materials, physics, sodium technology, molten salt breeder reactor program, component engineering, and proof testing. Principal areas include Zero Power Reactor experiments, EBR-II fast reactor facility, and pilot production and technical equipment in support of fuel development processes, chemical engineering, and metallurgical development efforts. The Fast Flux Test Facility will require equipment to develop and test components in thermal hydraulic sodium environments and provide loop systems and material development facilities.

Orders will be placed for Capital Equipment in FY 1969 to replace various items of reactor power plant equipment in the Shippingport Plant for installation of the LWBR demonstration core. Items that will be required include main coolant pump impellers, safety injection system and accessory electrical equipment.

Capital Equipment will also be required in FY 1969 to support fabrication of the LWBR core. Equipment will be required unique to the fabrication of binary fuel pellets and fuel rods, assembly of fuel modules and fabrications of the core structurals.

Support of the Pressurized Water Reactor Project will also require the replacement of various items of reactor power plant equipment during the operation of PWR Core 2 Seed 2.

2. Cooperative Power Reactor Demonstration Program ..... $ 180,000

The requested equipment funds for FY 1969 are needed for procurement and installation of replacement and upgraded equipment in support of reactors owned by the Commission under the terms of the second round

cooperative program.

3. Naval Propulsion Reactors ..... $ 4,300,000

The equipment funds requested for FY 1969 are required to support naval developmental programs on improved nuclear propulsion plants and reactor cores with continued emphasis on reliable and economic advanced cores with longer life. Specific requirements include equipment and the installation of equipment associated with the modification of the A1W prototype to permit the installation of the A4W/A1G partial prototype core, hot cell and water pit equipment for the Expended Core Facility, equipment associated with the instrumentation of the S3G and D1G critical facilities, X-ray photometer for the fuel and poison developmental programs, stack and gas monitoring equipment at the D1G prototype, improved temperature readout equipment and in-hull operational differential pressure detectors at the S5G prototype, special test equipment in mechanical and thermal-hydraulic programs in the A4W/A1G project, replacement X-ray equipment for the naval quality control programs, fuel handling equipment and new and replacement test equipment at the prototype sites.

4. Space Propulsion Systems ..... $ 4,000,000

The equipment requirements in FY 1969 are related to support of Westinghouse Electric Corporation, the major Nerva reactor subcontractor, LASL's efforts in the testing of reactors and the general support of NRDS operations. The estimates include equipment requirements for fuel fabrication research, development and production, cryogenic and metallurgy, non-destructive testing, component testing and reactor testing. The NRDS operations require equipment in support of the testing operations.

5. Space Electric Power Development ..... $ 4,500,000

Radioisotope Power Systems: - The emphasis on the development of larger radioisotope systems, the requirement for meeting strict quality control and reliability standards, and the increased technical complexity of the systems has placed a requirement on the development contractors to procure specialized and sophisticated equipment that is unique to the systems under development. The impact of the above factors began to some extent in FY 1967 and will increase during FY 1969 for continuing development programs. The development of systems initiated in FY 1968 and FY 1969 (such as NAVSAT, the 250-watt generator, Thermionic Space Generator, Large Heat Source) will proceed into the initiation of components and subsystems which will require the use of specialized equipment. This equipment includes thermal vacuum systems, electronbeam

Section B-1 - continued

welders, thermal conditioning apparatus, high temperature furnaces, simulated space chambers, laminar flow meters, and quality control and reliability testing instrumentation.

Reactor Power Systems: - The very high temperature and ultrahigh vacuum conditions required for the development, testing, and fabrication of materials for the Liquid Metal Reactor program at LRL cannot be met by equipment now at LRL. In addition, the Zirconium-Hydride Reactor program requires equipment for the development of advanced fuels and materials and reactor components, as well as for the replacement and upgrading of equipment during the conduct of the S8DR test program. The Thermionic Reactor Development program will require equipment for the fabrication and testing of developmental diodes. The type of equipment required in this activity includes high temperature and high vacuum furnaces, hardness tester, ceramic coating equipment, thermal analyses equipment, vacuum control and instrumentation, vacuum equipment and instrumentation for in-pile cluster test, and cesium handling equipment.

Power Conversion Development: - These requirements are primarily for the Compact Converter program which will emphasize the fabrication and test of experimental thermoelectric modules in FY 1969. The equipment required includes test stands, power supply, hot pressing equipment, melting equipment, and powder pressing equipment.

Space Nuclear Safety: - These requirements are primarily for the Sandia safety testing and safety analysis program in support of the radioisotope generator development program. The items of equipment to be procured include an electron microprobe, mass spectrometer, laser system for aerosol size distribution and multichannel analyzer.

Isotope Fuels (Space): - Approximately 50% of the Space Electric Power program FY 1969 equipment requirement is for the Space Isotope Fuels program, primarily at the Mound Laboratory. The Pu-238 fuel program requirements include a second conversion and encapsulation line (to increase the current one-shift capability from about 10 Kgs per year to about 20 Kgs per year) and specific large equipment items such as a vacuum hotpress and inert gas systems. The Po-210 fuel program requirements include equipment for process line and concentration cell renovation to provide for the planned increase (350 grams to 900 grams) in Po-210 processing in FY 1970, as well as for specific large items of equipment such as a metal preparation glove box line, source calorimeter, arc image furnace, and in-line purity analysis equipment. In addition, the ORNL curium fuel form development and the sol-gel process improvement will require equipment such as chemical vapor deposition equipment and high-temperature, high-vacuum creep testing machines and metallographic examination equipment.

Section B-1 - continued

6. Terrestrial Electric Power Development ..... $ 200,000

The terrestrial electric power development program requires the procurement of major items of equipment related to the development of test rigs and mock-ups in support of the fuels development program. These requirements include instruments, electrical and electronic equipment for an electronic-analog, electrically heated mockup and second test loops. Nondestructive testing equipment is required to support studies of remote inspection techniques, such as a digital memory oscilloscope, infrared and other thermal test equipment. Isostatic pressing equipment is required in support of studies on methods of pellet fabrication that will permit the use of a variety of pellet linear materials.

7. General Reactor Technology ..... $ 2,500,000

The equipment requirements for this category are essential to the base technology studies largely carried out by the National Laboratories. Under reactor physics, the cross section measurements and inelastic scattering programs require data handling and interface equipment for computer systems. Equipment is required to support on-line data processing at the ANL Fast Neutron Generator, RPI LINAC, HTLTR and ORELA.

The high temperature fuels development program requires a high temperature mass spectrometer for studying vaporization behavior. An electron beam welder and refractory metal annealing furnace are needed for the program on fabrication techniques. Additional equipment requirements for the reactor fuels and material program include creep test apparatus, multi-channel analyzer, electron microscope, laser micro-probe and hot stage metallograph. The recently reoriented fuels program at GE/Evendale in support of the Fast Breeder Reactor will require vacuum retort furnaces for strength testing of developmental alloys, prototype in-pile creep rupture test assembly, electron controller for refractory metal tube drawing, shielding equipment for creep stands, and remote equipment for post-test dimensional measuring of irradiated specimens.

Engineering Development requirements include an electric master-slave manipulator, specialized test assemblies for testing transducers in the instrumentation and control program, and instrumentation for heat transfer measurements. The Chemical Separation effort will require procurement and testing of components for fluoride volatility processes, glove boxes and alpha equipment for the aqueous flow sheet development for fast reactor fuels and a time-of-flight mass spectrometer to permit work on the chemistry of fission product fluorides.

Section B-1 - continued

8. Advanced Systems Research and Development ..... $ 530,000

The FY 1969 request for Advanced Systems will provide the equipment items needed to support the development effort on the several projects included in this category. A small amount of equipment will be needed for heat transfer and components testing associated with the Argonne Advanced Research Reactor. In support of development work on a fast pulsed reactor, instrumentation and controls will be required for fuel and material capsule testing. Equipment for the UHTREX experiment will be procured including data recording and data reduction instrumentation. Equipment for the Advanced Plutonium Fuel Technology program is needed to support the sodium technology work, studies of the interaction of fuels with sodium and cladding materials, and the evaluation of metal alloy and ceramic plutonium fuels. Items for this purpose include gas analysis apparatus, high temperature, high vacuum unit and equipment for irradiation and bond stability studies.

9. Nuclear Safety ..... $ 2,300,000

Because of the advanced technology to be demonstrated under this program, it is essential to develop and fabricate special instrumentation analytical equipment to handle the integral sampling and rapid analysis of information generated. A major portion of the FY 1969 equipment acquisitions under this program are required for the Loss of Fluid Test (LOFT) project (water reactors) and the fast reactor research and development (Argonne National Laboratory).

Examples of equipment needed include: (1) fission product sampling equipment and signal conditioning equipment to aid in the development of test equipment and mass spectrometer, process control and gamma-ray counting equipment for contamination-decontamination experiment development tests and analyses for the LOFT experiment; (2) out-of-pile experimental equipment including pumps, power sources and instrumentation required for out-of-pile tests and to establish firm designs for the fuel failure propagation loop for use in the fast reactor safety program; and (3) radioactive residue process equipment for the Waste Solidification Engineering Prototype (Pacific Northwest Laboratory).

10. Other Capital Equipment ..... $ 7,340,000

The reactor development program includes research and development work at six laboratories and thirteen operations offices. The diversified and advanced nature of this activity requires the procurement of numerous items and types of equipment which become obsolete due to technological advances. Equipment required for facilities and plant operations, services, and general support is also included under this

Section B-1 - continued

activity as it cannot be related to a specific research or development program. Examples of the types of equipment included are shop, radiation safety, special materials, motor vehicles, scientific and technical instruments, security and protection, and office equipment. Included in this category are the following computer requirements (1) $3,699,000 for acquisition of an additional IBM system 360 Model 2075 to support increased computer requirements, and (2) $290,000 for display consoles and associated terminals, at Oak Ridge National Laboratory.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Civilian Power Reactors	$ 1,823,000
Space Propulsion Systems	370,000
Space Electric Power Development	2,154,000
Terrestrial Electric Power Development	100,000
General Reactor Technology	440,000
Nuclear Safety	300,000
Other Capital Equipment	9,263,000
Total	$14,450,000

Mr. MORRIS. Thank you Dr. Shaw for an excellent presentation. The subcommittee will recess until 10 o'clock tomorrow morning.

THURSDAY, APRIL 25, 1968.

PHYSICAL RESEARCH PROGRAM

Mr. MORRIS. The committee is pleased to have before it this morning Dr. McDaniel, director of the physical research program.

You may proceed in your own way, Doctor.

OPENING REMARKS—PHYSICAL RESEARCH PROGRAM

Dr. MCDANIEL. I am pleased to appear before you today. This is the 21st time I have appeared before a House Appropriations Committee in one form or another, so I feel somewhat like an adult today although I feel like a child in the presence of this fine committee.

Mr. MORRIS. Sometimes you feel like a stepchild when they start passing out the money.

Dr. MCDANIEL. I was hesitating in my statement. I do not feel like a stepchild before this committee but more like a favorite child.

I do welcome the opportunity to describe the activities of our program and to respond to any questions that you may have about our activities.

As you know, fundamental research in the physical sciences is supported by this program, scientific investigations are carried out in fields of high energy physics, low energy physics, mathematics and computers, chemistry, metallurgy and materials, and controlled thermonuclear research. Much of the work is carried out in the large national laboratories and in the integrated contractors and to some extent in the universities of the country.

OPERATING EXPENSES

Our fiscal year 1969 budget request for operating expenses is $280 million. This is an increase of $15 million, or about 5.7 percent over fiscal year 1968.

As you know, this request was reduced by $3.1 million to $276,900,000 as a result of the actions taken by the Joint Committee on Atomic Energy in its authorizing legislation for fiscal year 1969.

I am sure that with the appropriation of $276.9 million our scientists and engineers will be able to pursue a productive research program.

I should add, though, there will be many, very many, worthwhile projects and programs which cannot be carried out within this allocation.

CAPITAL EQUIPMENT

As far as capital equipment is concerned our requirements for fabrication and procurement of capital equipment continue to grow while our financial resources as represented by the budget request of $30.9 million are $8.4 million below the amount appropriated for fiscal 1968. This requested amount was reduced $1 million by the Joint Com-

mittee to a level of $29,850,000 which is our request for appropriation now.

It is from these equipment funds that our scientists obtain the apparatus required to conduct their experiments. For research to be conducted properly there should be a balanced relationship between our operating expenses appropriation and the level of funding provided for capital equipment.

Our total request for line item construction projects as reflected in the budget is $58.2 million. This amount has been reduced $800,000 by the Joint Committee as a result of their decision not to authorize a project at the Brookhaven National Laboratory involving air pollution control modifications to the heating plant.

Of the $57.4 million authorized, we need $6.2 million to provide for necessary accelerator and reactor improvements and for general plant additions required throughout our progam.

Of the remaining $51.2 million, $26.2 million is required to continue the scheduled construction work on the Los Alamos Meson physics facility which was authorized in fiscal year 1968 at a total cost of $55 million.

The remaining $25 million is required for the 200 billion electron volts accelerator facility for continuation of design and engineering services, procurement of various technical components of the accelerator, and initiation of construction of the machine and its supporting facilities.

HIGH ENERGY PHYSICS

Turning to the high energy physics program, I could point out some of the principal highlights of the needs of the program. We are requesting an increase of $5.9 million, or about a 5-percent increase. Nearly half of this increase is earmarked for expanded utilization of the 20 Bev Stanford Linear Electron Accelerator. This facility is operating exceedingly well at full energy and intensity with an outstanding group of scientists and engineers.

Dr. Panofsky, the director, expects to achieve an average operating schedule of about 13 shifts per week during the latter months of fiscal year 1968. He has been able to do this because of operational economies attributable in part to longer life times on the klystron tubes. Should this favorable experience continue, it is our hope Dr. Panofsky will be able to maintain an operating schedule of approximately 15 shifts a week throughout the coming year.

200-BEV ACCELERATOR

Continuing with this program, we are requesting an increase of $1,450,000 for the 200-Bev accelerator. This increase would permit us to allocate $4 million for the research and development activities which must be done in order to proceed along the proper path toward construction of the accelerator.

During fiscal year 1969 the research and development program will involve fabrication and evaluation of models and the performance of computations, experimentation, and measurements required to develop specifications for the accelerator subsystems. In general, as Chairman Seaborg pointed out in his opening statement, the principal features

of the accelerator include a beam intensity of 1.5×10^{13} protons per second and an energy of 200 billion electron volts. This also provides an option for an increase in beam energy at a later date if such action is found to be desirable.

MEDIUM-ENERGY PHYSICS

In the medium-energy physics program we are requesting a net increase of $495,000 out of a total request of $11,595,000.

The largest single item provides an increase of $600,000 for research and development work on the Los Alamos Meson Physics Facility, which as I mentioned earlier was authorized in fiscal 1968.

Major tasks to be undertaken here include extensive life testing of the radio-frequency system, assembling a prototype injector and developing target areas systems. We are also increasing research activities related to the MIT electron accelerator from $150,000 to $450,000 in fiscal 1969.

I think these two points illustrate one of our major problems where we have new facilities which have recently been completed or are on the road to being completed that must be funded at an appropriate level.

Here we have the Los Alamos facility, an increase of $600,000, and the MIT accelerator $300,000, for a total increase of $900,000 required for just these two machines, whereas our entire medium energy physics increase is only $495,000.

In keeping with our policy of reducing the support of lower priority research facilities, and to accommodate the demands of the MIT and Los Alamos facilities, we are phasing out the research programs at several institutions. We are phasing out the work on the 240-Mev synchrocyclotron at the University of Rochester, the work on the 440-Mev synchrotron at Carnegie-Mellon University and the 68-Mev proton linear accelerator at the University of Minnesota.

LOS ALAMOS MESON PHYSICS FACILITY

Construction of the Los Alamos Meson physics facility has begun. A contract for $720,000 was awarded on January 12 for construction of the equipment test laboratory. The contractor has initiated work including excavations and the forming and placing of concrete. Today, April 25, we expect to open construction bids on the injector building and the Alvarez section. Contracts for the procurement of the copper-clad steel and brazing furnaces have been let and bids on the second phase of the site and utility work are scheduled to be opened today. Barring unforeseen difficulties we anticipate completion of this project in accordance with our earlier schedule which this committee knows about.

OTHER RESEARCH PROGRAMS

I will summarize briefly all of our other research programs in chemistry, low-energy physics, mathematics, computers and metallurgy and materials by simply saying that we are requesting an increase in these programs in fiscal 1969 of about $3.4 million, which is 2.9 percent over the fiscal year 1968. In all of these programs we are continually eliminating less productive research activities in order to permit higher priority projects to go ahead.

However, considering the effects of inflationary trends and increasingly sophisticated experiments, we believe the increase of $3.4 million will just about enable those people to continue the level of activity which they had been doing in the previous years.

CONTROLLED THERMONUCLEAR RESEARCH

I should like to turn now to my last major program, controlled thermonuclear research, which has as its ultimate goal, the harnessing of the fusion reaction for electrical power generation. The program presently consists of a combination of basic and applied research aimed at determining the fundamental laws of physics relevant to the confinement of thermonuclear plasma. Integral parts of the determination of these physical laws are, (1), a broadly based fundamental research program and, (2), the demonstration of longtime plasma confinement in experimental devices. We are requesting about $27 million, an increase of about $2.1 million over that appropriated for fiscal 1968, or rather over that which we anticipate spending in fiscal 1968.

Included in the request is a 2.8-percent increase in normal or base program operating funds, plus a total of about $2 million for the fabrication of major new experimental devices at the Los Alamos Scientific Laboratory, at the Princeton Plasma Physics Laboratory and at the Lawrence Radiation Laboratory.

That more or less gives a quick summary of our program.

Mr. MORRIS. That is about as comprehensive and as candid a summary of a $200 million-plus program as I have heard. I want to compliment you.

Dr. MCDANIEL. I would not like to leave the idea that because of the brevity that our program is not substantive. We have a fine staff in the headquarters which has the assistance of a large number of scientists and administrators, and the total volume of backup material which we could provide you is tremendous.

Mr. MORRIS. We realize it would be very voluminous.

We will insert pages RES–1 through 71 covering the physical research program in the record.

(Pages referred to follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

PHYSICAL RESEARCH PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$280,000,000
Estimate FY 1968	265,000,000
Increase	$ 15,000,000

Under the Physical Research Program there are conducted theoretical and experimental investigations directed toward discovery of natural laws and new knowledge and to improve understanding relevant to those aspects of the physical sciences related to the development, use, and control of atomic energy. The goal, ultimately, is to reduce the natural phenomena to fundamental principles so that facts may be understood and so that new principles can be formulated. Experimentation is undertaken, within this framework, in the fields of physics, chemistry, metallurgy and materials, and controlled thermonuclear research. There follows a brief description of principal objectives within each of the scientific disciplines:

Physics

1. To reach a comprehensive understanding of phenomena that contribute to formulation of a consistent general theory, explaining the behavior of nuclei, nuclear components and nuclear forces.

2. To further the study of nuclear forces and to develop both theoretical and empirical knowledge of nuclear structure and nuclear processes.

3. To obtain basic nuclear data, particularly in the field of neutron cross sections.

4. To improve existing experimental devices, such as accelerators and computers, that will be of use in the overall AEC program; and to develop new such devices.

5. To advance methodologies for solving complex mathematical problems that arise in connection with AEC programs.

Chemistry

1. To advance basic knowledge in fields of chemical science related to atomic energy.

2. To orient and develop this knowledge toward the practical operations of the Atomic Energy Program, where the state of knowledge permits and the need exists.

3. To provide the necessary quantities of rare, highly enriched special isotopes for use in the Atomic Energy Program.

Metallurgy and Materials

1. To formulate coherent concepts of the basic structures and mechanisms that govern the properties and behavior of materials related to the Atomic Energy Program.

2. To use the basic knowledge evolved in the development of materials technology in order to alleviate materials-related problems of the Atomic Energy Program.

Controlled Thermonuclear

1. To develop the experimental expertise and the basic physics necessary for the achievement of controlled thermonuclear fusion.

2. To heat and confine a plasma at a particle energy sufficient to yield significant amounts of thermonuclear energy during the time of confinement.

3. To study such plasma, and, if it be found feasible, to design and build a pilot thermonuclear plant yielding net power.

4. To produce economically competitive fusion power.

The increase of $15,000,000 in FY 1969 over the level of $265,000,000 estimated for FY 1968 is summarized as follows:

1.	An increase in High Energy Physics of	$ 7,000,000
2.	An increase in Medium Energy Physics of	500,000
3.	An increase in Low Energy Physics of	1,280,000
4.	An increase in Mathematics and Computer Research of	180,000
5.	An increase in Chemistry Programs of	2,300,000
6.	An increase in Metallurgy and Materials Programs of	1,240,000
7.	An increase in Controlled Thermonuclear Programs of	2,500,000
	Total Increase	$ 15,000,000

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
RES-4	1. High Energy Physics	$107,691,891	$113,400,000	$120,400,000
RES-13	2. Medium Energy Physics	10,975,106	11,100,000	11,600,000
RES-15	3. Low Energy Physics	27,758,072	28,820,000	30,100,000
RES-18	4. Mathematics and Computer Research	5,838,961	5,720,000	5,900,000
RES-20	5. Chemistry Research	52,658,949	54,000,000	56,300,000
RES-24	6. Metallurgy and Materials Research	26,092,526	27,060,000	28,300,000
RES-29	7. Controlled Thermonuclear Research	22,383,415	24,900,000	27,400,000
	Total Physical Research Program	$253,398,920	$265,000,000	$280,000,000

JUSTIFICATION OF CATEGORIES

1. High Energy Physics $120,400,000

Research in high energy physics has the goal of achieving an understanding of the fundamental forces which control the behavior of the particles within atomic nuclei, and of obtaining a more complete knowledge of the nature and behavior of the basic constituents of the physical universe. Over the past decade, most of the major high energy physics developments and discoveries have been made in laboratories in the United States. The success of the U. S. program has been based on the exceptional talent and enthusiasm of the individuals involved and on the willingness of the Federal Government to support a broad range of high energy physics activities. These activities include: the construction and operation of accelerators of many different characteristics; the development of complex particle detection and data analysis equipment; the conduct of extensive research programs which use the accelerators and auxiliary equipment; and the conduct of theoretical programs which interact with the experimental effort.

In the conduct of experimental programs, bubble chambers and electronic detectors such as spark chambers and scintillation detector hodoscopes will continue to be the principal devices used for detection of particle interactions. Streamer chambers and filmless spark chamber systems are being developed and the use of computers with spark chamber and counter systems for "on-line" data processing will increase. The development and provision

of improved data analysis apparatus such as the Flying Spot Digitizers (FSD), the Precision Encoding Pattern Recognition (PEPR) systems, and the Spiral Reader will continue for the purpose of providing experimental groups with the equipment required to most efficiently analyze the data from the high statistics experiments which are necessary to permit the exploration of many new areas in this complex field of research. Some units of these various devices have already entered highly productive phases.

University physicists have played a major role in the development of high energy physics research and continue to be intimately associated with it, even though the primary research tools have become concentrated at only a few large accelerator centers. This association is of great benefit to the accelerator centers, to the university physicists, and important to the success of the high energy physics field. It is considered essential to the continuing vigor and productivity of the field that it attract bright young people with fresh ideas. This is best done by close interaction with the universities.

The initiation of effort on the 200 Bev accelerator, parallel improvements in data handling and data reduction techniques, the need for initiation of new university user groups and the further development of some existing user groups, the greater sophistication of the new particle detection apparatus, the strong theoretical interest in and promise of the new symmetry and quark model rules for understanding elementary particles and resonance particles, the availability of numerous specialized high quality beams from six major accelerators, and the pursuit of technological advances such as new accelerator concepts and superconducting magnets are all factors which contribute to the need for increased funding of the research programs in FY 1969. There follows a breakdown of the estimates for each major accelerator:

A.	Princeton-Pennyslvania Accelerator..	FY 1967: $ 7,903,805	FY 1968: $ 7,950,000	FY 1969: $ 8,150,000
B.	Cambridge Electron Accelerator	8,445,986	8,050,000	8,200,000
C.	Alternating Gradient Synchrotron ...	18,430,878	19,750,000	20,375,000
D.	Cosmotron	1,439,510	0	0
E.	Zero Gradient Synchrotron	16,426,419	16,750,000	17,275,000
F.	Bevatron	15,347,079	14,750,000	14,750,000
G.	Stanford Linear Accelerator Center..	15,265,787	21,100,000	24,050,000
H.	General Research and Development ...	24,432,427	25,050,000	27,600,000
	Total High Energy Physics	$107,691,891	$113,400,000	$120,400,000

A. Princeton-Pennsylvania Accelerator (PPA)

	FY 1967:	FY 1968:	FY 1969:
a. Research	$ 2,775,843	$ 2,775,000	$ 2,900,000
b. Design and Development of Devices	212,006	225,000	225,000
c. Operations	4,915,956	4,950,000	5,025,000
Total	$ 7,903,805	$ 7,950,000	$ 8,150,000

The PPA will continue to operate on a 17 shift per week basis in FY 1969 with an average beam intensity of about 10^{12} particles per second. The external proton beam facility (EPB), which became available for experiments in the latter half of FY 1967, gives PPA the capability to conduct twice as many simultaneous experiments as were heretofore possible. Availability of the EPB also makes possible the performance of many highly sophisticated experiments which could not be conducted with secondary beams from internal targets. In addition, it is necessary to begin preparing in FY 1969 for operation and use the flat top for the magnet cycle which will be completed early in FY 1970. Both the Pennsylvania and Princeton research groups have strong need for increased support for their data analysis programs.

The requested increase of $200,000 should permit the program to continue at about the FY 1968 level. In order to achieve more extensive utilization of the new capabilities at the PPA it will be necessary to curtail certain on-going activities.

B. Cambridge Electron Accelerator (CEA)

	FY 1967:	FY 1968:	FY 1969:
a. Research	$ 4,725,450	$ 4,535,000	$ 4,540,000
b. Design and Development of Devices	311,460	315,000	315,000
c. Operations	3,409,076	3,200,000	3,345,000
Total	$ 8,445,986	$ 8,050,000	$ 8,200,000

CEA is currently bringing into operation the new linac injector which will substantially increase the beam current and the stability of operation of the accelerator. In addition, the laboratory has launched an imaginative and highly regarded experimental program to store and clash contrarotating beams of electrons and positrons in the accelerator itself. This is currently the only U.S. effort in the promising colliding-beams field, which is burgeoning in Europe and the U.S.S.R. The requested increase of $145,000 in funds for the accelerator will help to utilize the enhanced power of the accelerator for experiments and to pursue the colliding-beams storage ring effort. It will be necessary to continue to restrict the operating schedule to about 10 high energy experimental shifts per week in FY 1969. The funds requested for research will support the experimental programs of the Massachusetts Institute of Technology (MIT) and Harvard at a somewhat reduced level of activity. Preparations for the colliding-beams experiments will be accomplished at the expense of other research activities.

C. Alternating Gradient Synchrotron (AGS)

	FY 1967	FY 1968	FY 1969
a. Research	$ 10,751,333	$ 11,850,000	$ 12,325,000
b. Design and Development of Devices	3,968,932	4,000,000	4,000,000
c. Operations	3,710,613	3,900,000	4,050,000
Total	$ 18,430,878	$ 19,750,000	$ 20,375,000

The AGS, the highest energy accelerator in the United States, has been the source of many of the major advances in particle physics for the last several years and can be expected to continue to be the most fruitful proton accelerator in the U. S. until the 200 Bev machine comes into operation. It is expected to continue to operate on a round-the-clock basis in FY 1969 with an average beam intensity greater than 10^{12} particles per second.

The increase of $625,000 provides for maintaining operation of the AGS and the research program at the FY 1968 level. Exploitation of the unique capabilities of the slow extracted beam will be accomplished through adjustments in other elements of the AGS program. For example, only two of the three bubble chambers operating at BNL in FY 1968 will be operated in FY 1969.

D. Cosmotron

	FY 1967	FY 1968	FY 1969
a. Research	$ 828,620	$ 0	$ 0
b. Design and Development of Devices	0	0	0
c. Operations	610,890	0	0
Total	$ 1,439,510	$ 0	$ 0

Operation of the Cosmotron was terminated December, 1966.

E. Zero Gradient Synchrotron (ZGS)

	FY 1967	FY 1968	FY 1969
a. Research	$ 8,242,047	$ 8,650,000	$ 9,100,000
b. Design and Development of Devices	3,928,136	3,800,000	3,800,000
c. Operations	4,256,236	4,300,000	4,375,000
Total	$ 16,426,419	$ 16,750,000	$ 17,275,000

The ZGS is the second highest energy proton accelerator in the U. S. and has been operating in a particularly outstanding manner during the past year. It now operates steadily at intensities greater than 2×10^{12} protons per pulse which is somewhat higher than the present intensity of the AGS. The increased beam intensities available at the ZGS permit the performance of several simultaneous experiments, including those requiring

high statistics. The high intensities are especially important for effective utilization of the front-porch technique, whereby portions of the circulating beam are extracted from the machine at different energies during an acceleration cycle. FY 1969 will be the first full year of operation for the 500 liter (40-inch diameter) hydrogen bubble chamber. Also, the 12-foot bubble chamber and new experimental area authorized in FY 1966 will be available for testing and shakedown operation near the end of FY 1969. It is necessary to begin forming and training the operating nucleus for the 12-foot chamber.

An increase of $525,000 is requested. It is expected that the ZGS operations will average about 16 shifts per week during the latter half of FY 1968. This reduced level of machine operations is necessary to help support the operation of the 500-liter chamber and, later, the initiation of test running of the 12-foot chamber. The remainder of the ZGS program will continue in FY 1969 at about the FY 1968 year-end level of activity.

F. Bevatron

	FY 1967	FY 1968	FY 1969
a. Research	$ 10,956,909	$ 10,300,000	$ 10,300,000
b. Design and Development of Devices	478,355	500,000	500,000
c. Operations	3,911,815	3,950,000	3,950,000
Total	$ 15,347,079	$ 14,750,000	$ 14,750,000

The Bevatron external proton beam (EPB) facility has been significantly improved during the last year. Allowable intensity of each of the two external beam channels is now 2×10^{12} protons per pulse, as compared to the previous intensity of 8×10^{11} in a single channel. Efforts to improve the efficiency of extraction of the internal beam will continue in FY 1969 in order to allow fuller utilization of the new EPB capability. The second channel of the EPB is particularly important with respect to serving the growing needs of outside users, and the special needs of electronic counter and on-line experiments.

This new work plus development of a high frequency bunched beam to permit time-of-flight experiments will be supported through a reduction in Bevatron operations and curtailment of selected research programs. In the latter part of FY 1968 it will not be possible to maintain the Bevatron's round-the-clock operations on a continuous basis. This somewhat reduced level of operation will continue through FY 1969.

G. Stanford Linear Accelerator Center (SLAC)

	FY 1967	FY 1968	FY 1969
a. Research	$ 4,502,274	$ 7,600,000	$ 9,250,000
b. Design and Development of Devices	4,336,529	3,000,000	2,900,000
c. Operations	6,426,984	10,500,000	11,900,000
Total	$ 15,265,787	$ 21,100,000	$ 24,050,000

The SLAC accelerator is operating exceedingly well, at full energy and intensity, at full repetition rate, with interlaced positron and electron beams, and with an excellent and outstanding complement of detectors including two major bubble chambers, a 1.6 Bev/c spectrometer, an 8 Bev/c spectrometer and a 20 Bev/c spectrometer.

The 20 Bev electron accelerator will operate for an average of about 9 shifts per week during the latter half of FY 1968. The research program during this period will include use of the three spectrometers (1.6, 8 and 20 Bev) and two major spark chamber arrays. Operation of the bubble chambers will generate a total of about two million pictures.

With the requested increase in funding of $2,950,000 over the FY 1968 level, it is anticipated that the accelerator can achieve an operating schedule of an average of about 12 shifts per week during FY 1969. However, in order to achieve this level of operation it will be necessary to limit the extent of utilization of the major detection systems as well as activities associated with the design and development of devices.

H. General Research and Development

	FY 1967	FY 1968	FY 1969
a. Research	$ 19,931,519	$ 20,565,000	$ 21,410,000
b. Design and Development of Devices	240,922	235,000	240,000
c. Advanced Accelerator Design Studies	4,259,986	4,250,000	5,950,000
Total	$ 24,432,427	$ 25,050,000	$ 27,600,000

This activity can best be discussed under the following headings:

(1) University Research .....FY 1967: $ 15,504,802 FY 1968: $ 16,210,000 FY 1969: $ 17,045,000

The university research program supports activities related to the analysis and interpretation of the data obtained in experiments, and the design, development, fabrication and testing of the necessary apparatus for use in experiments to be performed at the major accelerator centers.

The university research programs provide the academic background whereby professors and their graduate students infuse additional new ideas into the program. This research is strengthened by the interaction of these academic groups with the national laboratories which provide the major facilities and capabilities whereby the experimental research programs are vigorously executed. The universities contribute to the long range stability of the program by training physicists in an active research atmosphere.

Strong university user groups are essential to the productivity and national character of the high energy physics program. A very effective method of achieving research accomplishments has evolved in which a large fraction of the research is conducted by university based accelerator user groups. In this mode of operation electronic experiments are planned in advance at the university, equipment is set up and tested in local laboratories, and at the appropriate time the scientist with his equipment goes to the major accelerator center where the basic data are obtained. Later, analysis and interpretation of the data are performed at the university. Similarly, bubble chamber experiments are planned and proposed by university groups, executed on bubble chambers at the national accelerator centers, and then analyzed at the university laboratory.

The close collaboration between theorists and experimentalists is an essential ingredient for the viability of the research program. The university theory groups correlate and systematize the experimental data, make fundamental interpretations of the physical phenomena, and make predictions which lead to experiments by university and laboratory experimental groups.

In recent years, new accelerators and significant improvements to existing accelerators have been provided which allow more difficult and demanding research problems to be attacked. In order to carry out these required studies, additional user groups should be established, the capabilities of the more recently formed groups strengthened, and the capability of the well established productive groups maintained.

The requested increase of $ 835,000 will permit a few of the more urgent needs discussed above to be satisfied.

(2) Associated Midwest Universities (AMU) .....FY 1967: $ 34,572 FY 1968: $ 30,000 FY 1969: $ 35,000

The activities of AMU in support of research, principally at the ZGS, will continue at the level of FY 1968.

(3) Ames Laboratory .....FY 1967: $ 399,925 FY 1968: $ 400,000 FY 1969: $ 420,000

Activities at the Ames Laboratory, concentrated on bubble chamber and electronic counter physics and an excellent theoretical program in elementary particle physics, will continue near the FY 1967 and FY 1968 levels.

94-075 O-68-pt. 3—25

(4) Lawrence Radiation Laboratory (LRL) .....FY 1967: $ 2,230,655 FY 1968: $ 2,250,000 FY 1969: $ 2,250,000

This activity includes all theoretical studies at LRL as well as activities related to developing new and improved data analysis systems for both bubble chamber events and spark chamber events. Also included is a small effort in cosmic ray physics. These activities will be maintained near the FY 1967 and FY 1968 level.

(5) Oak Ridge National Laboratory (ORNL) .....FY 1967: $ 399,148 FY 1968: $ 390,000 FY 1969: $ 400,000

This program includes a group performing calculations and studies pertaining to shielding requirements for high energy accelerators. Also included is a user group engaged in the analysis of bubble chamber film. These activities will continue near the FY 1968 level.

(6) California Institute of Technology (CIT) .....FY 1967: $ 1,603,339 FY 1968: $ 1,520,000 FY 1969: $ 1,500,000

The effort supported under this contract involves operation and use of the 1.5 Bev electron synchrotron, user group activities primarily in the realm of electronic counter and spark chamber experiments utilizing other accelerators, and theoretical studies of elementary particles. Greater emphasis will be placed on user type activities utilizing primarily the high energy LRL, BNL, and SLAC facilities as plans develop to phase out the synchrotron. This research effort will continue near the FY 1967 and FY 1968 levels.

(7) Advanced Accelerator R&D .....FY 1967: $ 4,259,986 FY 1968: $ 4,250,000 FY 1969: $ 5,950,000

Included under this activity are studies of new accelerator concepts and advanced accelerator technologies directed primarily toward extension of parameters such as beam energy and intensity.

A summary by contractor follows:

	FY 1967	FY 1968	FY 1969
Universities Research Association (200 Bev)	$ 195,000	$ 1,300,000	$ 4,100,000 1/
Lawrence Radiation Laboratory (200 Bev)	1,914,177	1,250,000	0 1/
Argonne National Laboratory	748,535	350,000	300,000
Brookhaven National Laboratory	1,402,274	1,250,000	1,200,000
Lawrence Radiation Laboratory (Other)	0	0	350,000
Contract Research	0	100,000	0
Total	$ 4,259,986	$ 4,250,000	$ 5,950,000

This activity supports effort on the 200 Bev accelerator as well as studies of new accelerator concepts and capabilities not related to any specific accelerator. These latter activities carried out at Argonne National Laboratory, Brookhaven National Laboratory, and Lawrence Radiation Laboratory include conceptual research and development on new and improved methods of injection, acceleration and extraction of beams from accelerators in order to improve beam intensity and accelerator performance, the development of superconducting magnet technology for use in accelerators, and the development of colliding beam storage ring techniques. One goal of this work is to develop the conceptual basis for the design, at a later date, of a proton accelerator having an energy significantly above 200 Bev. In addition to these general activities, research and development efforts associated with the conversion of the Alternating Gradient Synchrotron are also being conducted at Brookhaven. It should be noted that the LRL group is participating in the 200 Bev design effort in FY 1968. As their involvement in the 200 Bev diminishes, part of the design group will redirect their effort to the study of more general advanced accelerator concepts such as the so-called "smoke ring" accelerator. A net increase of $250,000 is requested for these activities in FY 1969.

Activities pertaining to the 200 Bev accelerator include fabrication and evaluation of models and prototypes and establishing specifications for subsystems of the machine with particular emphasis on the booster synchrotron, the ring magnets and the RF system. An increase of $1,450,000 is requested to permit these activities to proceed on a time scale such that results of the R&D program can be properly phased into the construction schedule requirements.

1/ The allocation of funding between Lawrence Radiation Laboratory and the Universities Research Association for FY 1969 has not yet been determined.

2. Medium Energy Physics ..... $ 11,600,000

A comparison of costs for this category follows:

Research	FY 1967: $ 4,614,552	FY 1968: $ 4,215,000	FY 1969: $ 4,285,000
Design and Development of Devices	1,081,776	1,140,000	945,000
Operations	2,394,212	2,545,000	2,570,000
Meson Facility Design Studies	2,884,566	3,200,000	3,800,000
Total Medium Energy Physics	$ 10,975,106	$ 11,100,000	$ 11,600,000

Research investigations in the medium energy region (50 Mev to 1,000 Mev maximum energy of primary proton or electron beam) are concerned with improving knowledge about the structure of the nucleus. Both the primary and secondary beams provided by intermediate energy accelerators (sector focussed cyclotrons, electron linacs, synchrocyclotrons and the 800 Mev proton linac under construction at the Los Alamos Scientific Laboratory (LASL) will be used. From the point of view of nuclear physics, the energy region in the range of several hundred Mev is for the most part unexploited. From the relatively few experiments that have been performed and by extrapolation from the lower energy domain, investigations in this area can be expected to yield important new information.

For the most part, the new information will be a consequence of the higher energy (and therefore shorter wave length) of the particles in the primary beam, and of the unique properties of the secondary and tertiary particles produced by the primary beam. These intense, short wave length, high resolution, nuclear probes will make it possible to observe the finer details of nuclear structure and to learn about the motions of nucleons inside the nucleus. Thus, it will be possible to determine not only average values of various nuclear quantities, but also fluctuations from the average. The experiments will make it possible to determine the short range character of the correlation function, which describes the probability that one nucleon is close to another nucleon. The probability of finding clumps inside the nucleus thus becomes measurable. Information of this kind will make it possible to formulate theories about the nucleus from which further detailed nuclear structure calculations may be carried out.

Since subnuclear particles such as the pion are believed to play important roles in nuclear forces, experiments on the pion-nucleon interaction are needed to obtain a better understanding of the nucleus. In spite of many years of effort to understand the pion-nucleon interaction, it has been only in recent years that much progress has been made. This increased knowledge of the pion-nucleon interaction has arisen from the use of medium

energy machines and polarized proton targets. Extensions of such work to higher energies are necessary but will require use of higher beam intensities and more sophisticated apparatus. The required beam intensity and energy for this class of experiments will be available upon completion of the Los Alamos Meson Physics Facility (LAMPF).

Another research topic receiving increased emphasis is the study of mesic atoms. Mesic atoms are formed when stopped negative mu (or pi) mesons are captured into an orbit about a nucleus of the stopping material. Because their masses are much larger than the mass of the electron, their atomic orbits are considerably smaller than the corresponding orbit for atomic electrons; and therefore, the mu meson actually spends a relatively large fraction of its time inside the nucleus. As a result, the mu meson, whose interaction is electromagnetic, can provide information about the charge and current distributions and the polarizability of the nucleus. By observing the x-rays emitted by mesons in atomic transitions, such properties of the nucleus may be studied. The results shed new light on the understanding of nuclear structure, dynamic as well as static.

Since the accelerator is the essential component in the production of the diagnostic probes for this activity, it is important that studies be pursued on improving the performance of medium energy accelerators and in studying and evaluating new ideas for accelerators. This category, therefore, includes accelerator development effort on medium energy machines.

The increase requested for Medium Energy Physics is $500,000. The most significant aspect of this request is an increase of $600,000 for the research and development effort on the LAMPF project. Major R&D tasks will include finalizing design concepts for control of the 805 megahertz section, performing extensive life tests on all major components of the radio frequency system, assembling a prototype injector and measuring beam emittance and effects of space charge, developing targeting, remote-handling and beam stop systems for the target area, and starting development of major instrumentation for experiments. An experimental program on the interaction between mesons and nucleons, initiated in FY 1968 will be continued in FY 1969 using accelerators at other locations. At Brookhaven, an increase of $45,000 is required for a medium energy physics user group. This group had performed outstanding research on the Cosmotron and plans to be a user of LAMPF. An increment of $300,000 is needed at MIT for pre-research build-up for use of the new 400 Mev Electron Linac. This accelerator is expected to be in operation in early FY 1970.

A reduction of $50,000 at Ames reflects a decrease in machine development studies and photonuclear research. The decrease of $65,000 at Argonne is a result of the termination of their mu-mesic x-ray program. Decreases totaling $200,000 at the University of Rochester and the Carnegie-Mellon University result from phasing out operations on these accelerators. The remaining decrease of $130,000 reflects a decreased effort in the Separated Orbit Cyclotron machine development program at ORNL.

3. Low Energy Physics .....$ 30,100,000

The Low Energy Physics Program is composed of the following activities:

A. Nuclear Physics	FY 1967: $ 22,509,847	FY 1968: $ 23,682,000	FY 1969: $ 24,860,000
B. Atomic and Classical Physics	2,268,566	2,313,000	2,440,000
C. Stable and Heavy Nuclides	2,979,659	2,825,000	2,800,000
Total Low Energy Physics	$ 27,758,072	$ 28,820,000	$ 30,100,000

A. Nuclear Physics .....$ 24,860,000

This activity includes experimental and theoretical research aimed at obtaining information about the structure and behavior of nuclei in their normal and excited configurations, as well as their interactions, both weak and strong, with other nuclei, protons, neutrons, and the subnuclear particles. Studies are carried out at the Commission's laboratories and at a large number of universities. The programs vary in size from those where the efforts center around a complex and costly facility (reactor or accelerator) manned by a large staff to those where small specialized tools occupy a few people, and finally, to individuals (theorists) who themselves use no experimental tools other than computers. The entire nuclear energy complex with its far reaching consequences has risen from basic nuclear physics within the last three decades. The many problems in this area of physics which have been solved have presented scientists with many more unsolved new problems - problems which, when solved, can be expected to have additional impact on modern day society.

There are three principal areas of research supported under the nuclear physics activity: theoretical physics, charged particle physics, and neutron physics.

The efforts of theorists have provided a major contribution to nuclear physics through the development of a better understanding of the nucleus and nuclear interactions and through the development of improved nuclear models. The sophistication of the models and their applicability have been significantly advanced and are more and more being predicated on first principles. New theoretical approaches are beginning to predict the positions and properties of excited nuclear states which are in fair agreement with existing experimental data.

In the charged particle research programs, protons, deuterons, heavy ions, and electrons obtained from accelerators are used as nuclear probes to study nuclear properties. This activity also includes studies of radiations emanating from radioactive sources and the development of new devices and techniques for the pursuit of these studies. Some types of research conducted under this program are elastic, inelastic, and reaction differential cross section measurements; heavy ion reactions studies; fission studies; and studies utilizing polarized targets and polarized bombarding particles. The program includes the study of nuclear reactions induced by gamma-rays, double beta decay, particle channeling, and nuclear decay schemes. The measurements define the energies associated with excited states of the nucleus, quantum numbers associated with the ground and excited states (parity,

spin, isobaric spin, etc.) of the compound and residual nucleus, information on how nuclear reactions proceed (compound vs direct), information on nuclear size and the energy required to bind a nucleon to a nucleus. Polarized particle measurements yield information on the question of spin-orbit coupling, and phase shift analysis of the elastic scattering experiments provide information about the potential associated with the nucleon-nuclei nuclear force. Under the charged particle program the world's first Emperor tandem Van de Graaff accelerator was brought into operation in FY 1968 at Yale University and a double Emperor tandem accelerator is scheduled to come into operation in FY 1970 at Brookhaven.

The neutron physics program is of special and direct importance to the Commission. This program is of importance both to basic nuclear physics and to the Commission's programmatic or developmental needs. It is coordinated at both the national and international levels. Neutron cross section data in many instances are of vital importance to many of the Commission's reactor and weapon development programs. Neutron physics research includes basic studies of neutron scattering (elastic and inelastic) and neutron induced reaction studies. It also includes neutron induced fission research which is designed to answer central questions in the understanding of the fission process.

An increase of $1,178,000 is requested for Nuclear Physics activities. At Ames Laboratory, an increase of $15,000 is needed for research groups utilizing the Ames Research Reactor for nuclear physics studies. The requested increase for Argonne National Laboratory is $175,000. In FY 1968 Argonne's EN-model tandem accelerator (12 Mev) will be replaced by an FN-model tandem accelerator (15 Mev). This will provide an extension to the experimental capability of Argonne in the Area of charged particle physics, and require additional support. At Brookhaven National Laboratory, the requested increase is $360,000. Most of the increase will be needed for building up the research program on the world's highest energy Van de Graaff accelerator (36 Mev), carrying out the expanded program of the National Neutron Data Center (formerly Sigma Center), and undertaking research at the newly modified 60" cyclotron. An additional $25,000 is needed at the University of Michigan largely to strengthen the cyclotron research program. An increase totaling $50,000 is planned for continuation of the programs at Columbia University.

An increase of $150,000 is requested for the Oak Ridge National Laboratory. A large fraction of this will be directed toward operation and research with the Oak Ridge electron linear accelerator (ORELA). In addition, the Nuclear Data Project requires increased support in order to keep from lagging too far behind in its activity. The increase at Yale ($125,000) is largely required for the research program at the Emperor tandem accelerator.

The increase requested for the contract research program is $278,000. The most significant portion of this request is in the support of research programs with new accelerators which include the model FN tandem at Purdue, the model FN tandem with cyclotron injector at Duke, the sector-focussed cyclotron at Princeton, and the 5.5 Mev Van de Graaff accelerator at Arizona. Included herein is $25,000 for the Lawrence Awards.

B. Atomic and Classical Physics .....$ 2,440,000

Research in atomic and classical physics includes optical spectroscopy of atoms, molecules, and crystals, atomic beam studies, research in low temperature physics, atomic cross section measurements, seismology, atmospheric physics, and cosmic ray physics. This field provides information on nuclear magnetic and electric quadrupole moments, and on the theoretical view points of shell structure and of collective rotational and vibrational motions. Also this field provides the most precise information on the static properties of the electron, proton, and neutron.

Atomic cross section and reaction rates as well as a full understanding of atomic and molecular phenomena are needed in predicting the effects of nuclear weapons. Problems in atomic physics are also encountered in the space program, the thermonuclear program, and in studies of the upper atmosphere. Other research programs are planned in areas such as seismology, geomagnetism, heat flow, physical properties of rocks and minerals, cosmic ray physics, geochronology, and atmospheric physics.

The increase ($127,000) in this activity is required for augmenting activities in atomic physics studies at the University of Michigan, auroral radiation studies and low temperature studies at the Pacific Northwest Laboratory, seismological studies at the University of California (Los Angeles), and nucleosynthesis and neutron albedo studies at the Oak Ridge National Laboratory.

C. Stable and Heavy Nuclides .....$ 2,800,000

The major part of this activity is the Electromagnetic Separations Program at the Oak Ridge National Laboratory where twenty-eight calutrons are utilized in separating stable isotopes and eight calutrons are utilized to provide enriched isotopes of thorium, uranium, plutonium, and americium. Not only is this activity the only U. S. program for providing these rare and important samples, but, in fact, this operation is the only significant "free-world" program for isotopic separation of research samples. (The USSR has now started to market such materials.) The uses of these samples are many and varied; for example, they are used in the determination of nuclear properties, fission measurements, neutron cross section measurements, superconductivity, biological studies, and production of high specific activity radioisotopes. Many of the requirements for samples make the separations more and more challenging, such as the separation of uranium-233 with less than one part per billion uranium-232 or the separation of americium-242; however, with the continuing process improvement effort, these types of separations are now being performed.

No increase is requested for separations programs at Oak Ridge National Laboratory and Mound Laboratory. A decrease of $25,000 is planned at Yale in that the program is not expected to continue beyond FY 1968.

4. Mathematics and Computer Research .....$ 5,900,000

Since its inception the program for the development of atomic energy and atomic weapons has utilized high-speed computers and the methods of modern mathematics. Recognizing the importance of this area of research to the effective prosecution of AEC programs, the Commission has supported three related but separate research efforts in the mathematical and information sciences. These are: computer research and development, mathematics research, and programming research. The first is concerned with the advancement of the art of designing computers, computer-like devices, and their components, while the second and third are devoted to enhancing basic knowledge in the fields of mathematics, the information sciences and computer programming methods. Projects are selected on the basis of their excellence and their potential contribution to the AEC mission, with emphasis on those areas of research which are not adequately supported by industry. A summary of these activities follows:

	FY 1967	FY 1968	FY 1969
A. Computer Research and Development ...	$ 2,660,128	$ 2,586,000	$ 2,410,000
B. Mathematics Research	2,292,549	2,114,000	2,292,000
C. Programming Research	886,284	1,020,000	1,198,000
Total Mathematics and Computer Research	$ 5,838,961	$ 5,720,000	$ 5,900,000

A. Computer Research and Development .....$ 2,410,000

This activity includes research and development on computer circuits and components and on the logical organization of data processing systems for both numerical and non-numerical applications. Research in this area continues to require support to assure that the developing and expanding needs of the Commission's programs for theoretical computation, data analysis and automation of nuclear facilities are met adequately. Areas requiring special emphasis at the present include: (1) time-sharing systems, to which access can be had from a number of remote stations; (2) the necessary equipment for the remote terminals and the interfaces between them and the control computer; (3) computer graphics, or the processing of information given in the form of pictures or drawings; (4) computing systems, consisting of networks of computers or computing elements; (5) systems for the automation of experimental sciences, in the acquisition, processing, and analysis of data from experimental devices, and in the automatic control of such devices; (6) improved computing components and devices. Research supported under this program is of central importance to the execution of the programs of the Commission's Laboratories, and is of the type which cannot be expected to be supported entirely by the computer industry. For example, in the widely applicable area of time-sharing systems, the manufacturers'

performance has been, as far as the needs of large scale scientific organizations such as the National Laboratories are concerned, distinctly unimpressive, and acceptable systems simply do not exist. As a second example, systems of interacting and cooperating computers merit a great deal more study than they are receiving. The level of support of this activity will decrease $176,000 as compared to FY 1968.

B. Mathematics Research .....$ 2,292,000

This activity includes research in those branches of mathematics which are important to the solution of problems in the physical sciences and the application of results to the general formulation and solution of problems important to the Commission's overall mission. The National Laboratories are becoming equipped with more powerful computers, making it possible to attempt the numerical solution of more difficult technical problems. The possibility of using the machines inefficiently, and worse, of making significant errors, is also much greater. More than ever before, it is essential to use the best and most efficient numerical procedures in preparing problems for machine solution. This will continue to be the case as computers of greater power become available. Furthermore, the arriving of machines of quite novel structure (such as ILLIAC IV and STAR) will require considerable innovations in the science of numerical analysis, as well as in programming languages.

An increase of $178,000 is requested. This will be used to strengthen existing programs as follows: $10,000 at Ames, $78,000 at ANL, $10,000 at LRL, $11,000 at NYU, $10,000 at ORNL, and $59,000 in the Contract Research Program.

C. Programming Research .....$ 1,198,000

Programming research is concerned with improving the techniques of writing programs for digital computers and thus making it easier to use them effectively. This will become increasingly important as machines become more powerful and more expensive. It is an unfortunate fact that the computer industry has concentrated its primary resources in computer engineering rather than in programming, and that the difficulties in using new computers effectively are frequently due to inadequate "software" more than to equipment troubles. It is, therefore, clearly important that the National Laboratories should contain first rate groups who can exercise leadership in those areas of the systems programming field important to AEC. This is particularly important in view of the procurement of very advanced computers by AEC Laboratories. The penalties, both in wasted time and money, of inefficient use of such expensive machines are quite severe. Emphasis is being placed on the development of programming languages and systems including those needed to handle graphic and other non-numerical data, and on developing satisfactory ways of averaging the hierarchy of storage devices now commonly used in large systems.

An increase of $178,000 is requested. This will be used to strengthen existing programs as follows: $10,000 at Ames, $40,000 at ANL, $40,000 at BNL, $10,000 at LRL, $10,000 at ORNL, and $68,000 in the contract research program.

5. Chemistry Research ..... $ 56,300,000

Included under the Chemistry Program are the following activities:

	FY 1967	FY 1968	FY 1969
A. Nuclear, Structural and Inorganic Chemistry	$ 22,443,531	$ 22,770,000	$ 23,570,000
B. Radiation, Isotope and Physical Chemistry	14,178,279	14,734,000	15,285,000
C. Systems and Materials Chemistry	6,087,690	6,131,000	6,380,000
D. Special Projects	2,921,521	3,180,000	3,405,000
E. Preparation and Purification of Special Isotopes for Research	7,027,928	7,185,000	7,660,000
Total Chemistry Research	$ 52,658,949	$ 54,000,000	$ 56,300,000

A. Nuclear, Structural and Inorganic Chemistry ..... $ 23,570,000

Research in this activity probes the structure and behavior of the chemical elements and their isotopes on scales ranging from subnuclear to macroscopic and from highly excited states of nuclei to cold molecular crystals. There are five areas of chemistry identified under this activity: (1) Heavy element chemistry provides basic understanding of the chemical and nuclear properties of the heavy radioactive elements and isotopes, natural and man-made. This understanding is important to their future technology and their contributions to knowledge of all elements, as well as to their formation, separation and analysis. (2) Nuclear chemistry is the study of the structure, radioactive decay and interactions of atomic nuclei with each other and with energetic particles, utilizing advanced combinations of chemical techniques, particle accelerators, reactors, isotope separators, gamma ray and particle detectors and spectrometers. (3) High temperature chemistry, the study of reactions of matter as solid, liquid and gas, at temperatures approaching the limits for confinement in the laboratory. (4) Structural and theoretical chemistry explores the geometrical arrangements and thermal rearrangements of particles in the different states of matter, their bearing on chemical and physical behavior and the prediction and correlation of the behavior by theoretical studies. The most important tools required are neutron beams from reactors, x-ray and electron sources, automatic sample positioners and detectors of the

distribution of the scattered radiations. Computers are used extensively for both data analysis, developing of chemical structural theory, and highly instructive simulation of experiments which are not physically feasible. (5) Inorganic chemistry provides new preparative avenues to the chemical combinations necessary for such operations as separations of elements based on differences in chemical behavior such as volatility, reaction rates, oxidation states, etc. Explorations for new inorganic combinations and scientifically or technologically important properties are an important aspect of the activity.

The requested increase for nuclear, structural, and inorganic chemistry is $800,000. Almost three-fourths of this increase is scheduled for research in nuclear chemistry ($330,000) and heavy element chemistry ($270,000).

A portion of these individual increases ($250,000) is related to increased operational costs of the Heavy Ion Linear Accelerator at Lawrence Radiation Laboratory and the recently modified cyclotron at Washington University which will be supported with AEC funds for the first time in FY 1968.

Another expense attributable to both of these fields results from the growing sophistication and strength of computer adaptation to on-line data handling. Major efforts along this very promising line are planned at Argonne National Laboratory and the Lawrence Radiation Laboratory.

The expected availability of transplutonium elements from the High Flux Isotope Reactor has spurred heavy element chemistry activity. The recently completed Transuranium Research Laboratory at Oak Ridge with its planned electron spectrometer will show increases in costs and research productivity. Other increases in the field of heavy element chemistry provide for work at Lawrence Radiation Laboratory and Brookhaven National Laboratory.

An increase of $50,000 in high temperature chemistry will permit additional effort on the coupling of high pressure techniques to high temperature studies and the use of high temperature molecular beams and other aspects of extending knowledge of the structure and behavior of materials at elevated temperatures.

The requested increase in structural and theoretical chemistry is $150,000. Much of this will be directed toward extending the use of neutron diffraction techniques. Neutron diffraction is a powerful tool for providing information about the location of hydrogen and other light elements in molecules where x-ray studies fail. Other structural probes coming into prominence and requiring additional funding are molecular beams and neutron quadrupole resonance spectrometers. New computers and computer techniques have advanced the art of making accurate representations of chemical bonds. Added impetus will be provided to theoretical efforts to interpret and systematize these results.

B. Radiation, Isotope and Physical Chemistry .....$ 15,285,000

Research in this area is divided into four disciplines: radiation and photochemistry, isotope effects, physical chemistry, and analytical chemistry.

Radiation and photochemistry research deals with the interactions of nuclear radiations, light, and particles with matter. Not only are the gross effects studied but the formation and fate of highly unstable intermediate products. The sequential piecing together of the course of such reactions leads to a detailed understanding of the mechanism of chemical changes induced by radiation.

The study of isotope effects leads not only to information about better methods of separating isotopes, an important aim of Commission supported studies, but to more fundamental knowledge of the structure of matter. Advanced theoretical, computational and experimental techniques when applied to the study of isotopes lead to methods of confirming or predicting observed differences in behavior and properties.

Physical chemistry covers many areas of research, some of the more prominent of which are chemical kinetics and thermodynamics, solution chemistry, energy transfer mechanisms, and the study of the properties of materials. The development of new methods and techniques strengthens the mode of attack on many problems throughout the atomic energy program.

Analytical chemistry deals with the determination of the composition of materials. A wide spectrum of methods is brought to bear on analytical problems including determinations based on differences in mass, optical and magnetic properties, on differences in chemical reactivity, in physical properties, or in inherent or induced radioactivity.

The requested increase for radiation, isotope and physical chemistry is $551,000. Of this, $250,000 is in the field of radiation and photochemistry. This will provide for expanded studies of fast reactions by pulse radiolysis, mass spectrometry, flash photolysis, and other advanced techniques of looking for highly transient intermediates. There will also be an extension of the current work at Argonne on the hydrated electron and increased effort at Oak Ridge on the study of the corrosion of reactor materials during irradiation. Additional support for the hydrated electron work is particularly important because of its growing significance in biomedical research.

The increase requested for work on isotope effects is $96,000, largely devoted to investigations at Brookhaven into chemical kinetics and rate and equilibrium processes. These investigations include theoretical studies using the powerful methods of statistical mechanics and experimental studies of such phenomena as the differing thermodynamic properties of isotopically substituted molecules. There will also be increased work at Argonne on the study of labelled molecules prepared by isotopic biosynthesis using the techniques of electron spin and nuclear magnetic resonance, mass spectrometry, etc.

Many physical chemistry projects of importance to the atomic energy program need expansion, among them the studies of the chemistry of solids and solid surfaces at the Lawrence Radiation Laboratory, the calorimetric studies of low temperature properties at Argonne and of technetium and lithium compounds at Oak Ridge, and the investigation of energy transfer processes in collisions at Brookhaven. The requested increase in physical chemistry is $155,000.

Expanded research efforts in chemistry create greater demands for precise, rapid, automatic, computerized analytical methods. Among those techniques for which greater sophistication is sought are mass spectrometry and neutron activation analysis. The requested increase in analytical chemistry is $50,000.

C. Systems and Materials Chemistry .....$ 6,380,000

The objective of the Systems and Materials Chemistry activity is to conduct fundamental research in chemistry and chemical and nuclear engineering. Long range studies under this activity are related to the materials, operations, systems, and processes of present and/or future importance to the development of atomic energy.

The activity is divided into four principal areas of research: Reactor and Materials Chemistry includes investigations of the chemical nature of those materials and systems of importance to the long range needs of the AEC. These encompass studies of the behavior of materials of immediate programmatic interest at extremes of temperature and pressure and include the search for new or unevaluated materials to meet specific practical needs. Systems Radiation Chemistry extends the investigations of materials to include the behavior of entire systems in the presence of radiation. Nuclear Engineering Chemistry weds conventional engineering techniques to nuclear technology and searches for new concepts and principles useful in the application of atomic energy. Separations Chemistry is devoted to the practical utilization of all available techniques and the development of new ones in the field of separations of similar nuclides from each other.

The total increase requested for Systems and Materials Chemistry is $249,000. The largest increase in this program, $150,000 is in the field of Reactor and Materials Chemistry reflecting expanded studies of calorimetry, and regenerative galvanic cells and molten and vaporized salt systems. An additional $60,000 is required for Nuclear Engineering Chemistry, to accelerate and foster the practical utilization of the results of basic research. The requested increase of $39,000 for Separations Chemistry will be devoted primarily to expanded studies to meet growing demand for more exacting separations in the radiochemical and heavy element processing fields.

D. Special Projects ..... $ 3,405,000

This program is devoted to the development of special methods of analysis. The program has been maintained at an essentially constant level of effort during the last several years. An increase of $225,000 is requested for the development of new techniques.

E. Preparation and Purification of Special Isotopes for Research ..... $ 7,660,000

The three major parts of this effort are (1) the National Transplutonium Element Production Program, (2) the Target Preparation Center for the fabrication of accelerator and reactor targets from highly-enriched radioactive and stable isotopes and other exceptionally pure materials, and (3) the separation and purification of rare isotopic materials by chemical methods for use by all AEC research programs. Processing of targets irradiated in the High Flux Isotope Reactor will produce an estimated 20 milligrams of berkelium (element 97) and 200 milligrams of californium (element 98) during this fiscal year. The increase requested for this activity is $475,000. At the Oak Ridge National Laboratory the increase of $415,000 is related to operation of the High Flux Isotope Reactor, the Transuranium Processing Plant and the Isotope Target Center. The residual increase of $60,000 is related to programs involving production of special isotopes for research.

6. Metallurgy and Materials Research ..... $ 28,300,000

The Metallurgy and Materials Program includes the following activities:

A. Physical Metallurgy and Ceramics	FY 1967: $ 11,275,758	FY 1968: $ 11,221,000	FY 1969: $ 11,862,000
B. Solid State Physics	14,816,768	15,839,000	16,438,000
Total Metallurgy and Materials Research	$ 26,092,526	$ 27,060,000	$ 28,300,000

The Metallurgy and Materials Program is responsible for the support of basic research on the structure, properties, and behavior of materials. Its objective is to achieve continual advancement of the state of knowledge and understanding in materials science, especially in those areas of particular interest to the Commission. The

task is approached in a selective way over the broad range of problems forming the frontier of knowledge in materials science. This selectivity is accomplished through several mechanisms. In the materials research supported at the national laboratories, special advantage is taken of such unique facilities as reactors, accelerators, computers, and special purpose laboratories to conduct research of Commission interest which cannot be conducted readily or efficiently under other circumstances. Support is also provided for university-based materials research of interest to the Commission.

The resources of the Metallurgy and Materials Programs, for support of an appropriate level of research, must be sufficient to maintain those parts of its existing programs which continue to be fruitful and relevant, and to increase support of selected programs where the increased productivity permitted will warrant the additional expenditure of funds. For the most part, resources for support of new programs or augmentation of continuing programs will be obtained by termination or reduction of programs judged to be of lowest priority. Demands on the Metallurgy and Materials Programs for support of worthwhile programs of Commission interest continue to grow. Therefore, to accommodate the increased costs of maintaining on-going programs arising from salary increases, small staff additions in some of the undermanned programs, increases in facility and support requirements, and cost of growing sophistication of the research, an increase of $1,240,000 is needed.

A summary of the program scope follows. Also, discussed are individual research topics for which increased effort is needed or on which new programs should be commenced.

The Metallurgy and Materials Program is divided between two major activities: (a) Physical Metallurgy and Ceramics, and (b) Solid State Physics. This division reflects the technical content of the program and also the principal administrative divisions in the AEC laboratories and in the offsite program.

A. Physical Metallurgy and Ceramics ..... $ 11,862,000

The physical metallurgy and physical ceramics disciplines are concerned with the relation between structure and properties in metallic and nonmetallic inorganic materials and how they respond to such significant variables as chemical composition, temperature, temperature changes, stress, or exposure to chemically active environments. In technology, these disciplines are applied to the tasks of designing new materials, tailoring known materials to needs, and to solving materials problems arising in service. The objective of supporting research under the Physical Metallurgy and Ceramics activity is to advance the understanding of the fundamentals underlying physical metallurgy and physical ceramics.

To provide for the increased costs associated with continuing research, and to support selected program expansions and new research programs which offer the opportunity of significant payoff, an increase of $641,000 over the FY 1968 level is needed for the total Physical Metallurgy and Ceramics activity.

The Physical Metallurgy and Ceramics activity may be described in terms of three areas. The scope of these areas and the proposed allocation of funds among these areas are presented below:

1. Materials, Properties and Processes .....FY 1967: $ 4,794,337 FY 1968: $ 5,008,000 FY 1969: $ 5,255,000

A part of the Metallurgy and Ceramics activity is devoted to research on topics arising directly from the needs and problems of nuclear technology. This research is also of general interest to the total Federal research and development program because most of the topics involved arise in other technologies. Some of the topics represent properties and processes utilized by materials engineers and others represent problems with which materials engineers must cope. Included in this area is general research on specific materials of Commission interest such as uranium, plutonium, and graphite.

In this area, an increase of $247,000 is needed. This will be used in part to offset increased costs in the continuing program. The principal topics needing augmented support are: strength and plasticity of materials, influence of alloying elements and impurities on mechanical properties of metals, corrosion, fundamental ceramics research, the metallurgy of transuranic elements, and physical metallurgy of superconducting materials. Special encouragement will be given to research on the defects and microstructures controlling mechanical properties of materials.

2. Structure of Materials .....FY 1967: $ 5,407,293 FY 1968: $ 5,134,000 FY 1969: $ 5,498,000

The processes, behavior, and treatments involved in the physical metallurgy and physical ceramics disciplines are controlled by fundamental factors such as atomic, electronic, and defect structures and processes. The development of understanding in metallurgy and ceramics requires that the fundamental atomic, electronic and defect structures themselves be thoroughly understood. Research in this area of Physical Metallurgy and Ceramics requires an increase of $364,000.

The principal research topics to be given increased emphasis are: atomic scale studies of metal and compound surfaces, kinetics of formation and stability of precipitates, structural determinations by neutron diffraction, superconductivity, thermodynamics of metallic systems, diffusion in solids, structure and properties of liquid metals and alloys, and theory of alloy phases.

94-075 O-68-pt. 3—26

3. Radiation Damage .....FY 1967: $ 1,074,128 FY 1968: $ 1,079,000 FY 1969: $ 1,109,000

One of the most significant and nearly unique problems encountered in Commission programs is coping with degradation of materials properties arising from displacement damage by high energy neutrons and fission fragments and from the introduction of impurities by transmutation and by fission. This portion of the program is directed toward increasing understanding of the fundamental processes involved in radiation effects and the relations between measured property changes and the fundamental processes. An increase of $30,000 is requested for this part of the program for build-up of new programs on research on radiation damage. Encouragement will be given to new research on damage to the more refractory metals such as tungsten, molybdenum, vanadium, and niobium.

B. Solid State Physics .....$ 16,438,000

Included in this activity of the Metallurgy and Materials Programs, are fundamental studies of materials in the condensed state undertaken by solid state physicists. The research spans both theoretical and experimental areas, and its aim is to understand the physical nature of condensed systems with emphasis on the structure and dynamics of crystalline solids. There is increasing need to utilize the more sophisticated experimental techniques available to help solve outstanding solid state problems. These techniques are frequently very costly, since they may use such probes as neutron beams from the High Flux Isotope Reactor at Oak Ridge and the High Flux Beam Reactor at Brookhaven. In addition, recent advances in newer areas such as superconductivity and channeling require additional staffing.

The total increase requested for Solid State Physics is $599,000. This activity is comprised of three components: 1) Materials Preparation and Characterization, 2) Crystal Physics, and 3) Energetic Particle Interaction; and their needs are discussed below:

1. Materials Preparation and Characterization .....FY 1967: $ 1,022,620 FY 1968: $ 1,010,000 FY 1969: $ 1,050,000

A very important factor in all materials research is the purity and quality of specimens used in experiments. Subtle effects are often masked and perhaps unknowingly created by small amounts of chemical impurities and by physical defects. Research within this program is directed towards the development of necessary techniques required for making research-quality specimens (usually single crystal) of the composition, quality, purity and perfection needed in certain areas of research. The increase requested amounts to $40,000. This increase will permit the on-going program to be maintained and provide for an increased effort in growth of ceramic crystals for use in other parts of the Metallurgy and Materials Programs.

2. Crystal Physics .....FY 1967: $ 10,335,661 FY 1968: $ 11,151,000 FY 1969: $ 11,602,000

The largest fraction of support in the Solid State Physics activity is utilized within this component of the program. Here, research is directed toward understanding the atomic and electronic structure of matter. Some of the topics and techniques actively under investigation include: Mössbauer effect, superconductivity, electron spin resonance, magnetic structures, Fermi surfaces, inelastic neutron scattering, crystal defects, the structure of liquids, neutron diffraction, thermal conductivity, magnetic susceptibility, and theoretical studies in conjunction with these areas.

An increase of $451,000 is requested to continue the on-going research and strengthen certain selected portions of the program. Additional funds are needed to fully utilize the neutron scattering facilities at the Ames Research Reactor, High Flux Beam Reactor and High Flux Isotope Reactor. A build-up is planned in neutron scattering studies of specimens using long wave length neutrons. The fields of low temperature physics and superconductivity are in a state of rapid advance making it necessary to plan for increased funding both for fundamental research and for research aimed more closely at development of applications. The use of synchrotron radiation in the study of solids is expected to require increased support.

3. Energetic Particle Interaction .....FY 1967: $ 3,458,487 FY 1968: $ 3,678,000 FY 1969: $ 3,786,000

The objective pursued under this component of the Solid State Physics activity is the quantitative understanding of radiation interaction with matter. The effects of neutrons, charged particles and ionizing radiations on solids are being studied at both AEC laboratories and universities, but, principally at the former. Although considerable progress of definite AEC interest has been made, some very complex and subtle problems have been uncovered and require increased attention. The Energetic Particle Interaction program will need an additional $108,000 beyond the FY 1968 level. Theoretical and experimental investigations of channeling will be continued and expanded. Low temperature irradiation studies will be increased and work on nonmetallic crystals will be expanded. Some increase in reactor charges must be provided for. Additional support will also be provided for studies of irradiation effects on superconductivity.

7. Controlled Thermonuclear Research (CTR) .....$ 27,400,000

Programs in controlled fusion research are conducted under the following activities:

A. Research and Development .....FY 1967:	$ 9,859,326	FY 1968: $ 9,740,000	FY 1969: $ 10,270,000
B. Confinement Systems	12,524,089	15,160,000	17,130,000
Total Controlled Thermonuclear Research	$ 22,383,415	$ 24,900,000	$ 27,400,000

The Commission is now underway with an intensification of the Controlled Thermonuclear Research program. Steps taken include:

1. Fabrication of large new experimental devices urgently needed to test recent concepts for improved plasma confinement. Approximately 60% of the increase requested for FY 1969 is required to carry forward this essential aspect of the revitalization of the CTR program.

2. Establishment of a CTR Standing Committee and associated Ad Hoc Panels. The purpose of this Committee is to ensure a close cooperative effort within the overall program; to consider major policy questions required to meet program goals; to identify important remaining questions of controlled fusion research and recommend priorities in seeking answers; to consider the need for major new facilities; and to help identify less productive program areas.

During the past year, the activities of the CTR Standing Committee, of the Ad Hoc Panels, and of the AEC and laboratory management have had a major impact on the CTR effort. Each of the laboratory programs was reviewed in detail, and the off-site programs were evaluated in relation to the total effort. A major degree of coordination and cooperation among working scientists at many sites was achieved.

Steps were taken at AEC sites to ensure that less productive programs were eliminated (or suitably strengthened) and that important programs proceed rapidly. The result in FY 1966 and FY 1967 was that about $3,000,000 was re-allocated to strengthen the overall CTR effort. In specific actions, the Scyllac at Los Alamos was identified as a crucial experiment in the high-beta research area; critical short term experiments were started in low-beta toroidal research; open-ended systems research efforts at the Lawrence Radiation Laboratory and the Oak Ridge National Laboratory were delineated; theoretical and engineering support efforts at Los Alamos were strengthened; and at Oak Ridge the theoretical effort was strengthened and experimental groups were consolidated. In FY 1968, detailed consideration is being given to low-beta closed systems, low-beta open systems, Astron

research and program balance. A target of $1,000,000 in elimination and redirection of less productive elements in existing programs has been set for both FY 1968 and FY 1969.

Major progress has been made in controlling the means whereby plasmas escape from magnetic bottles. These means are the so-called plasma instabilities, of which there are only two major classes -- the macroscopic (also called MHD or "gross") type and microinstabilities.

In the past several years, macroscopic instabilities have been suppressed in open-ended systems by use of the "minimum-B" magnetic bottle. More recently, similar principles have been applied to closed systems in experimental devices (called "toroidal multipoles") at the University of Wisconsin and General Atomic. Strong but indirect evidence has been compiled to show that the rate at which plasma escapes from closed systems can now be significantly reduced. The experiments indicate not only macroscopic stability of the plasma, but also a large degree of microscopic stability of the plasma as well. These results must now be definitively confirmed in improved multipole devices. If confirmed, they will constitute a major milestone in fusion research.

Additional progress in closed systems research came in FY 1967 when it was experimentally found that increased magnetic shear also helped to suppress instabilities and to provide improved plasma confinement. Further experiments in FY 1968 and 1969 will be aimed at quantitatively correlating these results with theories.

In Astron research during FY 1967, a seven-fold increase (from .7% to 5%) was achieved in the density of the electron layer. Further electron layer buildup now requires modification and improvement of the accelerator.

In view of the vital importance of major new experimental devices to further progress in controlled thermonuclear research, the costs of fabricating such devices have been segregated, thereby permitting the CTR program to be summarized as follows:

Base Program	FY 1967: $ 22,383,415	FY 1968: $ 24,300,000	FY 1969: $ 25,400,000
Major Device Fabrication	0	600,000	2,000,000
Total	$ 22,383,415	$ 24,900,000	$ 27,400,000

The base program includes all operating funds exclusive of major new device fabrication items (which are justified separately on a case-by-case basis).

The increase of $1,100,000 in the base program will maintain a viable CTR program in the United States but without significant increases in manpower. To accelerate areas of greatest potential, selective shifts of manpower will be made.

The estimates for the overall program are distributed in the following manner:

A. Research and Development			
1. Research	FY 1967: $ 7,235,201	FY 1968: $ 7,060,000	FY 1969: $ 7,495,000
2. Development	2,624,125	2,680,000	2,775,000
Total Research and Development	$ 9,859,326	$ 9,740,000	$ 10,270,000
B. Confinement Systems			
1. Research Operations			
a. Open Systems	FY 1967: $ 6,350,230	FY 1968: $ 6,825,000	FY 1969: $ 6,920,000
b. Closed Systems	6,173,859	7,735,000	8,210,000
Subtotal	12,524,089	14,560,000	15,130,000
2. Major Device Fabrication	0	600,000	2,000,000
Total Confinement Systems	$ 12,524,089	$ 15,160,000	$ 17,130,000

A. Research and Development ..... $ 10,270,000

The Commission's directed research effort, aimed at proving the feasibility of controlled fusion power, requires the support of a broad program in basic plasma physics and engineering developments. An increase of $530,000 is requested for such research and development work. Of this increase a) $435,000 is for basic research in plasma physics. Over one-half of the increase will be in the off-site university program to strengthen the effort in plasma research. The remainder is for specialized basic experiments at the major CTR laboratories. b) $95,000 is for engineering development activities at the CTR laboratories to provide technological support for the major new confinement devices. The principal area to be strengthened is the cryogenics work at the Princeton Plasma Physics Laboratory.

B. Confinement Systems ..... $ 17,130,000

Plasma confinement systems test the theories that guide the way toward the goal of controlled fusion power. An increase of $1,970,000 is requested for the confinement systems activity. Of this increase, $570,000 is required for the research operation of confinement systems and $1,400,000 is related to major device fabrication.

1. The increase of $570,000 for research operations is broken down between open and closed systems as follows:

   a. Open Systems: $95,000

   The increase is primarily for open system studies on the "Baseball" experiments at the Lawrence Radiation Laboratory. Now that macroinstabilities have been suppressed, low beta open systems research is concentrating on the study of the remaining major class of instabilities, the microinstabilities.

   b. Closed Systems: $475,000

   i) A net increase of $375,000 is required in low beta research in closed systems. Recent significant progress in this area has resulted in an intensification of effort aimed at confirming the indications that improved plasma confinement is also possible in closed systems.

   In FY 1969, plasma research in closed systems will be carried out at all four major laboratories and in the off-site program. The intensification will involve a redirection of research into multipole and high shear experiments at the Princeton Plasma Physics Laboratory, the modification of the Levitron at the Lawrence Radiation Laboratory and the establishment of small efforts at the Oak Ridge and Los Alamos Laboratories. A decrease of funds ($115,000) in off-site closed systems research is due to non-recurring costs for major procurements in FY 1968 at the University of Wisconsin.

   ii) An increase of $100,000 in Astron research. The recent substantial increase in the electron layer justified strengthening the Astron program. Buildup of the electron layer beyond the current level requires acceleration improvements accompanied by supporting development work.

2. An amount of $2,000,000 is requested for major device fabrication for new confinement systems. This represents an increase of $1,400,000 for major device fabrication for the following purposes:

   a. Scyllac.

   In FY 1968, an $8.5 million construction line item required for the Scyllac experiment at Los Alamos was approved. The device itself is to be built with device fabrication funds of $1.1 million spread over three years as follows: FY 1968 $100,000; FY 1969 $400,000; and FY 1970 $600,000.

b. Superconducting Multipole.

In FY 1968, fabrication was begun at the Princeton Plasma Physics Laboratory of a major new closed system device: the Superconducting Multipole. The cost of this device is estimated at $1,150,000 spread over three years as follows: FY 1968 $270,000, and FY 1969 $700,000; and FY 1970 $180,000.

c. Baseball II.

In FY 1968, fabrication was begun at the Lawrence Radiation Laboratory on a new open system device, the superconducting Baseball II, aimed toward suppressing microinstabilities through control of the velocity spread of injected plasma particles. The cost of this device is estimated at $1,200,000 spread over three years as follows: FY 1968 $230,000, FY 1969 $700,000; and FY 1970 $270,000.

d. Astron Accelerator, Phase I.

The cost of Phase I of the Astron accelerator improvements is estimated at $1,200,000 spread over two years as follows: FY 1969 $200,000, and FY 1970 $1,000,000.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

PHYSICAL RESEARCH - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$ 169,805,000
A Construction Projects	
A-1 Obligations for new projects	$(58,225,000)
A-2 Obligations for prior year projects	$(69,559,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	$(30,850,000)
B-2 Obligations from prior year appropriations	$(11,171,000)
Estimated Obligations FY 1968	$ 61,487,000
Actual Obligations FY 1967	$ 93,456,000

Obligations for the Physical Research Program for FY 1969 are estimated at $169,805,000, of which:

a. $58,225,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act or were previously authorized and for which a request for appropriation was deferred until FY 1969.

b. $69,559,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $30,850,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $11,171,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back".

SECTION A-1

The projects comprising Section A-1, which are requested for authorization in FY 1969 or which were previously authorized and for which a request for appropriation was deferred until FY 1969, are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-6-a	Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York	$ 600,000	$ 0	$ 600,000	$ 0
69-6-b	Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois	875,000	0	875,000	0
69-6-c	Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California	750,000	0	750,000	0
69-6-d	Accelerator improvements, Cambridge and Princeton accelerators	145,000	0	145,000	0
69-6-e	Accelerator improvements, Stanford Linear Accelerator Center, California	630,000	0	630,000	0
69-7-a	Conversion of steam plant to natural gas, Brookhaven National Laboratory, New York	800,000	0	800,000	0
69-8	General plant projects	3,225,000	0	3,225,000	0
68-4-f	200 Bev accelerator, Du Page and Kane Counties near Chicago, Illinois	250,000,000			
	Less CP&D	1,705,000			
	Net	248,295,000	7,333,000	a/ 25,000,000	215,962,000
66-5-h	Meson physics facility, Los Alamos Scientific Laboratory, New Mexico	55,000,000			
	Less CP&D	500,000			
	Net	54,500,000	14,600,000	b/ 26,200,000	13,700,000
Total		$309,820,000	$21,933,000	$58,225,000	$229,662,000

a/Of this amount, $4,633,000 will be obligated in FY 1968 and $2,700,000 will be carried over into FY 1969 as shown in Section A-2.

b/Of this amount, $7,311,000 will be obligated through FY 1968 and $7,289,000 will be carried over into FY 1969 as shown in Section A-2.

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-6-a Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York ..... $ 600,000

Funds requested for this project are required for the large research facilities which need annual modifications, improvements and additions. Accelerator and reactor additions and modifications depend to some degree on the extension of existing techniques that cannot be established in all details in advance. Some modifications are planned to adapt the existing accelerator and reactor facilities to newly planned research programs. Others result from unexpected failures of facility components, and from obscure effects which cannot be predicted and which may appear only after extended operating periods. Consequently, it is clear that changes in the list of modifications must be anticipated. The cost estimates for these projects are by necessity of a preliminary nature.

It is anticipated that the funds requested for FY 1969 will provide for improvements to the major research devices at Brookhaven as follows:

A. Alternating Gradient Synchrotron $300,000
   (1) Additional radiation shielding $100,000
   (2) Modifications and improvements to facilities and services, including power distribution revision, improvements in gas detection facilities; and additional portable buildings 200,000

B. High Flux Beam Reactor $200,000
   Improvements and modifications, including extension of the neutron flight path; construction of an in-line isotopic purity analyzer; improvements in irradiation facilities; and improvements in fuel elements.

C. 60" Cyclotron $100,000
   Improvements and modifications, including dividing the experimental area into two beam lines; modification of beam steering and magnet power; and providing beam dumps in the experimental area.

Total Project Cost $600,000

2. Project 69-6-b Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois ..... $ 875,000

Incorporated in this project are ZGS improvements planned to increase the efficiency, safety, and utility of this machine and its associated experimental facilities. The items shown here reflect current planning and are subject to later revision, since research and technological demands cannot always be predicted in advance. The $875,000 requested for FY 1969 is tentatively planned to be used as follows:

Experimental Area Electric Power and Cooling Water Additions	$ 100,000
Hydrogen Safety Improvements	75,000
Accelerator Ring Improvements	150,000
Ring Magnet Power Supply Improvements	100,000
RF and Beam Monitoring Systems Improvements	150,000
Targetry Improvements	100,000
Accelerator Controls Improvements	50,000
Injector System Improvements	150,000
Total Project Cost	$ 875,000

3. 69-6-c Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California ..... $ 750,000

This project consists of additions and modifications to upgrade and modernize the Laboratory accelerators to meet programmatic needs. It reflects a continuing effort to maintain the pace of physical and technological advancement by maintaining the scientific effectiveness of the accelerators. The needs shown here reflect current planning and are subject to later revisions since research and technological demands cannot always be predicted in advance. It is presently planned that the funds requested will be used to improve the research machines as follows:

A. Bevatron ..... $ 340,000
(1) External Proton Beam Shielding ..... $ 80,000
(2) High Frequency Buncher 260,000

B. 88" Cyclotron 120,000
(1) Duty Factor Improvements, Phase II

C. 184" Cyclotron 90,000
(1) Improve Second Dee System

D. Heavy Ion Linear Accelerator (HILAC) 200,000
(1) Provide Additional Experimental Area by Cave System Alterations

Total Project Cost ..... $ 750,000

4. Project 69-6-d Accelerator improvements, Cambridge and Princeton accelerators ..... $ 145,000

This project is required to modify and improve the Cambridge Electron Accelerator at Cambridge, Massachusetts, and the Princeton-Pennsylvania Accelerator at Princeton, New Jersey, as part of the continuing effort to sustain the performance capabilities of these research machines in accordance with the technological and research demands of the programs they support. Since these demands cannot always be predicted in advance, the items proposed for FY 1969 are subject to change. The $145,000 requested is tentatively planned to be used as follows:

A. Cambridge Electron Accelerator (CEA) ..... $ 45,000
Improvements to 480 Volt Distribution System

B. Princeton-Pennsylvania Accelerator (PPA) 100,000
Additional RF Power Equipment

Total Project Cost $145,000

5. Project 69-6-e Accelerator improvements, Stanford Linear Accelerator Center, California .....$ 630,000

The purpose of this project is to provide for necessary modifications to the accelerator-switchyard-target area complex at SLAC. These modifications, based upon operating experience acquired during FY 1967, are required to optimize the total systems performance. The improvements listed below are tentative in nature, and are subject to revision in recognition of further operating experience.

It is presently planned that the $630,000 requested for FY 1969 will be utilized as follows:

A.	Switchyard Shielding and Remote Handling Devices	$ 95,000
B.	Switchyard Low Power Slit	40,000
C.	Switchyard and Target Area Radiation Monitoring and Protection	40,000
D.	Modifications to the Instrumentation and Control Systems for Accelerator, Switchyard and Target Area	295,000
E.	Modifications to Target Area Electrical Distribution System	160,000
	Total Project Cost	$630,000

6. Project 69-7-a Conversion of steam plant to natural gas, Brookhaven National Laboratory, New York .....$ 800,000

This project is required to fulfill the provisions of Executive Order 11282 (Section 3), "Control of Air Pollution Originating from Federal Installations." The remedial measures proposed were developed on the basis of air pollution standards prescribed by the Secretary of Health, Education, and Welfare.

The emission of smoke, sulfur dioxide, and particulates from the Brookhaven steam plant will be reduced to acceptable levels by conversion from No. 6 fuel oil to natural gas burning, with No. 2 fuel oil as standby. Precise combustion control on all boilers will be accomplished by installation of an integrated centralized control console with a burner management system. In conjunction with the conversion, boilers 3 and 4 will be refurbished to increase the efficiency of each unit, two boilers at other locations will be converted, and four boilers will be eliminated by provision of a new steam line from the main plant.

Details of Cost Estimate: *

a. Engineering, Design, and Inspection at approx. 10% of Construction Costs, item b				$ 70,000
b. Construction Costs:				630,000
(1) Main Steam Plant:			$ 330,000	
Conversion of four boilers to natural gas/No. 2 fuel oil		$ 50,000		
Refurbishing of boilers 3 and 4		80,000		
(a) Tiles, baffles, casings, insulation, etc.	$ 55,000			
(b) Stack (common for both units)	25,000			
Controls:		200,000		
(a) Centralization	60,000			
(b) Burner management system	140,000			
(2) Site Oil Burners:			300,000	
Steam line to warehouse area		210,000		
Steam line to shops zone		90,000		
c. Standard Equipment				0
Subtotal				$700,000
d. Contingency at approximately 15% of above costs				100,000
Total Project Cost				$800,000**

*Estimate based on partial conceptual design.

**In addition to this capital expenditure, compliance with the regulations on Air Pollution affecting Federal Government activities will result in an increase in heating fuel cost of approximately $150,000 annually.

7. Project 69-8 General plant projects ..... $ 3,225,000

This project provides for minor new construction and other capital alterations, additions, and retirements to land, buildings, and utilities systems. The estimate also includes the cost of installed equipment which is an integral part of the general plant subprojects.

Although it is difficult to detail this type project in advance, various subprojects are under consideration. In general, the estimated costs of the subprojects are preliminary in nature and primarily indicative of the size of the project. It should be noted also that the continuing study of requirements will result in some of the projects being changed in scope; it will also result in other projects being added with the necessary postponement of some now planned, all depending on conditions or situations not apparent at this point in time.

The funds requested for FY 1969 are estimated as follows:

Ames Laboratory (all programs)	$ 250,000
Brookhaven National Laboratory (all programs)	1,360,000
Notre Dame Radiation Laboratory	10,000
Princeton Plasma Physics Laboratory	65,000
Princeton-Pennsylvania Accelerator	130,000
Cambridge Electron Accelerator	100,000
Lawrence Radiation Laboratory (Berkeley)	845,000
Stanford Linear Accelerator Center	365,000
Contract Research Program	100,000
Total FY 1969 Obligations	$3,225,000

8. Project 68-4-f 200 Bev accelerator, Du Page and Kane Counties near Chicago, Illinois $250,000,000*

This project is for the construction of a new national high energy physics laboratory near Chicago, Illinois. The 200 Bev synchrotron will provide the highest energy proton beam in the world, thus permitting experiments to be conducted in an energy range which is now inaccessible. The results of experiments at higher energies are vital for a better understanding of particle physics, the study of the fundamental constituents of atomic nuclei, and thus of all matter.

The principal research device of the facility will be a 200 Bev strong focusing proton synchrotron with a design intensity of about 5×10^{13} protons per pulse and a pulse repetition rate such that the average beam intensity would be about 1.5×10^{13} protons per second, employing a linac-booster synchrotron injection system. The design, which exploits the present state of the art, provides the capability of increasing the energy above 200 Bev at a later date, and includes features that allow for future addition to and expansion of

*Includes $1.7 million of CP&D funds.

experimental facilities with minimal disturbance to initial facilities and operation. The laboratory will include experimental areas and experimental support facilities sufficient to provide auxiliary services and housing for permanent staff and visitors in consonance with its national character.

The facility will be made available to any qualified user on the basis of merit of the experiment proposed. Visiting users, primarily from university laboratories, will carry out approximately 75% of the planned research program, while resident staff will carry out the remainder and will also have responsibility for operation and development of the accelerator and associated equipment. The facility is designed to accommodate approximately 2,000 people, including several hundred visiting users at any one time. Annual costs of operation and in-house experimentation are expected to reach a level of approximately $60 million per year, in about the second year of machine operation.

The amount of $25 million is being requested for FY 1969, which will provide for continuation of design and engineering services, procurement of various technical components, and initiation of construction on conventional facilities. The balance of funding required to complete the project will be requested after FY 1969.

Details of Cost Estimate:1/

a. Engineering, design, inspection and administrative costs for:		$ 33,700,000
(1) Conventional facilities, items b. (1), (2), (3), (4) and (6) at about 20% of construction costs ($77,500,000) and $1,000,000 of expended CP&D funds	$16,500,000	
(2) Technical components, item b. (5), at about 25% of construction costs ($66,500,000), and $705,000 of expended CP&D funds	17,200,000	
b. Construction Costs:		144,000,000
(1) Land and land rights	0	

1/Based on conceptual design and foundation exploration.

94-075 O-68-pt. 3—27

Details of Cost Estimate: continued

(2) Improvements to land		$ 6,500,000
Clearing, grading, and erosion control (approx. 3,000 acres)	$ 1,000,000	
Roads (about 15 miles), railroad siding	3,500,000	
Parking, hardstands, walks, etc. (about 115,000 sq. yds.)	500,000	
Storm-drainage system and reservoir for impounding water	1,000,000	
Fencing and landscaping	500,000	
(3) Buildings		31,000,000
Main support building, approx. 420,000 gross sq. ft. at about $28/sq. ft., containing space for General Laboratory and Administrative Offices, Computer Center, Film Processing, Library, Cafeteria, Auditorium, Light Service and Maintenance Shops, Medical, Lobby, Reception Area, and Control Center	11,800,000	
Heavy Laboratory, about 50,000 sq. ft. at approx. $30/sq. ft.	1,500,000	
Receiving and Warehouse, about 60,000 sq. ft. at about $10/sq. ft.	600,000	
Service and Maintenance, about 5,000 sq. ft. at about $20/sq. ft. and fabrication and service shops, about 50,000 sq. ft. at about $30/sq. ft.	1,600,000	
External Experiment Buildings, about 250,000 sq. ft. at about $45/sq.ft.	11,300,000	
Internal Experiment Building, about 40,000 sq. ft. at about $55/sq. ft. 1/	2,200,000	
Steam and Air Conditioning Plant, including equipment	2,000,000	

1/The relatively high cost per square foot is due to special construction requirements for this high-bay building.

Details of Cost Estimate: continued

(4) Other Structures		$22,000,000
Main accelerator housing, earth shielded, approx. 10 ft. x 12 ft. x 21,000 ft. long	$ 16,500,000	
Booster synchrotron housing, earth shielded, approx. 10 ft. x 12 ft. x 1,500 ft. long	3,500,000	
Linac housing, including preinjector, linac building, and equipment bay	2,000,000	
(5) Special Facilities		66,500,000
Linear-accelerator components, including preinjector, linac tanks, drift tubes, vacuum and cooling system, linac rf system, beam-transport systems, controls and instrumentation	9,700,000	
Booster-accelerator components, including injection, magnet and magnet power-supply systems, rf, vacuum, cooling, extraction and electrical systems, controls and instrumentation	14,400,000	
Main-accelerator components, including injection, magnet and magnet power-supply systems, rf, vacuum, cooling extraction and electrical systems, controls and instrumentation	34,000,000	
Internal-beam area components, including targets and target mechanisms, electrical systems, controls and instrumentation	200,000	
External-beam area components, including proton-beam transport and switching systems, vacuum, cooling, and power systems, controls and instrumentation	3,700,000	
Control-system components, including monitoring, interlock, supervisory-control, safety, electrical and cooling systems	4,500,000	

PHYSICAL RESEARCH PROGRAM - continued

Details of Cost Estimate: continued

(6) Utilities, including water supply and distribution, power supply and distribution, sanitary-sewer system with treatment plant, heating distribution system, emergency power, fire alarm and water distribution, and facility control and communication system	$18,000,000	
c. Standard Equipment		$ 10,000,000
(1) Cranes, kitchen and cafeteria equipment, laboratory and office furniture and equipment, shop equipment, medical equipment, materials-handling equipment, etc.	4,000,000	
(2) Fixed and movable shielding, including normal and high-density concrete blocks and special steel shielding	6,000,000	
Subtotal		$187,700,000
d. Contingency at about 15% of conventional facilities, standard equipment and engineering, and at about 25% of technical components and engineering		36,300,000
e. Escalation at about 14% of construction and engineering (of subtotal)		26,000,000
Total Project Cost		$250,000,000 1/

1/ Total includes $1,705,000 of expended CP&D funds, and $7,333,000 of funds authorized in FY 1968. No escalation or contingency have been applied to the expended CP&D funds.

9. Project 66-5-h Meson physics facility, Los Alamos Scientific Laboratory, New Mexico .....$55,000,000[1]

This project provides for construction of a nuclear physics research complex consisting of an 800 Mev linear proton accelerator, 2,300 feet long, and attendant experimental and support facilities.

A medium energy, high current proton accelerator will make accessible important areas of nuclear and pion physics which have been extremely difficult or impossible to investigate with existing research facilities. The accelerator will permit a necessary broadening and extension of the present scope of studies on the structure of the atomic nucleus, the nature of nuclear forces, and those meson phenomena which are responsible for the great stability of the atomic nucleus and for the great violence of nuclear reactions. Three decades of nuclear physics with low energy beams of nucleons have brought about major advances in our understanding of the nucleus and revolutionary applications of nuclear processes. There now emerges a need to intensify investigation of nuclear structure using mesons. The proton beam itself would be used directly in investigations of interactions of protons with nuclei. The energy and current specifications of the accelerator are dictated by the physics of the production of the mesons necessary for the experimental program. In addition to nuclear structure studies, the proposed machine will make possible certain fundamental experiments in particle physics which require high intensity. The total research capability will therefore serve as a bridge between nuclear and subnuclear physics.

The amount of $26,200,000 is being requested for FY 1969, which will provide for continuation of design services, procurement of accelerator components, the 60 cycle switchyard, and water cooling towers, and construction of buildings and utilities including the central control building. The balance of $13,700,000 required to complete the project will be requested after FY 1969.

Details of Cost Estimate:

a. Engineering, design, and inspection costs @ approx. 15% of construction costs, item "b" .....$ 4,400,000
b. Construction costs: 29,170,000
   (1) Improvements to land, including site preparation, drainage, storm sewer, road, parking, and paved areas .....$ 1,050,000

1/Includes $500,000 Construction Planning and Design funds.

Details of Cost Estimate: continued

(2) Buildings:		$ 6,000,000
(a) Injector Building, approx. 18,200 sq. ft. @ about $36/sq. ft.	$ 660,000	
(b) Central Control Building, approx. 22,800 sq. ft. @ about $18/sq. ft.	410,000	
(c) Equipment Aisle, approx. 76,700 sq. ft. @ about $13/sq. ft.	1,000,000	
(d) Maintenance Buildings (4) approx. 9,200 sq. ft. total @ about $23/sq. ft.	210,000	
(e) Experimental Building, approx. 78,200 sq. ft. @ about $28/sq. ft.	2,200,000	
(f) Laboratory-Office Building, approx. 43,500 sq. ft. @ about $24/sq. ft.	1,050,000	
(g) Nuclear Chemistry Building, approx. 12,500 sq. ft. @ about $38/sq. ft.	470,000	
(3) Other Structures:		$ 8,370,000
(a) Beam Channel and Access Tunnels, approx. 48,800 sq. ft. @ about $24/sq. ft.	1,170,000	
(b) Accelerator Structures	6,450,000	
(c) Service Corridor, approx. 15,000 sq. ft. @ about $20/sq. ft.	300,000	
(d) Domestic Water Storage Tank; miscellaneous equipment pads and foundations and structures	450,000	
(4) Special Facilities:		$11,500,000
(a) Special Building Equipment, including equipment cooling systems, ventilation and air conditioning systems (for special needs), viewing windows, shielding doors, remote handling and control systems, and hydraulic lifts for injectors	3,700,000	
(b) Injector and Accelerator Equipment, including vacuum systems, beam handling and data systems, and control systems	7,800,000	
(5) Utilities, including electric, water, sewer, steam, and telephone		$ 2,250,000

PHYSICAL RESEARCH PROGRAM - continued

Details of Cost Estimate: continued

c. Standard Equipment:		$10,380,000
(1) Laboratory and Office Furnishings	$ 100,000	
(2) Machine Tools	120,000	
(3) Cranes and Controls (10)	410,000	
(4) Miscellaneous Hoists	80,000	
(5) r.f. Systems (to be designed and engineered by the vendors)	9,670,000	
Subtotal		$43,950,000
d. Contingency at approx. 25% of above costs		11,050,000
Total Project Cost		$55,000,000 1/

1/ Includes $500,000 Construction Planning and Design funds, $4,200,000 for design work authorized in prior years, and $10,400,000 authorized in FY 1968 under the line item project. The FY 1969 appropriation request for this project totals $26,200,000.

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-4-a	Accelerator and reactor additions and modifications, Brookhaven National Laboratory, New York	$ 1,095,000	$ 400,000	$ 695,000	$ 0
68-4-b	Accelerator improvements, zero gradient synchrotron, Argonne National Laboratory, Illinois	1,900,000	1,000,000	900,000	0
68-4-c	Accelerator improvements, Lawrence Radiation Laboratory, Berkeley, California	1,740,000	1,050,000	690,000	0
68-4-d	Accelerator improvements, Cambridge and Princeton accelerators	400,000	270,000	130,000	0
68-4-e	Accelerator improvements, Stanford Linear Accelerator Center, California	865,000	550,000	315,000	0
68-4-f	200 Bev accelerator, Du Page and Kane Counties near Chicago, Illinois	a/	4,633,000	2,700,000	a/
68-4-g	Laboratory and energy storage facility, Los Alamos Scientific Laboratory, New Mexico	8,500,000	215,000	8,285,000	0
68-6	General plant projects	3,400,000	3,150,000	250,000	0
66-5-b	Bubble chamber and experimental area, Argonne National Laboratory, Illinois	17,000,000	13,731,000	3,269,000	0

a/See Section A-1 for details.

PHYSICAL RESEARCH PROGRAM - continued

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
66-5-e	Alternating gradient synchrotron conversion, Brookhaven National Laboratory, New York	$ 47,800,000			
	Less amount for construction planning and design	- 500,000			
	Net	47,300,000	$ 22,600,000	$ 24,700,000	$ 0
66-5-h	Meson physics facility, Los Alamos Scientific Laboratory, New Mexico	b/	7,311,000	7,289,000	b/
66-6-c	Land acquisition, Brookhaven National Laboratory, New York	2,500,000	2,305,000	195,000	0
66-6-d	Electron linear accelerator facility, Massachusetts Institute of Technology, Massachusetts	4,600,000	3,642,000	958,000	0
65-5-a	Argonne advanced research reactor, Argonne National Laboratory, Illinois	25,000,000	6,955,000	18,045,000	0
64-g-4	Tandem Van de Graaff facility, Brookhaven National Laboratory, New York	12,000,000	11,140,000	860,000	0
60-g-3	Transuranium processing plant, Oak Ridge National Laboratory, Tennessee	8,700,000	8,455,000	245,000	0
59-e-15	Research reactor, Ames Laboratory	4,822,000			
	Non-reimbursable excess utilized	-104,000			
	Net	4,718,000	4,685,000	33,000	0
Total				$ 69,559,000	$ 0

b/See Section A-1 for details.

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
A. High Energy Physics	$ 16,630,000
B. Medium Energy Physics	1,350,000
C. Low Energy Physics	3,230,000
D. Mathematics and Computer Research	375,000
E. Chemistry Research	4,375,000
F. Metallurgy and Materials Research	2,160,000
G. Controlled Thermonuclear Research	1,700,000
H. Other Capital Equipment	1,030,000
Total	$ 30,850,000

JUSTIFICATION

Equipment requirements for the Physical Research Program are estimated at $30,850,000 for FY 1969. The estimate is based on requirements as indicated by the needs of the research program planned for FY 1969. Included in the estimates for FY 1969 is approximately $2,650,000 for the acquisition of major computing capability. The major portion of the equipment provided under this heading will support the high energy, medium energy and low energy physics, mathematics and computers, chemistry, metallurgy and materials and controlled thermonuclear programs. Because of rapidly changing technology it is difficult to forecast needs with absolute accuracy. The items of equipment listed in this document are representative of the types of equipment required based on the current status of the experimental process. It is expected that the apparatus finally procured will reflect the then current state of the experimental art, and that flexibility to deviate from the items listed is both desirable and warranted.

A. High Energy Physics .....$ 16,630,000

Experimental programs in high energy physics are characterized by the use of large particle accelerators and large items of equipment necessary for their successful operation.

The improved Bevatron, the Zero Gradient Synchrotron, the Alternating Gradient Synchrotron, the Princeton-Pennsylvania Accelerator, the Cambridge Electron Accelerator and the Stanford Linear Accelerator will be available in FY 1969, and their combined program requires commensurate experimental equipment funds. The need for new equipment relates primarily to needs for increased data collection, analysis and evaluation which stems from the improved operating characteristics of the accelerators as well as the development of additional external beam facilities. These needs reflect extensive scientific advances made in recent years requiring refinement of experimentation to ensure that the scientific results will be of the first order. Many experimental studies are concerned with the investigation of particle events that are very rare and short-lived, but of fundamental importance. Consequently, present-day experiments are more difficult to conceive, design, conduct and analyze than were those carried out in the past. The equipment needs are for groupings and arrays of spark chambers, bubble chambers and their accompanying large magnets and power supplies, automatic and semi-automatic data analysis systems and associated computers.

There follows an explanation of each contractor's needs:

1. Ames Laboratory .....$ 60,000

The major part of this request is to provide for counter equipment to be used in experiments carried out at the Zero Gradient Synchrotron (ZGS).

2. Argonne National Laboratory .....$ 3,250,000

The equipment requested by Argonne National Laboratory is required to maintain a productive research program at the ZGS, to maintain the accelerator and associated major equipment items in operable condition, and to provide data analysis facilities necessary to process the experimental data. Particular emphasis will be placed in FY 1969 on further developing the first external proton beam facility and establishing beams in the new experimental hall where two major bubble chambers will be located. The FY 1969 request anticipates acquisition of the following major types of apparatus:

Particle Separators	$ 350,000
Electronic Equipment for Experiments	150,000
Spark Chamber System and Magnet	200,000
Cryogenic Systems	200,000
Beam Transport Magnets and Power Supplies	600,000
Detection and Target Systems	230,000
Equipment for Major Bubble Chambers	300,000
Shielding - Concrete and Steel	200,000
Semi-automatic Scanning and Measuring Devices	200,000
On-line Data Analysis System	170,000
Automatic Data Reduction Apparatus	150,000
Superconducting Magnet Development	100,000
Advanced Accelerator Development Equipment	130,000
Beam Survey and Test Equipment	120,000
Remote Handling Devices	80,000
General Experimental Support Items	70,000

3. Brookhaven National Laboratory ..... $ 3,150,000

A significant part of the request for FY 1969 involves equipment to be used in development of experimental beams at the AGS. Further development of the slow external beam facilities will give the AGS the capability to make greater utilization of the unique capabilities of this beam, which are necessary for an important class of experiments. Efficient handling of increased output of experimental data requires the provision of additional data analysis facilities. The procurements anticipated in FY 1969 include:

Cryogenic Devices	$ 140,000
Superconducting Magnets	150,000
Electronics	300,000
Bending Magnets	540,000
Experimental Magnet Power Supplies	260,000
Improved Beam Separators	150,000
Advanced Accelerator Development Equipment	200,000
Bubble Chamber Improvement Equipment	300,000
Beam Analysis and Test Equipment	250,000
Bubble Chamber Data Terminal	200,000
Data Measuring and Analysis Facilities	200,000
Additions to Counter Hodoscope Facilities	120,000
Additions to On-Line Data Facilities	340,000

4. Cambridge Electron Accelerator .....$ 1,400,000

Equipment funds provided under this heading are allocated to three contracts with two Universities. A breakdown of the estimate is shown in the following table:

Harvard University (2076)	$ 900,000
Harvard University (2752)	200,000
Massachusetts Institute of Technology (2098)	300,000

Harvard contract 2076 is concerned with the operation of the Cambridge Electron Accelerator, while the MIT and Harvard 2752 contracts support the accelerator user research groups.

The funds requested for Harvard 2076 are related to experimental support, and to the by-pass system and colliding beam experiments. Specific items include:

Spectrometer System Improvements	$ 105,000
Vacuum System	120,000
Cryogenics	115,000
RF Transmitter Modifications	100,000
Electronics	100,000
Magnets and Power Supplies	300,000
General Experimental Support Items	60,000

The funds requested for Harvard 2752 are for spark chamber detection systems, miscellaneous electronics and general support equipment.

The MIT request will provide for improvements to the automatic data analysis system; additions to the PDP-6 on-line to the PEPR System; films and tapes; and other items of equipment such as pulse height analyzers, power supplies, oscilloscopes, and electronics.

5. Princeton-Pennsylvania Accelerator .....$ 950,000

Equipment funds provided under this heading are allocated to the University of Pennsylvania and Princeton University, the latter being the operating contractor for the Princeton-Pennsylvania Accelerator. The funds requested are needed for the following major items:

Princeton University	$ 700,000
Electronics	100,000
On-line Data Handling and Interface Equipment	75,000
Equipment to Support Operation of Accelerator	75,000
Beam Separator and Power Supply	100,000
Experimental Area Equipment	50,000
Research Support Equipment for Princeton Research Group	250,000
General Equipment Support Items	50,000
University of Pennsylvania	$ 250,000

This will provide $150,000 for research equipment such as fast logic modules, scales, cameras, power supplies, optics and scopes which are required for carrying out experiments, and $100,000 for a large volume spark chamber magnet.

6. Lawrence Radiation Laboratory .....$ 1,100,000

Further development of the Bevatron external beam facility is needed in FY 1969. Establishment of new secondary beams requires additional beam transport and supporting equipment. In addition, the experimental groups have a need for improved data processing capability. This type of equipment includes:

Power Supplies	$ 220,000
Data Reduction Equipment	125,000
Interfaces and Data Storage Devices	70,000
Magnets (Bending and Quadrupole, etc.)	415,000
Electronics	80,000
Small Computers for On-Line Applications	90,000
Spectrometer	100,000

7. Oak Ridge National Laboratory .....$ 50,000

The equipment funds requested for the ORNL user group are to permit more effective analysis of bubble chamber events, and also to allow the shielding calculation group to gather certain experimental data required to confirm results of their calculations. Some specific items are:

Improvements to Scanning and Measuring Equipment	$ 25,000
Detection Equipment for Shielding Studies	15,000
General Equipment Support Items	10,000

8. Stanford Linear Electron Accelerator .....$ 5,390,000

The Stanford Accelerator is expected to require additional equipment for use in target areas, and increased data analysis capability. Specialized research equipment such as a Cerenkov counter, spark chamber magnets, and counting and detection equipment will also be required for those groups engaged in the SLAC experimental program. Acquisition of the final components for the major computer system is another large item in the FY 1969 request. Equipment needs include the following:

Large Computer System (Residual Funding)	$2,650,000
Equipment Associated with 8 and 20 Bev Spectrometer Facilities	575,000
Data Measurement and Analysis Systems	450,000
Cerenkov Counters	325,000
Electronics	200,000
Magnets and Power Supplies	550,000
RF Separator	200,000
Equipment Associated with Accelerator Operations	140,000
Shielding	100,000
Modifications to Large Volume Spark Chamber Magnet	200,000

9. Universities Research Association (200 Bev Accelerator) .....$ 700,000

To carry out the research and development in support of the design of the 200 Bev Accelerator, various items of electronic gear and test equipment are required for the National Accelerator Laboratory.

10. Contract Research Program .....$ 580,000

Equipment funds requested here support primarily the research programs conducted by university user groups. Such groups conduct more than one-half of the research at the major accelerator centers. Thus, the productivity of the high energy physics program depends in large measure on the effectiveness of the user programs. The principal need of the user groups is for improved capability for scanning, measuring and analyzing data so that the user groups can effectively advance into the realm of higher energy and higher statistics experiments required for major advances in our knowledge of elementary particle phenomena. The equipment needed for this purpose includes semi-automatic and automatic data analysis systems.

B. Medium Energy Physics $1,350,000

Experimental equipment is required in this program for medium energy accelerators (50-1,000 MeV) and for the research program conducted on these machines. In addition, equipment funds are required for items needed in connection with accelerator design efforts at LASL and ORNL. Procurement of additional equipment is necessary because of the general advancement in technology which has provided increasingly complex, but also increasingly expensive experimental apparatus.

The following is a listing of examples of some major items required in this program.

1. Ames Laboratory .....$ 10,000

The photonuclear research program at Ames requires these funds for general support items.

2. Argonne National Laboratory .....$ 10,000

The research program at ANL requires these funds for general support items.

3. Brookhaven National Laboratory .....$ 10,000

These funds are required to carry out the medium energy physics research program.

4. Columbia University.....$ 10,000

The mu-mesic x-ray program requires these funds for general support items.

5. Lawrence Radiation Laboratory .....$ 120,000

The 184-inch cyclotron program requires various kinds of experimental equipment. Some items planned for FY 1969 are magnets, stands and power supplies ($60,000), spark chamber instrumentation ($20,000), and other smaller items ($20,000).

6. Los Alamos Scientific Laboratory .....$ 500,000

This item provides for procurement of equipment required in connection with the R&D program associated with the Los Alamos Meson Physics Facility and the build-up of experimental equipment looking toward the use of this facility. Proposed acquisitions include inspection apparatus and coil winding apparatuses ($40,000), equipment for finalizing design for control of the 805 MH_z section of the accelerator ($185,000), high speed electronics for development of experimental area equipment and rf instrumentation for final development work on rf systems ($105,000), injector section test stand equipment ($100,000), power supplies for prototype focussing and steering magnets, water pump controls for targeting assemblies ($45,000), and other smaller items ($25,000).

7. Massachusetts Institute of Technology .....$ 450,000

The equipment requirements are based on operation, research, and future development of the new LINAC facility. Needs include a spectrometer for high resolution electron scattering ($400,000), power supplies, test equipment, scopes, analyzers, detectors, etc., ($50,000).

8. Oak Ridge National Laboratory .....$ 120,000

The request is for items needed for the Oak Ridge Isochronous Cyclotron (ORIC). Included in the request is an axial injector ion source with pulsing ($45,000), and magnet power supply ($35,000). The balance is required for the many smaller items used in the program.

9. Contract Research Program .....$ 120,000

Equipment funds requested here are essential for items integral with AEC-owned accelerators such as the isochronous cyclotrons at the University of California-Davis, Texas A&M University, and the University of Maryland.

94-075 O-68-pt. 3—28

C. Low Energy Physics .....$ 3,230,000

Equipment is required in this activity for carrying out the nuclear physics research program principally with accelerators (energy below 50 Mev) and reactors, for the programs on extra nuclear properties of matter, and for the isotope separation programs at Mound and the Oak Ridge National Laboratory.

1. Ames Laboratory .....$ 135,000

Equipment items are needed largely in connection with the research programs at the Ames Research Reactor and include semiconducting detectors ($15,000), bent crystal spectrometer ($25,000), amplifiers and associated electronic equipment for nuclear spectroscopy ($15,000), equipment for resonant scattering studies ($20,000), for delayed neutron studies ($20,000), for neutron capture gamma ray studies ($25,000), and additional items ($15,000).

2. Argonne National Laboratory .....$ 600,000

This request incorporates the equipment needs of several facilities. For the tandem Van de Graaff there will be needed ion sources ($50,000), computer hardware ($40,000), and an analyzing magnet ($25,000). In addition, there are requirements for a precision atomic beam apparatus ($90,000), time-of-flight and neutron detectors ($75,000), ion sources ($75,000), low temperature equipment ($30,000), and a cryogenic cavity for plasma physics studies ($40,000). A pulsed injector is required at the new 4 Mev accelerator ($80,000). Other items are required at the cyclotron, as well as a large number of minor items.

3. Brookhaven National Laboratory .....$ 650,000

Some of the major capital equipment requirements include polarization spectrometer modifications and accessories ($50,000) at the HFBR, slow neutron chopper modifications ($25,000), accessories and modifications ($20,000) to the capture gamma ray spectrometer, and the fabrication of an advanced programming and data handling system ($50,000). Acquisition of a neutron spectrometer ($100,000) at the HFBR for "second generation" experiments is planned. Expanding experimental programs at the 60-inch cyclotron will require additional computer components ($115,000), as well as increased memory capacity ($40,000). The effective utilization of the tandem Van de Graaff accelerator will require capital outlays for scattering chambers ($50,000), and various electronic equipment ($15,000).

4. Columbia University .....$ 125,000

Equipment requirements are for the Nevis velocity selector, the Van de Graaff accelerator, fission physics research, nuclear reactions, and nuclear spectroscopy.

5. Lawrence Radiation Laboratory .....$ 50,000

The principal items in this request include electric dipole equipment for atomic and molecular beam experiments ($20,000), computer and interface system ($25,000) and miscellaneous items ($5,000).

6. Massachusetts Institute of Technology .....$ 100,000

The major items of equipment include: split pole spectrograph additions ($10,000), cyclotron scattering chamber equipment ($35,000), and memory device ($25,000). Numerous items such as power supplies, scalers, and detectors are also required.

7. Mound Laboratory .....$ 35,000

The major items of equipment required are He-3 dilution refrigerator ($15,000), He-3 recovery system ($15,000), and miscellaneous items ($5,000).

8. Oak Ridge National Laboratory .....$ 550,000

Some of the major equipment needs include polarized proton target cryostat for providing polarized neutrons ($150,000), analyzing and transport magnets for high resolution electron beam ($75,000), Ge-Li detector array ($80,000), ion source testing facility ($50,000), data processing equipment ($50,000), digital spark chamber ($25,000), shielded glove boxes ($55,000), and off gas scrubber for calutron tanks ($15,000).

9. Yale University .....$ 230,000

Equipment needs are related to the tandem Van de Graaff and Electron Linac programs. The Linac has need of an injector ($35,000), and items for the Van de Graaff are automatic plate reader ($50,000), target room number 3 equipment ($100,000), and various miscellaneous items.

10. Contract Research .....$ 755,000

Equipment funds are needed for major items throughout the contract research program. Included are such items as polarized ion sources, multiparameter data acquisition systems, large magnetic spectrometers, beam handling equipment, on-line computers, and additions and modifications to AEC-owned particle accelerators.

D. Mathematics and Computer Research .....$ 375,000

This program requires auxiliary and peripheral equipment required to provide access to central computer facilities from remote sites, from experiments the data from which is to be dealt with on line, and from a variety of devices for reading and measuring experimental data. This includes small computers for data acquisition, buffering equipment, auxiliary memory devices, and switching equipment. The contract research program also at times requires the purchase of equipment which is not feasible to fabricate in the laboratory.

There follows a list of examples of major items required in this program:

1. Ames Laboratory .....$ 30,000

This includes funds to purchase a small analog computing system plus a digital control interface and a remote terminal.

2. Argonne National Laboratory .....$ 100,000

Proposed procurements include interfacing equipment, input-output equipment and small computers required for providing remote terminals and stations having access to the laboratory's central computing facility.

3. Brookhaven National Laboratory .....$ 40,000

Acquisitions tentatively planned are related to the development of printer-keyboard stations and graphics and includes such items as high frequency oscilloscopes, microcircuit testers and microcircuit visual inspection equipment.

4. Lawrence Radiation Laboratory .....$ 30,000

Items required include electronics and interface equipment and a CALCOMP plotter.

5. New York University .....$ 60,000

Equipment requirements include a magnetic tape input for a DDP 116-516 computer and remote computing terminal equipment for the time sharing system.

6. Contract Research Program .....$ 115,000

This amount represents the estimated requirements for equipment to support multiple access to central computers and for the interconnection between computers, and for experiments in data acquisition and on-line data processing (primarily at the University of Illinois and the University of Chicago).

E. Chemistry Research .....$ 4,375,000

The equipment utilized for chemistry research involves a variety of complex instrumentation reflecting both the diversity and complexity of the research undertaken. Development of new apparatus permits the chemist to gain increased understanding through extension of present research techniques and provides the means by which problems heretofore incapable of examination may now be studied. Not only are the kinds, sensitivities and resolving powers of stimuli and sensing devices being improved, the severity of conditions which can be explored through the experimental process are also being widened. There are several developments from which experimental programs are expected to benefit. These include: (1) more effective assimilation and analysis of nuclear, radiation and structural data resulting from the use of computers for on-line data acquisition, storage, analysis and control of the experiment (with nearly instantaneous feedback); (2) development and fabrication of special equipment necessary for working safely with transplutonium elements; (3) assimilation of the complex arrays of equipment required for productive use of accelerators, reactors, and isotope separators. Continuing improvements in areas such as shortening resolution time in electronic instruments through improved circuitry, and increasing sensitivity of instruments for radiation detection also contribute collectively in a very important way to the solution of chemistry research problems. There is, in addition, a continuing requirement for the standard and well-proved items as replacements or to provide additional capacity necessary for new or expanded research programs.

The following is a listing of examples of equipment items required in this program:

1. Ames Laboratory ..... $ 320,000

While much of the emphasis of Ames will be on exploiting the capabilities of the research reactor, other requirements include equipment acquisitions for rare earth spectroscopy and high temperature research. Major items required include:

Automated Polarized Neutron Diffractometer	$ 65,000
Neutron and Reactor Physics Equipment	40,000
Large Bore Superconducting Solenoid	16,000
Beta Ray Spectrometer	10,000
Grating Spectrograph	10,000
Argon Ion Laser	25,000
Solid State Spectrometer	10,000
Scintillation Detector System	10,000

2. Argonne National Laboratory ..... $ 980,000

Major items at Argonne are largely concentrated in meeting the needs of nuclear chemistry (especially at the ZGS), radiation and hot atom chemistry, and high temperature work. Major items include:

Two Parameter Analyzer	$ 22,000
Mass Spectrometer	20,000
Large Scattering Chamber	30,000
High Pressure Equipment	50,000
Laser and Iraser	30,000
Spectrodiffractometer	80,000
Multipurpose Diffractometer	40,000
Microwave Absorption Equipment	52,000
Electron Spin Resonance Equipment	50,000
Phase Detection System	25,000
High Resolution Cryogenic Nuclear Magnetic Resonance Apparatus	175,000
Rotating Bomb Calorimeter	30,000
Mass Spectrometer Sources	25,000

3. Pacific Northwest Laboratory .....$ 160,000

An increased sample load, and requirement for closer accuracy are responsible for most of these equipment needs. Major items proposed for acquisition include:

Multiparameter Analyzer with Digital Processing	$ 60,000
Scanning Electron Microscope	50,000

4. Brookhaven National Laboratory .....$ 495,000

Principal requirements at Brookhaven involve provision of additional capability for data handling, reduction and analysis in the fields of nuclear, radiation, hot atom and structural chemistry, especially for those programs utilizing the AGS and the HFBR. Major items include:

Remote Computer Station	$ 50,000
Counter-computer Interface Linkage	25,000
Automatic Data Reduction for AGS Scattering Chamber	60,000
Multiparameter Analyzer	40,000
HFBR Neutron Spectrometers	50,000
Plotter for Remote Computer Station	50,000
Infrared Interferometer	30,000
Electron Spin Resonance Apparatus	65,000

5. Knolls Atomic Power Laboratory .....$ 70,000

Further strengthening of mass spectrometric analytical capabilities will be provided with these funds.

6. Lawrence Radiation Laboratory .....$ 1,000,000

Data handling and auxiliary experimental equipment are required to exploit the strengthened beam capabilities of the 88" cyclotron and the HILAC. On-line data handling apparatus and large multi-channel analyzers are needed for use with new high-resolution solid state detectors, while equipment requirements for the inorganic materials program are related largely to the structural, chemical kinetics, high temperature and cryoscopic areas. Major items requested include:

Multichannel Analyzers	$ 30,000
Automated Data Handling Equipment	174,000
Computer Interfacing	35,000
Scattering Chambers	140,000
Shielding and Remote Handling Equipment	37,000
Alpha Spectrograph and Analyzer	100,000
X-ray Diffractometer	90,000
Electrochemical Machining Equipment	60,000
Electron Spin Resonance Spectrometer	35,000
Polarized Target Equipment	30,000
Fragment Identifier and Interfacing	25,000
Superconducting Magnet	20,000

7. Mound Laboratory ..... $ 40,000

Isolation and purification of radioactive decay products requires items such as counting and hot cell equipment.

8. University of Notre Dame ..... $ 115,000

Physical measurement instrumentations of a wide variety are needed to support advances in radiation effects chemistry. Equipment acquisitions are geared to exploit a number of improved capabilities of such instrumentation. Planned major items include:

Molecular Motion and Relaxation Apparatus	$ 30,000
Microwave Excitation Lamps	16,000
Pulse Radiolysis Equipment	38,000

9. Oak Ridge National Laboratory .....$ 1,010,000

Much of the equipment required at ORNL is to aid the HFIR and TRU efforts, and the growing research on transplutonium elements. Modern data handling equipment is also to be incorporated into the research operations. Major items include:

100 mc High Resolution Nuclear Magnetic Resonance	$ 90,000
TRU Glove Boxes and Protected Equipment Racks	105,000
TRL Glove Boxes	80,000
Advanced Data Acquisition for Multiparameter Analyzer	85,000
Electron Paramagnetic Resonance Spectrometer	40,000
Electron Microscope for Small Very Radioactive Samples	75,000
Computer-coupled Pulse Height Analyzer	100,000
X-ray Diffraction Unit	47,000
Critical Facility Core Components and Instrumentation	250,000

10. Princeton University .....$ 17,000

This request provides for counting equipment for nuclear chemistry using the PPA, the Princeton cyclotron and the isotope separator.

11. Yale University .....$ 23,000

Equipment which is basic to continued use of the Heavy Ion Accelerator must be replaced due to obsolescence.

12. Contract Research Program .....$ 145,000

The off-site contract research program takes advantage of special knowledge of experts at universities who must be provided advanced equipment if their skills are to be productively utilized. Particle and radiation detectors, and auxiliary equipment for particle accelerators are prominent in this requirement.

F. Metallurgy and Materials Research .....$ 2,160,000

Capital equipment required in support of the Metallurgy and Materials Research Programs reflects the need to extend physical measurements to areas not previously attainable and to perform research on important new subjects. In addition, it is necessary to design, fabricate or purchase apparatus for use at such facilities as the Ames Research Reactor (ARR), BNL High Flux Beam Reactor (HFBR), and ORNL High Flux Isotope Reactor (HFIR). The equipment request includes many small items peculiar to the solid state sciences. Although a fraction of the request is identifiable as replacement for worn or obsolete equipment, most of it represents needs in connection with scientific areas recently opened up as the result of new instrumentation, discoveries and facilities. The equipment request represents a minimum amount to maintain a vigorous research activity in this program where the diversity of activity requires a maximum in efficiency and data handling capacity. There follows a listing of examples of some major items required:

1. Ames Laboratory .....$ 245,000

Microcalorimeter ($15,000), tensile testing equipment ($12,000), X-ray diffraction and detection equipment ($20,000), high pressure X-ray camera ($8,000), equipment for the pure materials program ($25,000), superconducting solenoids ($64,000), HE-3 refrigerator ($6,000), digitized heat capacity measuring apparatus ($15,000), and an optical absorption signal averager ($10,000).

2. Argonne National Laboratory .....$ 505,000

Mechanical properties measuring equipment ($20,000), neutron diffractometer ($100,000), Mössbauer equipment ($30,000), optical properties apparatus ($30,000), high pressure nuclear magnetic resonance ($20,000), absolute susceptibility measuring apparatus ($20,000), single crystal orienter ($15,000), electron beam furnace ($20,000), electron-nuclear double resonance apparatus ($25,000), helium cryostat ($30,000), and superconducting magnet ($45,000).

3. Brookhaven National Laboratory .....$ 245,000

Conversion equipment for accelerator irradiations ($50,000), nuclear magnetic resonance instrument ($25,000), high temperature melting equipment ($30,000), and neutron spectrometer equipment ($50,000).

4. Idaho Nuclear Corporation .....$ 27,000

On-line data processing equipment ($20,000).

5. University of Illinois .....$ 150,000

Residual gas analyzer ($3,000), pulse analyzer system ($5,000), nanovolt null detectors ($5,000), helium cryostat temperature controller ($4,000), power supply and controls for electron beams ($5,000), electron microscope heating and tilting stage ($4,000), ultrasonic drill and grinder ($8,000), mechanical properties measuring apparatus ($10,000), electron spin resonance equipment ($12,000), apparatus for point defect studies ($15,000), X-ray source and counting equipment ($17,500), and high pressure apparatus ($10,000).

6. Lawrence Radiation Laboratory .....$ 170,000

High vacuum and high temperature furnaces ($13,000), X-ray spectrograph ($40,000), Instron tensile testing machine ($25,000), digital recording apparatus ($13,000), and constant strain rate apparatus ($8,000).

7. Oak Ridge National Laboratory .....$ 455,000

Hot cell electrical resistivity apparatus ($15,000), digitized data processing equipment ($15,000), high temperature vacuum furnace ($18,000), automatic X-ray diffractometer ($65,000), Mossbauer spectrometer ($18,000), Van de Graaff instrumentation ($15,000), accessories for 2 Mev ion accelerator ($40,000), crystal growing equipment for semiconducting materials ($15,000), superconducting system and He-3 refrigerator ($45,000), X-ray power supply ($15,000), cryostat and superconducting solenoid ($48,000), optical spectrophotometer ($20,000), electron diffraction apparatus ($25,000), and ultrasonic instrumentation ($15,000).

8. Pacific Northwest Laboratory .....$ 42,000

Vacuum annealing furnace ($15,000), and dynamic stress programmer ($10,000).

9. Puerto Rico Nuclear Center .....$ 24,000

X-ray electronic circuit panel ($10,000).

10. Contract Research Program .....$ 297,000

This item includes $30,000 in support of ceramics research, and miscellaneous equipment items.

G. Controlled Thermonuclear Research .....$ 1,700,000

Equipment is urgently needed in the Controlled Thermonuclear Research Program for the new plasma physics confinement devices now being fabricated. Requirements for the continual modification of existing devices will be deferred to the maximum extent possible.

1. Lawrence Radiation Laboratory .....$ 620,000

Proposed acquisitions include digital data acquisition system ($156,000), large power supplies ($106,000), miscellaneous power supplies ($83,000), vacuum pumps ($40,000), and diagnostic equipment ($50,000). Much of this equipment is related to the Baseball II.

2. Los Alamos Scientific Laboratory .....$ 270,000

Equipment needs include readout equipment for automatic data processing in the Scyllac plus typical items such as power supplies, lasers, vacuum equipment, and oscilloscopes.

3. Oak Ridge National Laboratory .....$ 310,000

Proposed acquisitions include automatic data processing equipment ($130,000), power supplies ($50,000), and vacuum and diagnostic equipment ($40,000).

4. Princeton Plasma Physics Laboratory .....$ 350,000

Equipment needs include diagnostic, cryogenic equipment, vacuum system, and electronic heating items primarily for the Superconducting Multipole.

5. Contract Research Program .....$ 150,000

A variety of specialized equipment is required for the university research program. Principal items include diagnostics equipment, oscilloscopes, vacuum apparatus, etc.

H. Other Capital Equipment .....$ 1,030,000

Equipment requested in this category includes scientific equipment used by the service divisions of the national laboratories as well as the general or multi-purpose type of equipment which cannot be identified with any specific research category or activity. In order to effectively support a research program of the magnitude estimated for FY 1969, there exists a continuing requirement for replacement of obsolete equipment as well as procurement of new and additional equipment.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
A. High Energy Physics	$ 6,084,000
B. Medium Energy Physics	455,000
C. Low Energy Physics	1,728,000
D. Mathematics and Computer Research	113,000
E. Chemistry Research	1,332,000
F. Metallurgy and Materials Research	656,000
G. Controlled Thermonuclear Research	430,000
H. Other Capital Equipment	373,000
Total	$11,171,000

HIGH-ENERGY PHYSICS PROGRAM

Mr. MORRIS. It has been noted that under the stretchout program for the current fiscal year a reduction of $4,600,000 was made by the Commission in this item.

Why cannot a similar deferral be made in the 1969 estimate?

Dr. MCDANIEL. The reduction to which you refer is related to the high-energy physics program, I believe.

Mr. MORRIS. That is right.

Dr. MCDANIEL. That was a very shocking reduction to the scientific people and to those administering the program. This has already caused the people to close the operation of many of their facilities and is causing people to cut all of the corners that are possible.

For example, we are putting in cold storage a bubble chamber at the Argonne National Laboratory which our scientific people would like to use. Therefore we will simply have to do without the results of that research.

A further reduction in fiscal year 1969 would result in digging so deeply into the program it would be almost a disaster.

Mr. ABBADESSA. There is another point, too, Mr. Chairman. The increase in the program was larger last year when we took the cut. For instance, in 1967 this program was about $108 million, and in 1968 the program was about $118 million. We reduced this increase from about $10 million down to about $7 million.

This year the program is at the $113 million level and the Joint Committee has reduced the 1969 program request to about $119 million, so there is about a $6 million increase. This is below where we ended up last year after taking the cut, so the program itself is not in as good a position to take that kind of a cut as it was at this time last year.

Mr. MORRIS. Dollarwise.

Mr. ABBADESSA. Dollarwise; that is correct.

DESIGN AND DEVELOPMENT OF ACCELERATORS

Mr. MORRIS. The breakdown of the estimates for the major accelerators includes a total of about $11.7 million to continue design and development of devices.

Just what does this involve and why is it essential to maintain this level of expenditure in fiscal year 1969?

Dr. MCDANIEL. This total amount is about the total in the budget for high-energy physics, medium-energy physics, and other programs. Perhaps I should preface my answer by saying that in this program scientists use facilities which have the shorthand term "accelerators," and these are the tools of the scientists. Therefore the development of these tools is to be expected in their programs.

Taking high-energy physics; for example, the 200-Bev accelerator research and development is included at a cost of about $4 million. That certainly is a necessary thing if we are to proceed with the 200 Bev.

The national policy on high-energy physics said we should build a 200-Bev machine now, and plan later on, say 15 years from now, to have a larger and better accelerator.

We have three groups that are looking into the future—at the Lawrence Radiation Laboratory in Berkeley we have $350,000 in the budget; Brookhaven has about $300,000 in the budget; Argonne has about $300,000 in the budget. These funds are for long-range studies aimed at developing newer and more economical and efficient methods of acceleration.

In Berkeley the electron plasma accelerator experiments which we discussed with the Joint Committee and which have excited the imagination of the scientific people would be carried out under this program.

Also at Brookhaven we have a conversion project for the alternating gradient synchrotron authorized by the Congress and it is now under construction at a total cost of about $48 million.

In connection with this project there are research and development activities totaling about $900,000.

In the medium-energy physics category, the Los Alamos meson facility must also have such supporting activity carried out. We have $3.8 million earmarked for this most necessary purpose.

In addition at each of the accelerators in operation at Brookhaven, Argonne, the Lawrence Radiation Laboratory, SLAC, the CEA, and Princeton-Penn, there are some activities necessary for the improvement of those accelerators which must go on.

In the low-energy physics field I think you will find there is almost no expenditure for the development of accelerators.

In the chemistry budget there is some $600,000 earmarked for research and development on the omnitron accelerator for the chemists who are looking into this.

In addition there is a research activity devoted to HIPAC activities on a small scale.

I do not know that all these items add up to precisely the $11 million but it is on that order of magnitude. These are studies essential to the activities of the laboratory.

OTHER AGENCIES DOING RESEARCH WITH ACCELERATORS

Mr. MORRIS. What other agencies can you think of offhand that are contributing to either the AEC in the operation of their accelerators or have accelerators of their own?

Dr. MCDANIEL. The Department of Defense certainly has some interest in these activities. The National Science Foundation has some activities, in particular they are supporting a 10 Bev electron machine at Cornell University. Some activities of this nature are also going on under the auspices of the National Aeronautics and Space Administration. However, the Department of Defense and the National Science Foundation are the two largest. NASA has some work at their Langley Field, Va., synchrocyclotron laboratory but they are small compared to what we are talking about here.

Mr. MORRIS. Do you know how much money is being spent in agencies other than AEC in this field?

Dr. MCDANIEL. We can provide that for the record. We have made a survey in recent weeks.

(Information requested follows:)

HIGH-ENERGY PHYSICS PROGRAM, FUNDING SUMMARY, ALL AGENCIES

[Costs in thousands of dollars]

	Fiscal year		
	1967	1968	1969
Operating expenses:			
Atomic Energy Commission	$107,692	$113,400	$119,358
National Science Foundation	6,528	6,640	9,429
Department of Defense	6,115	1,204	1,450
National Aeronautics and Space Administration	1,400	1,840	1,680
Total operating expenses	121,735	123,084	131,917
Capital equipment (obligations):			
Atomic Energy Commission	21,392	15,666	16,630
National Science Foundation	808	891	1,050
Department of Defense	58	129	80
National Aeronautics and Space Administration	0	0	0
Total capital equipment	22,258	16,686	17,760
Construction [1] (obligations): Atomic Energy Commission	31,108	21,447	61,399
Total construction	31,108	21,447	61,399

[1] No construction activity reported by the other agencies.

Dr. TAPE. There have been some shifts in recent years where the Defense Department has felt it could not continue increasing support in some of these areas, and as a result of the deliberations within the executive branch some of the extremely worthwhile work which DOD has been supporting is now being assumed by other agencies.

I think you will find coordination within the executive branch in this area is really very good.

UNIVERSITY RESEARCH

Mr. MORRIS. As outlined on page RES–9, a total of $17,045,000, an increase of $835,000, is requested for university research under general research and development.

Why is this increase essential in fiscal year 1969?

Dr. MCDANIEL. This is the total for the high-energy physics work in universities proper. We have in the Atomic Energy Commission special facilities at Argonne, Brookhaven, Stanford, Princeton-Penn, Cambridge, and Berkeley, highly useful facilities designed with the purpose in mind of being utilized by scientists both at the national laboratories and in the universities. University scientists can continue their normal traditional activities in the universities and also come to these national facilities to carry out experiments.

These funds are the funds that we would provide to the universities for the preparation for carrying out experiments at the national laboratories, and subsequently for analysis of the data that comes out of the experiments. The amount which we carry in the 1968 column equivalent to that is $16,210,000, and in the relook at the fiscal year 1969 total we will allocate $16,913,000 in that area which is a little more than $700,000 increase out of the $16 million, or about 3 or 4 percent.

This comes at a time when some of our best machines are reaching the stage where they have the most utility. The Stanford linear accelerator now is operating very nicely, for example. If the scientific people are to use that machine as it was originally designed then these increases are required.

This is an area, as Dr. Tape pointed out, where reassessment within the Department of Defense has resulted in some reductions in support.

The National Science Foundation will certainly do all it can to pick up some of the high-quality research contracts which the Department of Defense will not support.

We will have to pick up one or two where they are in close association with our laboratories.

Dr. TAPE. This has not been an automatic transfer. This has been each agency looking at the program and making its own appraisal.

Mr. MORRIS. We want to clarify the record here. You do not have any kind of a side agreement with the Department of Defense, do you?

Dr. MCDANIEL. No.

Mr. MORRIS. Every time they are tired of funding something they do not pass it over to AEC for financing?

Dr. MCDANIEL. No.

Dr. TAPE. If you ask DOD they would say we have been pretty difficult.

Dr. MCDANIEL. We discussed this in the Joint Committee and there is detailed discussion of the one contract which we would pick up. I believe the readers of this report could refer to that for details.

Mr. MORRIS. I know this matter was discussed in the Joint Committee. It was brought out that AEC was the main agency so far as high-energy physics was concerned. In reality it has applications in other areas, as well as in the atomic energy field.

Dr. TAPE. The President has designated the AEC as the executive agent.

That does not mean that we sponsor or that we fund all work in the area, but that we should be cognizant of all of the needs and, as Dr. McDaniel has indicated, that we survey the situation periodically so we know what the total Government requirements are.

MANDATORY INCREASES

Mr. MORRIS. Of the budgeted increase of $7 million under high-energy physics program, how much would you classify as being mandatory?

Dr. MCDANIEL. I believe all of it would be.

Mr. MORRIS. Would you furnish for the record a breakdown of it?

Dr. MCDANIEL. Yes, sir.

(Information requested follows:)

The increase requested is considered essential to avoid serious long-range damage to this program. After taking into account the $4.1 million increase required for the high priority needs at the Stanford Linear Accelerator Center (SLAC) and the 200 Bev accelerator, the requested budget permits only a 2-percent increase for the remainder of the program. The requested funding level is very restrictive and will require sizable cutbacks in certain parts of the program, since there are many forced increases in cost which cannot be met within the requested ceiling, for example, a 3- to 4-percent increase in costs due to inflation and an additional 3- to 4-percent increase in the costs of doing research

because of the increasing complexity and sophistication of experimentation required to make the most significant advances on the forefront of the field.

Furthermore, the very tight budgets of the past 2 years have forced serious reductions in materials and supplies in favor of retaining highly trained personnel. (It should be noted that after providing SLAC with a minimal increase for its first full year of operation in fiscal year 1968, the remainder of the program was left with no increase, and indeed a slight decrease, from fiscal year 1967.) Any further reductions from the fiscal year 1969 request would result in additional release of personnel and in serious reductions in research productivity. The requested fiscal year 1969 budget already contemplates reductions in highly skilled personnel and the forced discontinuance or reduction in operation of several facilities, for example, the Argonne National Laboratory will not operate the 500-liter bubble chamber, the Princeton Pennsylvania accelerator group will shut down its rapid cycling bubble chamber, the Brookhaven National Laboratory will operate only two of its three bubble chambers, and the California Institute of Technology is reducing operation of its synchrotron in anticipation of a complete shutdown early in fiscal year 1970.

The authorization legislation for fiscal year 1969 has already reduced the requested increase from $7 million to $6 million. The remaining $6 million of the increase is required for the following:

SLAC +$2.75 million

Fiscal year 1968 was the first full year of operation for SLAC and the facility is still building up toward a stable operating level. The increase requested will permit the accelerator to continue operating in fiscal year 1969 at the level achieved during the last quarter of fiscal year 1968, i.e. a projected yearly average of 13 shifts per week for high-energy research and accelerator studies. This also includes operation of the bubble chambers which operated only during the latter part of fiscal year 1968.

200 Bev +$1.35 million

This increase is required to maintain the momentum of the highly qualified 200 Bev accelerator design group already assembled at the National Accelerator Laboratory and to permit a small increase in staff so that vital design programs can be carried out on an appropriate time schedule.

General R. & D. +$0.66 million

This increase is required to permit support of one of the most outstanding university research groups in the United States which is losing its support as a result of the recent DOD policy decision to discontinue support of high-energy physics and to enable the level of productivity of several of the higher priority groups presently supported by the AEC to be maintained.

AADD +$0.25 million

This increase will permit the Lawrence Radiation Laboratory to continue studies on the new concept of coherent linear acceleration of particles.

Other programs (totaling $70.4 million) + $0.95 million

This increase (1.4 percent) provides only a small portion of the funds which would be required to maintain the level of activity of these programs. It will be necessary to terminate or reduce operation of certain facilities and to release some highly skilled personnel.

LOW ENERGY PHYSICS PROGRAM

Mr. MORRIS. As outlined on page RES–15 and 16, a total of $24,860,000 is requested for nuclear physics under the low-energy physics program, an increase of $1,178,000.

Specifically, why could not this program be held to the 1968 level, which included an increase of over $1 million?

Dr. MCDANIEL. An increase of $1,178,000 would provide for only a token increase in most of the research contracts.

To answer your question one can hold these programs to lower levels. The real point which needs to be answered is whether we should hold them to the lower level.

In my own opinion these programs ought not to be held to the lower levels. It would result in the loss of very valuable nuclear and neutron physics research, results which are beneficial in the intermediate and near term to other programs of the Commission as well as furthering our understanding of nuclear structure.

The answer to your specific question is that they could be held but I would urge they not be held to the lower level because of loss of the attendant research.

With the increase, as pointed out earlier, the scientific people working in fiscal year 1968 will just about be able to carry out the same level of activity in fiscal year 1969, so there is not an increase in the technical work as these dollars would indicate.

CONTROLLED THERMONUCLEAR RESEARCH PROGRAM

Mr. MORRIS. Beginning on page RES–29, $27,400,000 is budgeted for controlled thermonuclear research, an increase of $2.5 million.

The authorization bill has reduced this by $400,000.

Why is the remaining increase of $2.1 million essential in fiscal year 1969 considering the recent increases in the level of this program?

Dr. MCDANIEL. The objective of this program as you well know is to provide the world with a new source of energy and one which would be plentiful, cheap, and free from environmental problems of pollution which stem from other existing means of generating electric power.

If we were to hold this program at its 1968 level we would have to do one of two things. We would either have to curtail the fabrication of the new confinement devices or we would have to reduce the manpower.

If we did either this would seriously jeopardize the progress which we think we are making toward achieving our goal.

Mr. MORRIS. Is this a long-range program, relatively speaking?

Dr. MCDANIEL. Yes, that is correct. It is long term. People who are in the program and who have expressed opinions talk in terms of the next decade when they believe they will have achieved enough information to come before this committee and other committees and say "We have been successful."

Mr. MORRIS. In reality our whole society is based on technology and this is a technology development for the future. Is that correct?

Dr. MCDANIEL. As I said earlier, this is to develop a completely new source of energy—fossil fuels, fission fuels, and fusion fuels are the only three we know about that could possibly be used.

Dr. TAPE. One should emphasize the statement both you and Dr. McDaniel are making. It is a technology development. Dr. McDaniel said it is also pointed at energy.

Energy developments are keys to our whole domestic and world society; there is no question about it. Some of the curves you saw yesterday indicated that energy requirements are skyrocketing.

Dr. MCDANIEL. Certainly it is a technological development. To develop the technology it is necessary to do some of the most critical and fundamental research activities that underlie the technology.

Mr. MORRIS. In total, $265 million is available for the current year for operating expenses of the physical research program.

About what percentage of this will result in the completion of projects or activities during the current fiscal year?

Dr. MCDANIEL. As a general rule each of the scientists that are represented by that $265 million complete a project—and I am talking only of the senior people in the project. They complete and publish or otherwise circulate the results of their experiments so that every year I think you can be assured that most of the scientific people represented in this program will have completed a project. That is just the scientific experiment I am talking about. There is turnover within the program every year such that each man is turning out something new.

As far as contract turnover in our Washington-administered program is concerned, we have a contract termination rate—that is, we actually say to the contractor "Your work is finished. Thank you very much."—of 30 or 40 contracts each year. In summary we are terminating a large number, and within each contract there are projects terminating.

In the National Laboratories, where a contract is a continuing sort of thing, projects are terminated and final reports are written, again on the average of about one per senior scientific man per year.

Mr. MORRIS. Will you provide the committee with a breakdown on the contract terminations?

Dr. MCDANIEL. We have statistics on that and I will be happy to provide that for the record.

(The information follows:)

April 25, 1968
pp. 2914

DIVISION OF RESEARCH

TERMINATED CONTRACTS - FY 1967

WASHINGTON ADMINISTERED PROGRAM

SUMMARY

	No. of Contracts	Amount
Chemistry	27	$ 481,270
Metallurgy and Materials	14	450,864
Controlled Thermonuclear	5	153,512
Total	46	$ 1,085,646

TERMINATED CONTRACTS - FY 1967

CHEMISTRY

	Termination Date	Amount
Arkansas, University of AT(40-1)-2069 Amis, Edward S. Oxidation-Reduction Reactions of Neptunium, Uranium, and Other Ions, and Other Phenomena in Pure and Mixed Solvents	4/14/67	$ 25,000
Boston University AT(30-1)-2383 Lichtin, Norman N. Radiation Chemistry of Organic Compounds	3/31/67	11,000
Brooklyn, Polytechnic Institute of AT(30-1)-1715 Morawetz, Herbert Solid State Polymerization Initiated by Gamma Radiation	9/15/66	9,000
California, University of Los Angeles, California AT(11-1)-34, #13 Scott, Robert L. Fluorocarbon Solutions	7/31/66	19,000
Columbia University AT(30-1)-1669 Gast, P. W. Isotopic Geochemistry	2/28/67	21,035
Columbia University AT(30-1)-2498 Bersohn, Richard Theoretical Chemistry	8/31/66	24,000
Fisk University AT(40-1)-2760 Lawson, James R. and Fuson, Nelson Infrared Spectroscopic Studies of Polyatomic Inorganic Ions in Solid Solutions	12/31/66	12,250
Illinois Institute of Technology AT(11-1)-1025 Kresge, A. J. Aromatic Hydrogen Exchange	1/14/67	25,000

TERMINATED CONTRACTS - FY 1967

CHEMISTRY

	Termination Date	Amount
Indiana University AT(11-1)-120 Merritt, Lynne L., Jr. Studies of Chelate Complexes and Instrumentation in Analytical Chemistry	8/31/66	$ 21,000
Indiana University AT(11-1)-504 Gucker, Frank T. Thermodynamic Properties of Solutions	1/31/67	7,000
Indiana University AT(11-1)-977 Bonham, Russell A. Determination of the Structures of Molecules at High Temperatures by Electron Diffraction	8/31/66	12,000
Johns Hopkins University AT(30-1)-2918 Gryder, J. W. Interaction Between and Identification of Ionic Species in Solution	11/30/66	15,500
Kansas, University of AT(11-1)-1099 Griswold, Ernest and Kleinberg, Jacob Some Problems in the Chemistry of Transition Metals	1/31/67	14,442
Maine, University of AT(30-1)-2873 Braunstein, Jerry Electrolytic Solutions	8/31/66	19,449
Maryland, University of AT(40-1)-2040 Lippincott, Ellis R. Structural Studies and Advanced Instrumentation in Raman Spectroscopy	2/28/67	9,500
Maryland, University of AT(40-1)-2983 Atkinson, Gordon Ion Association in Polyvalent Symmetrical Electrolytes	5/14/67	22,000

TERMINATED CONTRACTS - FY 1967

CHEMISTRY

	Termination Date	Amount
Minnesota, University of AT(11-1)-622 Reynolds, Warren L. Mechanisms of Inorganic Oxidation-Reduction Reactions in Non-aqueous Media	6/14/67	$ 15,418
New York University AT(30-1)-1938 Sundheim, Benson R. Studies in Fused Salts	12/14/66	28,000
Ohio State University AT(11-1)-1504 Dorfman, Leon M. Pulse Radiolysis of Organic and Aquo-Organic Systems	5/31/67	36,000
Pennsylvania, University of AT(30-1)-2821 Evers, E. Charles A Study of Ion Association: The Conductance and Viscosity of Electrolyte Solutions from Fused Electrolyte to Infinite Dilution	8/31/66	15,676
Purdue University AT(11-1)-164 Edgell, Walter F. Studies in Molecular Spectroscopy	12/31/66	30,000
San Diego State College AT(04-3)-411 Jensen, R. C. Photofission of Radium, Bismuth, and Lead	7/31/66	25,000
Southern Research Institute AT(40-1)-2073 Ellis, Richard B. Surface Tension and Viscosity and Raman Spectra of Fused Salts	11/14/66	25,000
Tennessee, University of AT(40-1)-1983 Eastham, Jerome F. and Keenan, Charles W. Isotope Studies of Hydrogen Transfer Reaction Kinetics and Mechanisms	9/30/66	4,000

TERMINATED CONTRACTS - FY 1967

CHEMISTRY

	Termination Date	Amount
Vanderbilt University AT(40-1)-1087 Jones, Ernest A. The Vibrational Spectra, Force Constants, and Thermodynamic Properties of Fluorine Compounds	11/30/66	$ 13,000
Washington University AT(11-1)-581 Potratz, Herbert A. Geologic Dating of Corals and Other Calcareous Materials	9/30/66	10,000
Western Reserve University AT(11-1)-1273 Gillis, Hugh A. The Radiation Chemistry of Liquid Hydrocarbons of Low Molecular Weight	3/31/67	12,000

METALLURGY AND MATERIALS

Battelle Memorial Institute W-7405-ENG-92 (Task #21) Rudman, Peter S. The Charge on Interstitial Ions in Groups IV-A and V-A Transition Metals	6/30/67	13,000
Catholic University of America AT(40-1)-2861 Meijer, Paul H. E. Ultrasonic Studies of Alkali Metals	8/31/66	19,933
Columbia University AT(30-1)-3551 Galligan, James M. and Li, James C. M. Studies of Radiation Damage and Hardening	4/30/67	26,339
Franklin Institute AT(30-1)-2730 Pomerantz, Martin A. Solid State Investigations Utilizing Electron-Bombardment Phenomena	1/14/67	35,000

TERMINATED CONTRACTS - FY 1967

METALLURGY AND MATERIALS

	Termination Date	Amount
Illinois, University of AT(11-1)-1491 Gilman, J. J. Laser Radiation Damage Studies	9/30/66	$ 42,685
Litton Systems, Inc. AT(11-1)-722 Wehner, Gottfried K. Surface Bombardment Studies	8/14/66	29,076
Loyola University AT(40-1)-3303 Keiffer, David G., Jr. Electron Spin and Optical Absorption in Compacted Silica	10/31/66	15,951
Massachusetts Institute of Technology AT(30-1)-3134 Ogilvie, Robert E. Fundamentals of Diffusion	10/31/66	79,000
Massachusetts Institute of Technology AT(30-1)-3208 Gatos, Harry C. Studies on the Distribution of Impurities in Solids	6/14/67	33,000
Pennsylvania, University of AT(30-1)-1893 Brown, Norman Study of Alloys by Electron Transmission Microscopy	8/31/66	2,455
Rensselaer Polytechnic Institute AT(30-1)-3004 Childs, Wylie J. Dendrite Growth in Supercooled Metals	8/31/66	22,000
Southern California, University of AT(11-1)-113, #16 LeBlanc, Marcel A Study of Magnetization, Thermal, and Transport Current Phenomena in High Field Superconductors	12/31/66	65,000

TERMINATED CONTRACTS - FY 1967

METALLURGY AND MATERIALS

	Termination Date	Amount
Stanford University AT(04-3)-298 Macres, Victor F. and Huggins, Robert A. Kinetics in Solid State Systems	7/31/66	$ 25,375
Westinghouse Electric Corporation AT(30-1)-3203 Gulbransen, Earl A. Reactions of Hydrogen with Alloys of Zirconium	5/31/67	42,050

CONTROLLED THERMONUCLEAR RESEARCH

Stanford Research Institute AT(04-3)-425 Pasternak, Ralph A. Interaction of Hydrogen and Other Gases with Clean Metal Surfaces	8/15/66	47,987
Swarthmore College AT(30-1)-3292 Garrett, Milan W. Magnetic Field Theory, Calculations, and Design, Based on Zonal Harmonic Series	7/31/66	14,229
Texas, University of AT(40-1)-3516 Powers, Edward J. Investigations of Anomalous Diffusion in a Linear E-type RF Arrangement	6/30/67	No Fund Contract
Westinghouse Electric Corporation AT(30-1)-2823 Lange, W. J. and Singleton, J. H. Surface Physics and Ultrahigh Vacuum Techniques	3/31/67	69,358
Yale University AT(30-1)-3568 Bernstein, Ira B. A Review of the Kinetic Theory of Waves in a Plasma External Magnetic Field	11/30/66	21,938

ACCELERATOR IMPROVEMENTS—LRL

Mr. MORRIS. As outlined beginning on page RES–37, $750,000 is budgeted for accelerator improvements at the Lawrence Radiation Laboratory. Why are these improvements essential in fiscal year 1969?

Dr. MCDANIEL. This $750,000 consists of four major projects—one for the bevatron, $340,000; one for the 88-inch cyclotron at $120,000; one for the 184-inch cyclotron at $90,000, and one for the heavy ion linear accelerator at $200,000. I will take those up item by item and discuss the need for those.

With regard to the $340,000 for the bevatron, the Government authorized, and the Laboratory has recently completed, major modification to the bevatron which increased its utilization factor by a large amount. I believe the project was about a $10 million project.

There are several smaller items that need to be done each year. There are two items in this project, one a high-frequency buncher for $260,000 and one for external proton beam shielding, $80,000. The latter item is procurement of large amounts of concrete and other shielding materials to protect the experimental workers and the experiments from the radiation.

The high-frequency buncher is a device which would assist in getting a higher quality beam out of the area and therefore this expenditure is required in order to better utilize the bevatron.

The $200,000 heavy ion linear accelerator project is the next largest one. This machine is used as one of the major accelerators in the transplutonium-heavy element research program. It is now undergoing some modification to provide for safer operation and for a little additional space around it. That is what this is for.

Mr. MORRIS. You can expand on that in the record if you will.

Dr. MCDANIEL. I believe it would be well.

(The information follows:)

Additional justification for Project 69–6-c; accelerator improvements, Lawrence Radiation Laboratory, Berkeley, Calif.

Improvements scheduled for fiscal year 1969 are considered essential for the continued effective and efficient use of the following accelerators:

A. *Bevatron.*—External proton beam shielding and a high-frequency buncher for accelerated beam are needed to maintain the high-energy physics program on the bevatron by continuing to meet the needs for higher beam intensities and for increased capability and flexibility to conduct experiments. The demand by outside users and LRL groups for beamtime continues to be far greater than that available.

B. *88-inch cyclotron.*—Planned improvements will increase the overall duty factor to over 70 percent from the present 5 percent, thus contributing to the research conducted under one of the Nation's most fruitful programs in nuclear chemistry. The need for an improved duty factor is based on the increasing importance of coincidence type experiments for understanding nuclear structure and reactions.

C. *184-inch cyclotron.*—The present second dee system is capable of leveling only about 50 percent of the sharply peaked cyclotron beam. An improved second dee system would increase the efficiency to 100 percent, thus providing twice as much useful beam both internally and externally, and therefore decreasing experimental time requirements.

D. *Heavy ion linear accelerator.*—The number of experiments being conducted at the heavy ion linear accelerator has increased substantially over the past few years. Alterations to the cave system are required to service experiments leading to the discovery of heavy elements and to the understanding of other nuclear reactions of heavy elements, which are unique in this country.

Dr. TAPE. I was about to interrupt; let me give you a general answer. Any generalized facility of this nature needs facilities improvements from time to time. Because of the definition of the funds such improvements must be construction funds.

Many people would think of this as a normal annual expense one would do in improvement, but here we set them forth for you as to what is needed on a year-by-year basis.

Dr. McDANIEL. These are very critical items.

Dr. TAPE. Each year there will be a few critical things that need to be taken care of and each year you will find a slightly different itemization but each machine will have to have something done to it.

Dr. McDANIEL. I can tell you in this case as an example that the Laboratory had needs for perhaps 10 times as much as this and they had many staff meetings at the Lawrence Radiation Laboratory in which fists almost flew in defense of individual projects, and these are the items which finally survived.

I know for a fact that these are very high priority needs.

200 BEV ACCELERATOR—FISCAL YEAR 1969 FUNDING

Mr. MORRIS. Beginning on page RES–41, $25 million is budgeted for fiscal year 1969 for the 200 Bev accelerator.

Please outline the present status of the planning for this briefly if you will.

Dr. McDANIEL. Congress has authorized the appropriation of $25 million for the initiation of the construction of the accelerator and this is the request which we have here, Mr. Chairman.

The State of Illinois has appropriated $30 million for the procurement of the site, and the State of Illinois is prepared to move promptly in the acquisition of the site where the accelerator would be located.

The prospective contractor for the design and operation of the final facility, has offices now in Oak Brook, Ill. near the site. They have a small staff. They are beginning to operate. They are beginning to design the machine. They are ready to go.

200 BEV ACCELERATOR—URA CONTRACT

Mr. MORRIS. Will you provide for the record an outline of the nature of the contract that you have with the Universities Research Association?

If you want to, also, you can expand a little more on the status of the planning of the 200 Bev unit.

Dr. McDANIEL. We would be happy to do that.

(The information follows:)

The National Accelerator Laboratory issued a design report in January 1968. This report described the technical design of the 200 Bev facility and includes a preliminary project cost estimate, and a construction schedule as well as operating cost projections. The design forms the basis upon which the laboratory and the Commission have developed their plans. The design report will be updated periodically to keep abreast of the development of the project.

The 200 Bev project was authorized by the Congress in April 1968, at a funding level of $25 million.

The Universities Research Association (URA) was formed in June 1965, to provide a nationally based organization by means of which universities and other research organizations could cooperate with one another, with the Government of the United States, and with other organizations toward the sup-

port and use of laboratories and research facilities, toward the development of knowledge in the physical and biological sciences, and the management and operation of such national projects as the 200 Bev accelerator. The association was incorporated in Washington, D.C., where it has offices at 2100 Pennsylvania Avenue, NW. Its president is Dr. Norman F. Ramsey of Harvard University. The operating unit of URA responsible for the accelerator is headed by Dr. Robert R. Wilson, laboratory director, and is presently located at Oak Brook, Ill.

URA is organized into two mutually complementing governing bodies, the council of presidents and the board of trustees. The association's affairs are conducted under the authority of the member universities through the council of presidents while the principal management responsibility is delegated to the board of trustees or to the officers of URA.

The council of presidents consists of the presidents of each of the university member institutions. Normally, they meet once a year to review the actions of the association, to elect new member institutions, to elect members of the board of trustees, to change the bylaws, and to transact other business. There were 34 initial members in URA. Twelve new institutions were elected in 1966, and two more were recently added, including a foreign member, the University of Toronto.

The board of trustees consists of 15 regional trustees elected by the council of presidents from nominees by each of 15 groups of neighboring member institutions. Approximately half of the regional trustees are scientists and one-half are administrators. In addition, there are six trustees at large to represent broad sections of public interest. The board holds at least three regular meetings a year. In the intervals between the meetings of the board, the activities and affairs of the association are managed by an executive committee, which is composed of the chairman of the board of trustees, the president of the association, and not fewer than five nor more than nine other trustees.

The Universities Research Association contract with AEC was executed on January 23, 1968, and includes all terms and conditions required by AEC and the Federal procurement regulations to assure compliance with statutory and other requirements, and to assure that the contractual services are performed efficiently and economically.

The contract assigns responsibility to URA for design, fabrication or procurement, erection, test, and inspection, assembly and installation of the systems, components, buildings, et cetera, comprising the accelerator and conventional facilities, for the conduct of studies related to scoping and design of the facilities, and for research and development necessary to support the pre-operational buildup of experimental facilities.

The contract anticipates employment of a mutually acceptable architect-engineer/construction-management subcontractor for design and construction of the conventional facilities. The design, procurement, fabrication, and installation work and services relative to the accelerator and its associated components are to be performed by URA with such assistance as it may obtain subject to the terms and AEC approvals provided in the contract.

The Commission can request the association to undertake work necessary for the completion of the accelerator complex other than that specifically to be performed by URA, but retains the right to assume the role of prime contractor for such other work if it concludes that prosecution by URA of such work or the result being achieved is inadequate or unduly costly.

The contract recognizes the Commission's responsibilities to exercise general control over the contract work and to have full access to information concerning performance of the work. Prior Commission approval is required for commencement of work on preliminary design and construction, respectively, of each of the major components of the accelerator. And approval is also required prior to inception of preliminary design, detailed design and construction of each of the major components of the conventional facilities. Additionally, written approval of the Commission must be obtained prior to any significant change in previously planned work included in a phase approved by the Commission. Adequate controls with respect to project costs and funding are included in the contract. The contract permits use by the Commission of expert or consultative services of individuals or groups in regard to scientific, technical, or other aspects of the project. Further, the Commission has the right to have representatives present at meetings which the association holds with its subcontractors or vendors for the purpose of reviewing any of the work, and the right to have representatives meet with and confer with such subcontractors concerning their work.

In order to keep the Commission fully informed of the activities under the contract, the association is required to make such reports as the Commission may reasonably request.

Mr. MORRIS. Will this association follow competitive bidding practices if it comes to the construction stage?

Dr. MCDANIEL. We have not worked out all of the details on that. The answer to your question is that we will follow the normal construction practices of the Commission in such cases. Some will be normal bidding procedures. Others will be negotiated bids.

Dr. TAPE. The point Dr. McDaniel is making is that we would follow the standard AEC procurement practices for construction in this area. However, in machines as technical as this, there are items where you have to go sole source; but this again is part of the standard procurement practice. There is no deviation here from regular practice.

Dr. MCDANIEL. Probably this would be done somewhat like the Stanford Linear Accelerator procurement package.

Mr. MORRIS. This is a large project.

Dr. MCDANIEL. It is.

Mr. MORRIS. The committee desires to be kept informed specifically on each of these contracts if construction money is appropriated.

Dr. TAPE. Very good.

Mr. MORRIS. Not after the fact but during the fact.

200 BEV ACCELERATOR—TOTAL COST ESTIMATE

Mr. ROBISON. As I read last year's hearings we spoke of $240 million for this project.

Dr. MCDANIEL. That is correct.

Mr. ROBISON. So this is a $10 million change?

Dr. MCDANIEL. Yes, sir.

Mr. ROBISON. Representing what, increased costs of construction?

Dr. MCDANIEL. This represents several months of design activity by the scientific people and the administrators to develop the new concept which now consists of a 200 Bev accelerator with the capacity and the capability for going to higher energy, and the total cost of that facility is estimated at $250 million.

Dr. TAPE. In terms of what we were talking about last year I think one could even say it represents a decrease in cost.

Last year for the $240 million, we were talking about a machine limited to 200 Bev and an intensity which was less than the recommended design intensity but with a capability of later increasing it.

In the instructions to us from the Congress last year we were asked to look again at this question of intensity, and to look at whether or not it would be possible to build in options to expand and extend the energy at a later date. This is the major achievement of Dr. Wilson and his group in this past year. They have sought ways and means of building the accelerator and still be able to include in it the option to go to the higher intensity.

This they have done. They have reevaluated their costs, contingencies, escalations, and so on, and the total now for the construction schedule which they have set is $250 million. So there are many minuses and pluses and we come back at about what we were last year but $10 million more.

Mr. ROBISON. Dr. McDaniel showed us a rough timetable for appropriations in last year's hearings including a request in fiscal 1968, if we appropriated it, for $10 million. Did we appropriate $10 million?

Dr. MCDANIEL. $7,333,000 was appropriated last year, Mr. Robison.

Mr. ROBISON. Then you said for fiscal year 1969 you estimated $65 million would be needed, but actually this is now only $25 million. Is that right?

Dr. MCDANIEL. When we started our negotiations with the administration people in the Government on how much money to request in fiscal year 1969, Professor Wilson and our people urged that more money be appropriated in the first year of construction than is contained in this budget.

It was felt that there should be an expenditure of the order of $70 to $75 million during the first year of construction.

Considering the very tight fiscal problems which we all know too well it was then determined by the executive branch that we should request only $25 million of the Congress recognizing that that is likely to have some effect on the schedule that may in the long run increase costs but it was a deliberate decision taken by the executive branch to reduce expenditures to the very bare minimum required in fiscal year 1969.

You are correct. This is a reduction over what normally we would have come to the Congress for during the first year of construction.

Mr. ROBISON. It is probably impossible for you, at this time, to give even a rough estimate as to what you might be requesting next year because there are so many imponderables, both fiscal and technical.

Mr. MORRIS. They have a plan which we are——

Dr. MCDANIEL. For $250 million. We will be happy to submit that plan for you in the record.

Mr. MORRIS. We would like to have it.

(Information requested follows:)

The schedule of obligations planned in connection with construction of the 200 Bev Accelerator is as follows:

Fiscal year:	*Obligations*
1968	$4, 633, 000
1969	27, 700, 000
1970	90, 000, 000
1971	80, 000, 000
1972	25, 000, 000
1973	20, 962, 000
Subtotal	248, 295, 000
Add construction planning and design funds previously expended	1, 705, 000
Total	250, 000, 000

BREAKDOWN OF FISCAL YEAR 1969 REQUEST

Mr. MORRIS. I would like to have you furnish for the record, also, a breakdown of the $25 million request. This would be a breakdown of the engineering services, procurement of various technical components, and any initiation of construction on any conventional or other facilities which might be involved.

Dr. MCDANIEL. We will be glad to list those.

(Information requested follows:)

Breakdown of planned obligations in fiscal year 1969

	Millions
Universities Research Association (URA):	
Engineering, design, inspection, and administration	$1.8
Prototypes	1.5
Contingency (25 percent) and escalation (4 percent)	0.9
Subtotal URA	4.2
DUSAF:	
Engineering, design and inspection	2.9
Main accelerator enclosure	4.3
Booster enclosure and gallery	3.6
Linac enclosure	1.9
Site development	2.0
Water distribution and wells	0.4
Advanced procurement—electrical and utility equipment	1.6
Sewerage (mostly storm)	0.8
Contingency (15 percent) and escalation (4 percent)	3.3
Subtotal DUSAF	20.8
Total	25.0

Contracts will be placed for the construction of the linac housing and the booster housing. These components of the building complex are required early in the project schedule because the linac and the booster are the first parts of the accelerator to be assembled and the first to be tested. A fraction of the main ring (main accelerator housing) will be started so that staging and assembly space will be available in later years when large components begin to arrive. A portion of the project site work, water distribution, and sewer installation, will proceed concurrently with the construction. In addition, orders for some long leadtime electrical utility items will be placed.

The work planned for fiscal year 1969 in the area of technical components is largely engineering work including prototype fabrication.

BREAKDOWN OF FUNDS APPROPRIATED IN FISCAL YEAR 1968

Mr. MORRIS. I also would like in record at this point a current report on the status of the $7,333,000 which was provided in the 1968 fiscal year.

Dr. MCDANIEL. I can submit it for the record.

(Information requested follows:)

Congressional appropriations for fiscal year 1968 totaled $7,333,000 for the performance of partial engineering services on the 200 billion electron volts accelerator. Of this amount obligations of $4,633,000 are planned for fiscal year 1968. The balance of $2,700,000 will be carried over into fiscal year 1969. The estimated breakdown of the $4,633,000 is as follows:

DUSAF	$2,378,000
URA	2,247,000
Corps of Engineers	8,000
Total	4,633,000

UNIVERSITY RESEARCH PROGRAM

Mr. EVINS. With regard to our earlier discussions regarding high-energy physics, we heard the testimony of the National Science Foundation before the Subcommittee on Independent Offices. There has been drastic reductions in the budgets of both National Science Foundation and the National Aeronautics and Space Administration for contracts with universities.

Has there been any comparable reduction in the estimates for AEC with private contractors or with universities in this field? I believe NSF is now down to about $10 million.

Dr. TAPE. Let me answer the question in very general terms with respect to the universities.

When we analyzed the budget which went to the Congress in terms of what we considered would be support of our work through university contracts, the total was of the order of $93 million for the whole Commission program, not just Dr. McDaniel's program but across the board for research in which we wanted academic science participation.

It looked to us as though it would be about $93 million for the budget we submitted to the Congress if that budget were approved by the Congress. The actions thus far taken in the authorization legislation I think means that we are at present just about the same as we were last year namely, about $90 million. In other words, if you were to approve the numbers which have been included in the authorization legislation, we are probably just about where we are now in fiscal year 1968.

There will be pluses and minuses by field of endeavor, and so on. I through perhaps I could give you a general answer as to the total, and perhaps Dr. McDaniel might discuss it further.

Dr. MCDANIEL. I would say our program dollarwise would be about the same. This will actually result in the termination of some contracts.

Mr. EVINS. NASA and National Science Foundation university contracts are down, but yours remains at about the same level.

Dr. MCDANIEL. The contracts will go down. The dollar level is about the same.

Dr. TAPE. The numbers of peoples supported will probably be less.

PROJECT RESULTS

Mr. EVINS. Are the project objectives being met and are you achieving productive results?

Dr. MCDANIEL. Like all endeavors, some of the research contracts were terminated because they were not performing right. So, we cannot say that every research contract has achieved its goal.

On balance, we believe we are achieving our goals, although the fiscal stringencies require some slowdown.

Mr. EVINS. How are these contracts initiated?

Dr. MCDANIEL. The proposals come to us.

Mr. EVINS. How many of the proposals are you able to fund at the present level of appropriation?

Dr. MCDANIEL. I can quote some statistics here.

We had on hand 217 proposals the 1st of January 1967. We got in 444 new ones during the year, making a total of 661 proposals to review during the year. We approved 45 of those. During the year we terminated 47.

Dr. TAPE. It is a very tough review.

200-BEV ACCELERATOR-SCHEDULING

Mr. EVINS. The next item the chairman was discussing was the 200-Bev accelerator. This is the big accelerator on which the site decision has been made. It has been long in the process of evaluation, and the decision has been made and it is proposed to go forward.

How has the original plan been changed, if at all, in light of budgetary developments and the war situation? Is it moving along basically as originally envisioned, or has there been a second look and evaluation?

Dr. MCDANIEL. There has been an evaluation at every step along the road. The one I quoted to Mr. Robison a moment ago is indicative that the Government is looking at it thoroughly.

We should go ahead at this stage of the game, but we should go ahead at a little slower pace than the scientific people would prefer to go. They preferred to ask for twice as much money in this fiscal year as we are asking for.

We are doing this deliberately, recognizing that in the long run it may cost a little bit more, but we are slowing it down just a little bit. At every stage of the game there is very detailed analysis, and I can testify to that.

Mr. EVINS. That is all, Mr. Chairman. Thank you.

Mr. MORRIS. The gentleman from New York.

RESEARCH AND DEVELOPMENT COSTS

Mr. ROBISON. Let me quote from page 41 of the Joint Committee's report for this year:

> Research and development costs represent a very significant part of the Federal budget.

Can you tell me, or can Dr. Tape or anyone tell me, how much in dollars the Federal Government is contributing in support of the national effort in research and development of all types?

Dr. TAPE. About $16 billion or $17 billion. I find it a difficult number to talk to because included in that is most of the big military development. I am not sure that is really your question. Maybe it is.

Mr. ROBINSON. Yes; it is a part of my question.

Why do you not just give me your own thoughts about the overall picture and the way the public and the Congress should attempt to look at the Federal contribution, to research and development. As you say, it is about $16 billion.

Dr. TAPE. I think it is more than that now closer to $17 billion.

Mr. ROBISON. Roughly how is it being divided?

Dr. TAPE. That is the total research and development for all of the executive agencies of the Government. Its major contribution comes from the military side. Of that amount, about 10 percent, as I recall, something on the order of $1.5 billion, has been described as basic research as contrasted with the development.

The view that I personally have is that $1.5 billion is not an adequate representation of what I think is necessary for the total. The $1.5 billion covers all of the scientific endeavors that we are talking about, both in the physical sciences, life sciences, engineering, and so on. It has in it some contribution to the support of academic science, from the point of

view of both the Science Foundation, where their charge is broadly based, and the mission agency.

We work with the universities to get research done to satisfy our mission interests, but yet take as broad a view as we can. As you can see, of late this level of support has tended to flatten out, and we are in a period of a stable dollar level, although the gross national product is increasing and the cost per unit of research is increasing.

So, I think our productivity in research, if you want to call it that, is slacking off a bit.

The question of how big the total R. & D. effort should be, I think, is very much a function of what our applied projects and objectives are. If we are going to the moon, then the R. & D. component will be bigger than if we are not going to the moon. If we are to push hard on ABM and POSEIDON developments and Vietnam technology, then the R. & D. total will be bigger than it might otherwise be.

The base of $1.5 billion I think should be an expanding base, because that is the base on which all the future technological development has to be constructed.

Mr. ROBISON. To quote the next sentence from the same report:

> It is from this research, however, that future developments of technologies essential to our national security and general welfare will be derived.

Dr. TAPE. That is just what I was trying to say.

LEVEL OF PROGRAM 10 YEARS AGO

Mr. ROBISON. Skipping a couple of sentences:

> The physical research program of the Atomic Energy Commission is a large and growing effort.

Dr. McDaniel, what was your program in dollar total 10 years ago?

Mr. ABBADESSA. It was about $90 million.

Mr. ROBISON. Now it is $280 million.

Dr. MCDANIEL. Ten years ago high-energy physics, which now constitutes about half of my program, was scarcely off the board. It was just beginning. It was a scientific area which was just opening up. So, half the program was just beginning.

Mr. ROBISON. You and I talked about this last year at some length. I enjoyed it, though I do not know if you did. We discussed the importance of AEC's going into research in the high-energy field as compared to work being done in the so-called low-energy field.

I think you told me, then, that the Commission does almost all of the research being done by anyone in this country in the so-called high-energy field.

Dr. MCDANIEL. It is still 90 percent.

Dr. TAPE. Ninety percent is a good number.

OTHER FEDERALLY SUPPORTED RESEARCH

Mr. ROBISON. Another sentence of the report: "It is important that it be recognized that this program"—yours—"is but a portion of our Nation's overall research effort."

Quite frankly, this is what I am trying to get at.

Beyond here I see another sentence:

* * * however, the committee also believes that henceforth the Commission in connection with its annual budget submissions should examine the feasibility of providing collateral information on the cost of other federally supported high energy physics, so that the Congress can place the Commission's requests in perspective with all other research programs.

Dr. McDaniel. We have started that activity. We are now collecting from the National Science Foundation and from the Department of Defense and from the National Aeronautics and Space Administration their information. In fact, they are just getting it to us now. We have it from the National Science Foundation and the Department of Defense and NASA will come to us in a few days. We will be happy to furnish you with a sample of this (see insert on p. 443).

Mr. Robison. I think this is important. My only quarrel with the last sentence I quoted is that it asks you to give Congress "collateral information," as the Joint Committee puts it, on the cost of only high-energy physics research. It seems to me we need it for other areas as well, because one of the problems which constantly frustrates me in my job is trying to correlate your research, DOD's research, NSF's research, and all the rest of them. We on this committee see it only in bits and pieces, as we do here today.

The Joint Committee is talking about the overall Federal effort or national effort in support of all kinds of research.

Dr. McDaniel. I recognize your problem. In the high energy physics field, we perhaps are in a unique position to provide this information because we are doing, as I said, 90 percent of the work and, therefore, are considered the leaders in the field, and therefore can collect the information that is available.

On the other hand, to cover the entire area of science, we would be completely over our depth in providing you the information you need, sir.

Dr. Tape. There is an attempt at this, Mr. Robison, in the National Science Foundation report on Federal funds. Annually they do survey the entire Government for a report on just this point. The numbers I was quoting earlier are the ones I recall from the Federal funds. I was not sure I had the exact figures. They do try to break it down by field of endeavor, by performer, where it is done, who is doing it, and so on.

There is also being developed within the Government a much more extensive system for compiling this type of information in terms of the field of endeavor and the totals, who is doing it, and so on.

As Dr. McDaniel said, I think we in high-energy physics can do a pretty good job here, because the uncertainties in what goes on elsewhere will be some fraction of the 10 percent which we are not covering ourselves.

ROLE OF NATIONAL SCIENCE FOUNDATION

Mr. Robison. I might get a different answer from somebody from the National Science Foundation, but how would you define for me what you understand the National Science Foundation's mission to be? What is it?

Dr. Tape. I am not sure I want to try in front of Mr. Evins here.

Mr. Robison. I would like to know.

Mr. Evins. Their mission is to broaden the base of scientific knowledge in all fields. They do not have a specific mission like AEC for high-energy physics. It is as broad as the national base.

The charter of Congress to the National Science Foundation is to elevate and upgrade and broaden the base of knowledge in all fields of science.

Mr. ROBISON. It conducts, though, very little research on its own? Most of its work is by contracts with universities?

Dr. TAPE. It is all through contracts, as I understand it. It is principally by grants, as Mr. Evins has said. They do have a few installations like our national laboratories, but in general these are much smaller; for example, the Radioastronomy Observatory in West Virginia and Virginia, the Astronomical Observatory at Kitt Peak, Ariz., and the Atmospheric Sciences Laboratory in Colorado—these are the types of laboratory facilities that they have under contract. Most of their university work is by grants.

Sometimes we have talked about their mission as being, in addition to this very broadly based charter that Mr. Evins has referred to, a filling-in type of mission to make sure that the gaps that exist in the Federal support of science are filled in. I think this is a necessary part and a vital part.

I hate to have their mission described as a gap-filling mission, though. I know it is much more positive than the concept of gap filling.

I think, Mr. Robison, as far as I personally am concerned, one of the deficiencies in our system today is that the Science Foundation has not, in my opinion, been able to be more aggressive and stronger in the support of this broadly based mission. I think most of the mission agencies would much prefer to see the Science Foundation in a stronger position than it is today.

Mr. ROBISON. Does it actually have a coordinating mission of any sort?

Dr. TAPE. Probably not in the sense that you are referring to. It does have many overall Government functions with respect to certain fields of science and with respect to information in terms of developing where the problems are. In general, I think you will find they are looking at certain areas which do not have what are sometimes called godfathers.

Mr. EVINS. They are interested in upgrading the university laboratories through grants for facilities, for equipment, for special projects for research in physics, chemistry, and mathematics, and in all fields of basic research.

Dr. TAPE. They are much more able to do institutional development to upgrade the institution.

Mr. EVINS. Their budget for fiscal year 1969 is $500 million.

FUNDING PRIORITIES

Mr. ROBISON. I got in some trouble with some of my friends from Cornell by suggesting that the NSF request might be reduced a little, about a month or so ago. That was in response to what I considered to be the very serious nature of our fiscal and monetary problems, plus what I viewed as the certain additional demands on the Federal budget to be made now to meet what some people are calling the crisis of the cities.

Again, we are back to that question of priorities.

Mr. EVINS. Colleges and universities like the National Science Foundation very much. They have a broad basis of support and friendship and favor.

Mr. ROBISON. One sentence, Dr. McDaniel, from page RES–6 says:

> In addition, the laboratory has launched an imaginative and highly regarded experimental program to store and clash contrarotating beams of electrons and positions in the accelerator itself.

In certain areas of urban centers, people are clashing in a way which is of deep concern to all of us. I want to support and defend the action of this subcommittee on the floor, whatever it may be. I hope to be able to do that. I hope we will find a consensus here.

Mr. MORRIS. You will, because you will be a part of it.

Mr. ROBISON. But I very well may, and we all very well may face, when we get to the floor, if anybody is thinking about these other problems, this question: Is it not more important for us to think about human beings clashing in our cities than it is about electrons clashing in an accelerator? I do not know how you can answer it. I hesitate even to ask you the question, but if you can give us something for the record in a few paragraphs, or if you want to add it later on, it might be of some assistance to all of us.

Dr. MCDANIEL. The thing I am about to say will not answer your basic question. I personally believe, in a period of fiscal crisis such as we are going through, that the moneys that survive the process as dedicated to basic and fundamental understandings of nature will in the long run pay off handsomely. I would urge that any necessary reductions of overall expenditures not be made disproportionate in the research field.

My own feeling is that these human problems are extremely important and must be solved. However, I do believe that they can be solved at the same time that the highly intellectual people, the scientists participating in these researches, are allowed to carry on their activities which, in the long run, in my opinion, will contribute as much to mankind as a few relief dollars or a few expenditures to solve the problems of the moment.

I am asking that you do not make a disproportionate cut.

Mr. ROBISON. We are not talking about a few relief dollars. I am sure you did not mean that. The Kerner commission is saying we must mount a "massive and sustained" attack on the root causes of civil disorders, though many of us all disagree about the causes and how much money should be devoted to this effort.

Dr. MCDANIEL. My total request is equivalent to about $1.50 per individual in the United States. I personally believe this expenditure by each individual will in the long run do a great deal for humanity in terms of increasing the economy and increasing the general knowledge.

Mr. ROBISON. I am glad to have that per capita figure developed for the record. I think that is helpful.

Dr. TAPE. I would merely say, Mr. Robison, that the worry I have related to the question you have posed is that our response should not be one of jumping and oscillating from one extreme to the other. I think we have in this country a very able and imaginative scientific

research community in the universities, the laboratories of the Government, and so on. I think it would be a great misfortune merely to say we need this money now to put over there, and let's cut all this off and destroy it.

None of us is trying to do that. None of us is proposing to do that. So, the problem is to find our way down some narrow path which preserves the strengths that we have today for the future, and at the same time tries to meet some of these more recent needs, recent in the sense that we have recently given them recognition. Mr. Morris said earlier today he did not think the needs were very recent because they had been with us for a long time.

It is that problem of finding a narrow path down through here which we are all searching for.

Mr. ROBISON. I conclude by saying if you could only more clearly help us find that path than anyone has been able to do so far, then you ought to run for President, and there is a vacancy at the moment.

Mr. MORRIS. I thank the gentleman from New York.

Thank you, Dr. McDaniel, for an excellent statement.

Dr. MCDANIEL. Thank you, Mr. Chairman. It is a pleasure to be here.

BIOLOGY AND MEDICINE PROGRAM

Mr. MORRIS. The commitee will now hear from the Division of Biology and Medicine. The committee is happy to welcome Dr. Totter before the committee.

This, I believe, is the first time that you have appeared before this committee in this capacity. The committee congratulates you and is looking forward to hearing about your program.

We would appreciate it if you would provide for the record a little of your background.

Dr. TOTTER. Thank you, sir.

I came to the AEC for the second time in 1962 from the University of Georgia, where I was chairman of the division of biological sciences. Prior to that I had been with the AEC from 1956 to 1958, and at the Oak Ridge National Laboratory from 1952 to 1956.

Before that, I spent 13 years at the University of Arkansas School of Medicine at Little Rock.

Mr. MORRIS. Thank you. You may proceed to discuss your program.

Dr. TOTTER. I am pleased to have the opportunity to appear before this committee and to discuss the biology and medicine program for fiscal year 1969.

ACCOMPLISHMENTS OF BIOMEDICAL RESEARCH PROGRAM

Before passing on to a discussion of some of our future plans, I would like to mention several accomplishments in the biomedical research program during the past year.

In his opening statement, Dr. Seaborg mentioned the recent discovery of the singlet oxygen a long-lived reactive intermediate in reactions of several kinds, including those involving radiation. This discovery is significant because it may provide an explanation of oxygen enhancement of radiation damage.

STUDIES OF ATOMIC BOMB CASUALTY COMMISSISON

Followup studies of atomic bomb survivors by the Atomic Bomb Casualty Commission in Japan continue to provide unique information on later radiation effects on human populations. Recent new information on the late occurrence of leukemia, breast cancer, and other neoplasms has become available.

It has also been shown that clinically normal survivors of Nagasaki and Hiroshima possess chromosome abnormalities in their peripheral lymphocytes, white blood cells, 20 years after exposure.

OAK RIDGE NATIONAL LABORATORY PROGRAM

The program at Oak Ridge National Laboratory for developing centrifuge rotors for isolating and purifying cell particles has resulted in the purification of influenza virus and a purified vaccine known as zonamune as commercially available.

In other research at ORNL, recent observations indicate that mechanisms are operative to repair genetic damage induced in the mammalian germ cell. These studies showed that no mutations occurred in litters produced 7 weeks after exposure of female mice to low doses, which is a significant reduction below that observed in young produced in the first two litters.

We now have an operational sampling capability from the earth's surface to 250,000 feet with a combination of balloon, aircraft, and rocket sampling systems. This enabled us to measure the debris from the sixth Chinese nuclear test of 1967. This fusion test caused the first injection of large-scale nuclear debris into the midlatitude atmosphere, and important data on the movement of the debris from this particular event are still being obtained.

Reasonable agreement has been maintained through 1967 between predicted and observed levels of global fallout deposition. Less strontium-90 was present on the ground at the end of 1967 than at the beginning of the year because the loss of strontium-90 due to radioactive decay exceeded new fallout during 1967.

NUCLEAR MEDICINE

In another area there have been significant advances in the entire field of nuclear medicine. Improvements have been made in developing rapid scanning products utilizing a stationary camera.

We also have available a technetium generator, and the ability to produce short-lived isotopes for medical use has reduced the time required to complete a procedure as well as the radiation dose to the patient.

FISCAL YEAR 1969 PROGRAM

Turning now to plans for fiscal year 1969, the authorized amount of $89.5 million represents an increase of only $1 million over fiscal year 1968 availability. This amount will permit the continuance of the highest priority programs, but will not allow for growth of other important activities. As a matter of fact, curtailment will be required in some areas.

We fully intend to prosecute our studies associated with possible radiation hazards to uranium miners, and this effort will be continued vigorously. These efforts, of course, are closely coordinated with the Public Health Service and the Bureau of Mines.

We are conscious of other Federal programs in areas related to those of interest to the AEC, and many formal and informal contacts are maintained with these various agencies.

Within our program there is a continuing process of review and evaluation so that individual projects may be brought to a conclusion when they have passed their most productive phase, to make room for new work of high priority or greater urgency.

SOMATIC EFFECTS OF RADIATION

Nearly every budget category will remain at or near the current level. In the somatic effects category some increase will be necessary for the programs on retrospective and prospective studies of human beings, including the work of the Atomic Bomb Casualty Commission. Every effort is being made to hold down the cost of the project in Japan consistent with the need to assure enough funds for a viable program.

We will also emphasize the late effects of relatively low doses of radiation received accidentally, as in radiation accidents or in continuous exposure to very low doses for prolonged periods of time.

One aspect of these studies relates to the use of radiation and chemicals in suppressing the immune response system of individuals who are to receive transplanted organs such as kidneys, hearts, or livers. We are attempting to relate as closely as possible our experiments with animals to man. In doing this, we will continue the large-scale retrospective epidemiological study of radium toxicity involving several hundred persons who have been exposed to radium. These studies serve as a baseline of intercomparison upon which to predict the potential hazards of other radionuclides studied in the experimental animals.

RADIATION GENETICS

In our radiation genetics program we are continuing to study the genetic effects of radiation on plants and animals. We believe that the primary targets of radiation-induced genetic change are the chromosomes and the genes located within the chromosomes. So much of our work is directed to the mechanisms by which radiation produces changes in the structure, function, replication, and transmission of genetic elements.

COMBATING DETRIMENTAL EFFECTS OF RADIATION

Although there is no increase in the program in combating detrimental effects of radiation, we expect to pursue these studies to develop means for protecting against and alleviating the effects of radiation.

MOLECULAR AND CELLULAR LEVEL STUDIES

Similarly, there is no increase for the very important category of molecular and cellular studies. It is our strong conviction that this work holds the key to the ultimate understanding and control of virtu-

ally all radiation effects. These studies are aimed at finding out which molecules of the cell are damaged, and how much damage results in cell death. They provide the foundation of knowledge upon which studies in radiation genetics, somatic effects of radiation, and combatting the effects of radiation will be interpreted and understood.

ENVIRONMENTAL RADIATION STUDIES

Research in environmental radiation is of particular significance in controlling the quality of the environment, and these programs are carefully coordinated with other Government agencies. We are concerned to know the effects of radiation upon ecological systems in order to establish limitations on the radioactive materials that can be safely discharged into natural environments such as by nuclear reactors.

I have already mentioned our atmospheric monitoring program and we consider it essential that this program be maintained not only for AEC use but also for other agencies of the Government. We of course make use of the capabilities of the Department of Defense in the actual operation of this program.

In our research in radiological and health physics and instrumentation, we are primarily interested in the information required for the formulation and establishment of improved radiation protection procedures and for the development of instruments uniquely required for the AEC's biology and medicine program. We are pleased with the efforts of the instrumentation industry in providing basic instrumentation. One of the greatest advances in our instrumentation program has been the use of the semiconductor materials which has resulted in a greatly improved energy resolution. This in turn permits the determination of many radionuclides within a single sampling which had been impossible with earlier detectors. Another important instrumentation development is the contribution of ultrahigh resolution microscopy which enables direct indication of specific subgroups, perhaps eventually even specific atoms, in large complex molecules.

The small nuclear energy civil effects program provides information needed by the AEC for its own nonmilitary defense planning as well as information for other agencies of the Government which have operational roles in nonmilitary defense. The civil defense project at Oak Ridge is particularly promising in its studies of advance systems that will be effective in the 1970's.

The cancer research program continues to use the unique machines available in AEC laboratories. We are particularly interested in the possibility of fast neutrons for cancer therapy and these and other types of radiation are being investigated. Our biggest problem is that costs of clinical research are increasing very rapidly because of increasing expenses for patient care.

The food preservation program will be conducted at its present low rate. It is expected that wholesomeness studies can be undertaken on one food product, perhaps papayas, in the hope that this food can be cleared by the Food and Drug Administration for public consumption.

Turning briefly to our budget for equipment we are finding that individual items of equipment are far more costly owing to advances in design and concepts than just 2 or 3 years ago and that it is necessary to provide the most up-to-date equipment if we are to expect the best results from our research effort. We hope to be able to provide at least one small cyclotron for the production of short-lived isotopes for use in clinical research. We are making every effort to reduce unnecessary radiation exposure to human subjects under treatment and the furnishing of these small cyclotrons for the production of short-lived isotopes is one means in which this can be accomplished quickly.

At some time we will also need to replace the research vessel used by the Puerto Rico Nuclear Center for its marine studies. The present vessel was a retired Army Transportation Corps ship which is rapidly becoming unseaworthy. Title to this ship was transferred to the AEC and modifications were made a number of years ago to adapt it to research purposes.

I would be pleased to answer any other questions members of the committee may have about our budget.

Mr. MORRIS. At this point we shall insert pages B&M 1 through B&M 30 of the justification sheets.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

BIOLOGY AND MEDICINE PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$92,051,000
Estimate FY 1968	88,450,000
Increase	$ 3,601,000

The biomedical research program is designed to assist the development of atomic energy for national security and general welfare by understanding the effects of radiation, by learning to overcome its biological hazards and by taking advantage of its beneficial aspects. An operating budget of $92,051,000 for FY 1969 is proposed to permit program objectives to be pursued effectively and commitments to be met.

Research to resolve questions of the biological effects of radiation on man and his environment is increasing as a result of the growing number of practical applications of nuclear energy including civilian power. This budget makes provision for phasing out a number of individual projects, and for deferring the initiation of all but the most urgent and promising research efforts. These program areas are described in more detail in the justification which follows. Some of the highlights are identified below:

1. A study which deals with the future of the Atomic Bomb Casualty Commission has recently been completed. The study concludes that the program should continue as long as useful scientific data are still forthcoming, preferably for at least two decades. This program represents a unique opportunity and responsibility to study the effects of radiation on a large human population, and continues to be of particular significance to nuclear medicine and radiation biology.

2. Additional attention will be given in a number of laboratories to studies of the problem of exposures of uranium miners to radiation including the biological aspects, preventive measures and improved detection instrumentation.

3. An arid lands ecology program will be developed at the Pacific Northwest Laboratory, taking advantage of the climatic and geographical features of the area. This will be comparable in scope to studies in other ecological environments such as the southeastern United States and Puerto Rico. Existing studies in plant physiology will be coordinated with and augment those in terrestrial ecology, micrometeorology and soil sciences.

4. An AEC effort is planned in conjunction with the research activities of the World Weather Program, consisting of large-scale field studies near Barbados in the Caribbean, with participation by several agencies of the United States and by other countries. These studies will be of particular significance to the AEC because of the opportunity they provide to obtain information on air-sea interchange of gases and particulates, long-distance diffusion, and momentum flux.

5. The level of effort in combating detrimental effects of radiation, molecular and cellular level studies, marine sciences and chemical toxicity will be reduced in FY 1969, although selective increases may be possible including the exploitation of research tools such as nuclear magnetic resonance and electron microscopy in molecular biology.

6. Support of certain international conferences, translations, and books are included in the biomedical research budget when pertinent to the program.

Continued liaison has been maintained with other agencies of the Government having an interest in related programs, particularly the Department of Health, Education and Welfare, the Department of Defense, and the National Aeronautics and Space Administration. This budget has been prepared to assure that it is complementary to the programs of these agencies.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.		Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
B&M 3	1.	Somatic Effects of Radiation	$24,266,504	$26,050,000	$27,370,000
B&M 6	2.	Radiation Genetics	6,954,655	7,330,000	7,650,000
B&M 7	3.	Combating Detrimental Effects of Radiation	1,987,286	1,950,000	2,000,000
B&M 9	4.	Molecular and Cellular Level Studies	16,188,618	16,300,000	16,860,000
B&M 11	5.	Environmental Radiation Studies	17,471,143	18,340,000	19,030,000
B&M 16	6.	Radiological & Health Physics & Instrumentation	7,658,559	7,240,000	7,500,000
B&M 18	7.	Chemical Toxicity	645,601	600,000	631,000
B&M 19	8.	Nuclear Energy Weapons Effects Studies	1,353,950	1,100,000	1,120,000
B&M 21	9.	Cancer Research	5,389,380	5,800,000	6,020,000
B&M 22	10.	Selected Beneficial Applications	3,250,018	3,300,000	3,420,000
B&M 24	11.	Radiation Preservation of Foods	581,728	440,000	450,000
		Total Biology and Medicine Program	$85,747,442	$88,450,000	$92,051,000

JUSTIFICATION OF CATEGORIES

1. Somatic Effects of Radiation $27,370,000

a. Radiation Effects - General ... FY 1967: $15,067,761; FY 1968: $16,100,000; FY 1969: $16,920,000

The objective of this research is to arrive at a composite detailed analysis of the immediate and long-term effects of acute and chronic exposures of whole organisms to radiation of various types. This major objective is met by supporting investigations of the effects of radiation on cells, tissues, and organ systems of experimental mammals, as well as on some model non-mammalian organisms. The integration of results from such studies should provide a better understanding of radiation effects on living organisms and a sound basis for predicting the effects of radiation on man.

Program highlights	Increase in FY 1969
Effects of Whole Organism Irradiation	$+420,000

A full programmatic review of the program of the Atomic Bomb Casualty Commission has recently been completed. The study concludes that the program should continue as long as useful scientific data are still forthcoming, and that it is of vital significance in the area of nuclear medicine and radiation biology. Some increase in the cost of living is expected to continue, in the light of the rising Japanese economy.

The epidemiological study at Oak Ridge and Richland of the possible relationship between radiation exposure and mortality among former employees of the AEC contractors will be continued.

Response of Organ Systems and Tissues	+400,000

The medium (low) level long term effects program at Oak Ridge National Laboratory to assess the effect of chronic irradiation on mammals will be increased; this is a long-term program designed to study tumor development, cataractogenesis, life-span shortening and other phenomena associated with low level irradiation as encounterable in practical utilization of nuclear energy for mankind. The unique aspect of this program is the strict control of environment (microbial, viral and parasitic) in order to determine the role viruses and

1. Somatic Effects of Radiation - continued
   a. Radiation Effects - General - continued

Increase in FY 1969

Response of Organ Systems and Tissues - continued

parasites may play in bringing about the effects attributable to the interaction of radiation and viruses.

Advantage will be taken of the conversion of the Cosmotron-Van de Graaff at Brookhaven National Laboratory for use in biomedical studies. This work will center on detailed microdosimetric measurements but will extend to the semi-micro and macro distribution of dose as it is related to biological effect.

Total ..... $+820,000

An understanding of the effects of radiation on man and his environment becomes more important as a new era of peaceful uses of nuclear energy emerges (for example, development of reactors for power and desalination). Data on the effects of radiation on humans is understandably meager, having been derived from cases of accidental exposure and patients undergoing therapeutic radiation exposures. The ability to arrive at meaningful limits of radiation exposure, as well as effective countermeasures, must result, therefore, from extrapolation of data obtained with experimental animals of various types. A number of species of plant and animal systems have been and continue to be used in an effort to arrive at generalizations applicable to humans.

Advantage is taken of unique experimental material for elucidation of basic biological principles, for investigation of determinants of radiosensitivity, effects on growth and differentiation, and ability of living material to repair radiation-induced damage.

Of utmost importance in industrial application of nuclear power is an understanding of the effects of very low level (chronic) irradiation of populations of individuals. The effects of greatest importance are those effects produced that require observation of irradiated subjects during their entire life span. Data on effects of total dose, dose-rate, as well as other environmental parameters which may modify the radiation effects, are needed to better understand latent effects such as aging and carcinogenesis. Recent developments in animal care including the availability of germ free animal containment cells now permit a better assessment of the true radiation causality for latent effects in the absence of complicating factors such as low level infection by microorganisms of various types (bacteria, viruses, and other

94-075 O-68-pt. 3—31

1. Somatic Effects of Radiation - continued
   a. Radiation Effects - General - continued

parasitic agents). A better understanding of the biological effects of heavy particle irradiation is also necessary because of the increased probability of exposure to such radiation in space travel as well as the potential of such radiation in cancer therapy.

b. Toxicity of Radioelements ... FY 1967: $9,198,743; FY 1968: $9,950,000; FY 1969: $10,450,000

The objectives of this program are to determine the hazards of internally deposited radionuclides associated with nuclear energy especially those arising from nuclear fallout, from peaceful applications and from the mining and milling of uranium ores. Associated studies seek information on the mechanisms of uptake, distribution, and elimination of these nuclides in order to set standards for the safeguard of those associated with the atomic industry and the population at large.

Program highlights	Increase in FY 1969
Inhalation Studies	$+340,000

Additional studies are planned of the hazards resulting from inhalation of radon and radon daughters by uranium miners. These studies will assist in the establishment of acceptable levels of exposure. Pulmonary damage resulting from deposition of plutonium in the lung will also receive increased emphasis.

Other Routes of Administration	+160,000

Some growth is anticipated in the studies relating to the development of myelogenous leukemia in animals exposed to strontium 90 at an early age, and in the comparative effects of x-irradiation and radioiodine on the thyroid.

Total	$+500,000

With the decrease of hazards from nuclear fallout associated with testing and the fact that the studies of the past fifteen years are coming to an end, this phase is declining. However, space nuclear systems activities have increased to a point where increased efforts must be focused on matters affecting the safety of current and future space nuclear systems, especially studies involving the inhalation of plutonium and other nuclides which will be used as nuclear fuels for these devices. It is also expected

1. Somatic Effects of Radiation - continued
   b. Toxicity of Radioelements - continued

that by FY 1969 a plutonium registry will have been initiated and that costs associated with locating individuals with plutonium body burdens, record gathering, and data reduction for automatic processing will all require increased funding for this essential effort.

Current developments in the uranium mining industry have pointed to the fact that much additional information is needed to protect uranium miners from undue exposure to radiation and yet make the mining of uranium economically feasible. Therefore, for the next few years increased efforts are necessarily being directed to studies in this area. This will include such aspects of the problems as the nature of the aerosols involved, the significance of particular daughter radionuclides and whether they are free or particulate bound, the importance of various physiological parameters on deposition, retention, and ultimate pathologic effects, and the development and evaluation of various protective measures and devices.

2. Radiation Genetics $7,650,000

The objectives of this research are to determine the mechanisms involved in the production of genetic damage at the gene and chromosome level, to ascertain the alteration in the sequence of events involved in the subsequent biochemical steps leading to expression of the damage produced in the individuals of succeeding generations, and to understand the effect on populations and the mode and rate of elimination of this damage with time from populations.

Program highlights	Increase in FY 1969 -
Biochemical and Developmental Genetics	$+130,000

Emphasis will be placed on differentiation of primordial germ cells, factors controlling repression and derepression of genes in development of living organisms, and the relation of mutational change to alteration in protein molecules. Increases in level of effort will occur at Argonne National Laboratory and Oak Ridge National Laboratory.

Human and Mammalian Genetics	+ 80,000

Several aspects of human and mammalian genetics will be emphasized, primarily in the off-site program. Among these are studies of the genetic factors involved in abnormal behavior, genetic

2. Radiation Genetics - continued

Increase in FY 1969

Human and Mammalian Genetics - continued

control of immunological reactions to foreign tissues (critical in organ and tissue transplants), and genetic variation in relation to various environmental stresses such as chemicals (drug), and radiation.

Population Genetics and Mutation Rate Analysis ..... $+110,000

New methods will be exploited for the measurement of induced mutation rates arising as a result of exposure of individuals or populations to radiation. The study of problems such as chromosomal abnormalities are of importance in evaluating the fitness of human populations and long-term genetic effects of radiation.

Total ..... $+320,000

The research program in radiation genetics obtains experimental data on the primary interactions of radiation and other mutagenic agents with the genetic material in the production of gene mutation and chromosome aberrations and correlates these changes in structure or chemical content with alterations in the function of the gene. Although the major objective in this area of research is an understanding of radiation effects on man, genetic experimentation with humans has definite limitations; therefore, basic information needed for this purpose must be obtained from experimental work utilizing various plant, animal, and microbial forms of life. Research in this important area should lead to a better understanding of the structure of the genetic material, the nature of the genetic control of biological processes at all levels of organization in development in living organisms including man, and the impact of mutant genes of varying degrees of effect on populations of individuals.

In addition to research on the nature of genetic damage and to its effect at all levels of organization, considerable research effort will be expended to elucidate the mechanisms involved in and the conditions necessary for the repair or prevention of radiation-induced genetic damage at both the gene and chromosome level.

3. Combating Detrimental Effects of Radiation $2,000,000

The objective of this research is to combat or to alleviate radiation damage either by (1) protective (chemical) procedures applied before irradiation or (2) by therapeutic stimulation of cellular repair or recovery. In the general area of radionuclide contamination, research is conducted to improve systems for removal of these radioactive elements from man and his source of food materials.

3. Combating Detrimental Effects of Radiation - continued

Increase in FY 1969

Program highlights

The level of effort of biological studies to counteract the detrimental effects of radiation will decline. Some increase will be devoted to improving bone marrow and other tissue transplantation, by combating the secondary disease resulting from heterologous tissue transplants.

Total ..... $+ 50,000

There is still much information needed to develop better radioprotective chemical agents of possible application to man. The chief interest at present is to develop chemical protectants with a large difference in the level of toxicity and the maximally protective concentration. It is important to characterize new protective chemical agents in terms of chemical structure and the cellular sites with which they react.

There are two general areas of importance in promotion of recovery of mammals: (1) after high radiation doses in which the entire cell population is killed, it is necessary to transplant living cells as replacement therapy, and (2) after lower doses there is a need to stimulate cellular repair in the normal stem-cell populations of the irradiated animal. Much more effort has been expended on the former area in that there are important implications for tissue and organ transplantation in general. A by-product of investigations of the immunological response to tissue transplantation has been a profound characterization of general immunological response, including the cell types involved and their competence in antibody production. Recent experiments suggest the importance of aging in loss of immunological competence of antibody producing cell types and the possible therapeutic advantage of infusion of competent cells into individuals lacking the ability to combat routine infection and disease.

There is a continuing effort required to develop techniques and chemical agents for mobilization and removal of radioactive elements, accidentally deposited in mammalian tissue, especially bone. Research is being done to prevent undesirable deposition of therapeutic radionuclides in certain body tissues to improve utilization of these isotopes for tumor therapy. Studies are needed to elucidate the mechanism by which these nuclides are removed from the body.

4. Molecular and Cellular Level Studies $16,860,000

The objectives of this program are aimed ultimately at the comprehension of how and what radiation does to individual cells of living material. The effects produced by radiation are studied at each level of organization to determine the primary changes induced in structure and/or function of the cell or cellular organelles utilizing biophysical and biochemical techniques. Included in this program are investigations on the absorption and transfer of energy in biological systems, and subsequent biochemical changes produced, and the eventual expression of these changes at the molecular, cellular, or higher level of organization.

Program highlights	Increase in FY 1969
Photobiology and Biophysics	$+320,000

Increases will occur at Argonne National Laboratory for studies of the properties of macromolecules and membranes using biophysical techniques, at the Lawrence Radiation Laboratory, Berkeley, for studies in chemical biodynamics and photosynthesis, and at Oak Ridge National Laboratory for studies on the ultraviolet induced lesions in DNA and the enzymes believed involved in their repair using spectroscopic and electron spin resonance methods.

Biochemistry and Cell Physiology	+240,000

Studies on the structure functions and control mechanisms of sub-cellular units will be employed. Of particular interest are new techniques for separation of cellular constituents. Some increase in effort will be directed to the molecular processes that underlie cell differentiation and the formation of specialized tissues.

Total	$+560,000

Before any logical approach to prevention or control of radiation damage is possible, it is essential that the underlying nature of radiation damage in cells be understood. The program in molecular and cellular studies is aimed at generating background information required for formulating a rational approach for the prevention and treatment of radiation damage in living organisms. Understanding the basis of damage at the cellular and molecular level (that is, how the sensitive molecules are affected by the radiation and how this absorbed energy leads to changes in biochemical processes which eventually are seen as radiation damage) will make it possible to plan control measures for alleviating or preventing this damage.

4. Molecular and Cellular Level Studies - continued

As a result of many years of research in this area utilizing many different biological systems, a large body of important information has accumulated. It is now generally known which cellular sites and processes are most sensitive to radiation, yet, even with this information, the precise changes induced and the mechanisms involved in repair of the damage produced are not understood. It is, therefore, essential to acquire more basic information about such things as molecular structure of sensitive cellular constituents as well as their role in the biosynthetic function of the cell. The current program is aimed at obtaining this kind of information and in particular stresses basic studies on processes and structures which are known to be susceptible to radiation damage.

The programs in photobiology and biophysics are directed towards a better understanding of the initial events involved in the interaction of radiation with biological molecules as well as with the intact living organism. The photobiological systems are used because of the ease with which these materials can be used and because of the many analogies between the mechanism involved in the absorption and transfer of light energy and the transformation of this energy into chemical form and those involved in the interaction of ionizing radiation with sensitive molecules in biological systems.

Fundamental studies of the biochemistry of various biological systems are encouraged because they are vital for a better working knowledge of processes in the cell where radiation effects could have profound consequences. Some prime examples of studies of this type are those which examine structure and function of nucleic acids, the regulatory aspects of cellular metabolism, as well as the structure and function of cellular organelles such as the nuclei, membranes, mitochondria and chloroplasts.

The complex sequence of events involved in growth and differentiation of organisms are under investigation within this category. The role of the various interrelated processes of protein synthesis, gene control of biochemical action, cell division, and differentiation of cells and tissues in the growth and development of highly complex organisms are studied for an understanding of the basic processes as well as for a better knowledge of how radiation alters any one of the many components in this organized biological "blue print" and how this change affects the organism itself.

5. Environmental Radiation Studies $19,030,000

a. Terrestrial and Fresh-Water Ecology ... FY 1967: $5,362,510; FY 1968: $5,800,000; FY 1969: $6,030,000

Objectives of this research are to investigate biological organizations at the community level in relation to the total complex of climatic, soil, and biotic factors that control them, and to determine the effects of radiation on them. The end objectives are to relate these biological systems and the various processes and phenomena operating in them, as affected by radiation, to human society.

Program highlights	Increase in FY 1969
Plant and Animal Systems	$+140,000

An ecological research program at Argonne, inaugurated in FY 1968 under the auspices of the Associated Midwest Universities, will be directed to studies of prairie recovery, soils phenomena and insect populations. The establishment of a gamma source and associated research is planned for the northern coniferous forest in Wisconsin.

At Oak Ridge National Laboratory the major increase involves studies of two small drainage basins within a larger one. Weir systems will have been installed by the close of FY 1968 and automatic measurements of water run-off, sedimentation, percolation, biotic absorption and uptake of applied radionuclides will be made.

At the Pacific Northwest Laboratory the ecological program will have developed substantial guidelines, especially the major project on Arid Lands Ecology being inaugurated on the ecological reserve of 120 square miles (Project ALE).

Soils, Plants and Soil-Plant Relations	+ 40,000

Laboratory research is primarily undertaken at Pacific Northwest Laboratory, University of California at Los Angeles, and Oak Ridge National Laboratory. However, additional field studies will be required at both the Nevada Test Site and for Project ALE. A shift from plant and animal systems to soil complexes is anticipated at Puerto Rico Nuclear Center.

Fresh-Water Systems	+ 50,000

Intensified investigations will develop at Oak Ridge in two drainage basins. Additional limnological studies, particularly in the Arctic, will be undertaken.

Total	$+230,000

5. Environmental Radiation Studies - continued

a. Terrestrial and Fresh-Water Ecology - continued

The environment of mankind is undergoing rapid alteration through the intensification of existing activities and the development and application of new processes and materials. Among those forces which have had demonstrable impact on the environment and exhibit potential for future perturbations is man's diversified use of nuclear energy. It is important, therefore, that the interrelated biotic and physical natures of the biosphere of the earth and their modification by nuclear phenomena be understood. The investigations involve biological assemblages such as forest, grassland, desert, tundra, and fresh-water systems; biological processes such as behavior, food production, food webs and chains, succession, migration, and reproduction; and such population phenomena as trends, periodicities, fluctuations, and persistence of community organization.

There is a need for further information to direct proper utilization and conservation of fresh-water resources, and studies will be undertaken to fill the gaps in the knowledge of the fate of radioactive contaminants and of their effects upon fresh-water environments and aquatic organisms. Some important radionuclides are accumulated by organisms high in food chains both by direct absorption from the water and by transfer through the chain. Because the concentrations of minerals in fresh waters are generally lower than in saline water, biologically important radionuclides are generally more readily accumulated from the environment by fresh-water organisms than by marine forms.

b. Marine Sciences ..... FY 1967: $3,767,669; FY 1968: $3,900,000; FY 1969: $4,000,000

Objectives of the research program in marine sciences are to provide information required to predict and explain the pathways taken and the possible effects on marine resources of radioactivity resulting from waste disposal operations, reactor operations, special isotopic power applications, past nuclear tests or tracers used for research.

Program highlights	Increase in FY 1969
Biological Uptake, Concentration, Distribution, and Effects of Radioactive Elements	$+ 40,000

Additional research is planned on the organic chemistry of radioisotopes in sea water, and on the role of bacteria and fungi to determine their role in recycling man-made isotopes.

5. Environmental Radiation Studies - continued
   b. Marine Sciences - continued

	Increase in FY 1969
Circulation and Mixing	$+ 60,000

There will be an extensive investigation of circulation of fallout in South Atlantic Ocean waters and for intensification of ecological studies in the coastal waters of the Eastern Continental Shelf. The French nuclear tests are tagging southern hemisphere surface waters with new fallout; this provides an exceptional opportunity to determine circulation patterns and rates of the little known South Atlantic, important because it is the source of deep water in the four major ocean basins, and because rates of movement are still largely speculative.

Total	$+100,000

The marine sciences program covers research in biological, chemical, geological, and physical oceanography. These are directed to determining the biogeochemical cycling and the dispersion by physical influences of radionuclides in marine environments. The program also includes studies of the effects of radiation upon marine organisms and the discovery and development of new radiological techniques for oceanographic research.

The research in marine biology is related to the accumulation and cycling of radionuclides in the food web. Much of the past work has dealt with the inorganic aspects; that is, influences of elements on the biota using inorganic chemical procedures. It has also been recognized that biological activity can modify the availability of inorganic elements to other parts of the food web.

Thermal pollution associated with nuclear power reactors located along streams, lakes and coastal waters is of immediate and long time concern to the AEC. A pilot effort is now being negotiated to explore this problem. This involves biological, physical and chemical aspects.

5. Environmental Radiation Studies - continued

c. Atmospheric Radioactivity and Fallout ... FY 1967: $8,340,964; FY 1968: $8,640,000; FY 1969: $9,000,000

Research objectives are to acquire and make available the best scientific information and analyses concerning the production, distribution, and effects of radioactive fallout from past and possible future nuclear explosions, nuclear reactors for power or propulsion, or from any other situation which might result in the dissemination of radioactive material in the atmosphere or biosphere. Applications of the results of these studies are made throughout the nuclear energy program in planning and designing nuclear facilities, devices and operating procedures, in developing standards and guides for environmental radiation control, and in assessing the implications of nuclear weapons tests or nuclear war.

Program highlights	Increase in FY 1969
Atmospheric Sciences	$+170,000

Studies of the coagulation, deposition, and sampling of airborne particles; the transport and dispersion of stack effluents, accidental release clouds and nuclear explosion debris in the lower and upper atmosphere; and the scavenging of atmospheric contaminants by rain and snow will continue with less than a cost-of-living increase. The exceptional opportunities for clarifying dispersion and deposition over ocean surfaces, offered by the detailed meteorological and oceanographic background data to be collected in the 1969 Barbados Experiment of the inter-agency World Weather Program will be exploited to the extent that scientific manpower and equipment can be diverted from other on-going studies.

Radioactivity in Soils, Food and Man	+140,000

There will be further work at Lawrence Radiation Laboratory, Livermore, directed toward the movement, uptake, localization and turnover of radionuclides in plants and animals and in human organs, tissues, cells and sub-cellular structures. Some increase is planned for the small but very productive study of iron 55 in humans at Pacific Northwest Laboratory.

5. Environmental Radiation Studies - continued

c. Atmospheric Radioactivity and Fallout - continued

	Increase in FY 1969
Other Studies	$+ 50,000

Because of the declining amounts of radionuclides in the atmosphere, work is necessary to improve and refine methods of analysis for radionuclides and to develop activation analysis techniques for using stable elements as meteorological tracers. Studies of fallout formation and source effects will be continued at the present level of effort.

Total	$+360,000

Atmospheric sampling will be continued at its presently reduced level, primarily with the objective of improving fallout predictions. A readiness capability will be maintained to resume the large-scale high altitude atmospheric sampling program in the event of renewed stratospheric testing.

Micrometeorological studies of the rise of hot stack plumes, turbulence, and transport are undertaken at several locations, and these are useful in the development of a model for urban air pollution in addition to their direct program interest in reactor siting.

The biomedical laboratory at Lawrence Radiation Laboratory, Livermore, will be completed by FY 1969, but full occupancy will not occur until FY 1970 or later. The program has a direct influence on nuclear device development and test planning in both the Weapons and Plowshare programs and has many applications in other areas of nuclear technology. It deals with the prediction of fission product and induced radionuclides in device and environmental materials, the documentation of the chemical and physical forms of the radionuclides including particle size distributions, and transport of the various physical and chemical species through the air, soil, ground water, fresh- and salt-water environments, the effects produced by their uptake, localization and turnover in plants and animal organs, tissues, cells and subcellular structures, possible means of reducing human exposure by countermeasures at any step in the above sequence, and some studies of radiation effects at the subcellular level. The studies include both theoretical and experimental approaches, supplemented by a comprehensive information integration system for collecting, analyzing, abstracting, collating and summarizing the available world-wide literature on topics selected on a priority basis.

6. Radiological and Health Physics and Instrumentation $7,500,000

a. Radiological and Health Physics ... FY 1967: $4,192,836; FY 1968: $4,200,000; FY 1969: $4,350,000

The objectives of this program are to acquire a detailed understanding of the basic physical processes whereby radiation interacts with matter, and provide a comprehensive description of the spatial and temporal distribution of the radiation interaction products. A knowledge of the fundamental processes which precede radiobiological change is prerequisite to the complete interpretation of radiobiological effects, to the improved design of radiobiological experimentation, and to the formulation of advanced radiobiological dosimetry. The research program in health physics is directed toward the acquisition of information and techniques required for the development of radiation protection procedures.

Program highlights	Increase in FY 1969
Radiological Physics	$+ 50,000

A new experimental project is planned at Oak Ridge National Laboratory to study fundamental radiation interaction mechanisms in liquids.

Health Physics	+100,000

Increased efforts are planned in the current program developing techniques and procedures for the evaluation of hazards associated with uranium mining.

Total	$+150,000

Information and methods for the protection of people against excessive exposure to radiation will be further developed. This will include the assessment of natural and artificial radioactivity, the estimation of external and internal radiation dose and the formulation of exposure standards.

Underlying the experimental program are theoretical radiation physics studies at both Argonne National Laboratory and Oak Ridge National Laboratory. There are also plans to initiate projects directed at a detailed characterization of the secondary electron degradation spectra in a variety of media, and at the specific energy absorption mechanisms involved.

6. Radiological and Health Physics and Instrumentation - continued

a. Radiological and Health Physics - continued

The remainder of the radiological physics program includes studies of electron interactions in gases and solids, photoexcitation and photoionization studies, heavy particle ionization phenomena, excited state lifetimes and energy transfer mechanisms, and microscopic distribution of deposited energy.

The internal dosimetry project at Oak Ridge National Laboratory is the major program in this country directed toward the development and evaluation of data relevant to the formulation of internal dosimetry recommendations for radioisotopes encountered in health physics operations.

The application of radioisotopes in medical diagnosis is undergoing rapid development. To meet dosimetry concerns within this discipline, an expansion is planned in the off-site program to initiate projects directed toward internal dosimetry evaluations for these particular radioisotopes. Other off-site programs include accelerator stray radiation dosimetry, development and application of inter-comparisons techniques for various neutron detectors, and studies of aerosol filter techniques and performance.

The program at Argonne National Laboratory which developed instrumentation and techniques for the measurement of the natural radiation background will reach a successful completion.

b. Radiation Instruments ..... FY 1967: $3,465,723; FY 1968: $3,040,000; FY 1969: $3,150,000

The objective of the instrumentation program is to advance radiation protection techniques and biomedical research by developing new and improved instruments.

Program highlights	Increase in FY 1969
The limited increase will be directed to the development at Pacific Northwest Laboratory and Rocky Flats of apparatus for mapping the distribution of plutonium in wounds and a detector probe for final localization during surgery, the development of dosimeters and air monitors for use in uranium mines, and the development of apparatus for neutron spectroscopy to energies of 100 MEV.	
Total	$+110,000

6. Radiological and Health Physics and Instrumentation - continued
   b. Radiation Instruments - continued

The present program consists of studies which are expected to continue at or slightly below the current level of effort. Investigations are in progress to (1) improve the performance of radiation instrument components (synthesis of liquid scintillators, scintillation mechanisms in sodium iodide, development of rare earth doped scintillators, and enhanced resolution and internal amplification in semiconductor devices); (2) improve dose measurements (calorimeters for absolute energy absorption measurements, tissue equivalent detectors, and electrometers, semiconductor and gas counting systems for the localization and measurement of internal emitters, and thermoluminescent systems for low-level personnel and environmental gamma dosimetry); (3) improve radioactivity analysis (gamma spectrum statistics, background suppression techniques and low-level beta counters); (4) develop new biomedical instruments (in vivo dosimeters, the applications of image intensifier tubes to light microscopy, radioisotope scanners for human and animal studies, pattern recognition devices for analysis of chromosomes, radon personnel dosimeters, field ion microscope and a scanning electron microscope); and (5) research in the ultra purification of semiconductor materials.

7. Chemical Toxicity $631,000

The basic objectives of this research are to develop information for use in setting and maintaining adequate health and safety standards.

Program highlights	Increase in FY 1969
The level of effort for this research category will continue at approximately the FY 1968 level. However, new activities involving potentially toxic chemicals (primarily at the University of Rochester) will be initiated.	
Total	$+31,000

Studies are conducted on the toxicity of both radioactive and non-radioactive materials that are associated with the production or utilization of the products of nuclear energy programs. In some instances the chemical toxicity may present a greater hazard than does the radiation associated with the element or compound. These studies are basic to the design of safe and effective working conditions in the atomic energy industry.

8. Nuclear Energy Weapons Effects Studies $1,120,000

a. Nuclear Energy Civil Effects ... FY 1967: $1,263,724; FY 1968: $1,100,000; FY 1969: $1,120,000

This research program is directed toward developing nuclear effects data from theoretical, laboratory and field experiments. These data are required so AEC can fulfill its responsibilities to supply data on weapons effects and appropriate countermeasures for non-military defense, emergency preparedness planning, and for use in AEC's own activities. The emphasis is on developing nuclear effects data which have immediate practical application value.

Program highlights	Increase in FY 1969
The civil defense research project at Oak Ridge National Laboratory, supported by the AEC, the Office of Civil Defense and the Advanced Research Projects Agency, will continue its activities. The group is expected to look at the effect of a nuclear attack upon nuclear power plants.	
Nuclear effects research will take advantage of unique capabilities at the Nevada Test Site.	
Total	$+ 20,000

The Civil Defense Research Project at Oak Ridge National Laboratory is directed toward advanced systems for population defense in the 1970's with special reference to urban populations. The interdisciplinary staff defines and evaluates the characteristics, capabilities and costs of future civil defense concepts appropriate to evolving nuclear weapons systems, giving due consideration to strategic, engineering, scientific and social feasibilities and the interactions of passive and active measures for the defense of the U. S.

In FY 1969 AEC-supported work will include these studies: (1) the employment and operational effectiveness of nuclear power systems during and after nuclear war; (2) biological threats to shelter populations and countermeasures. Experimental investigations will be made of the flash sterilization of air by intense ultra violet light and laser beams, with the objective of killing organisms at low temperatures. Further analysis will be made of advanced, low cost biological detectors which provide rapid, reliable

8. Nuclear Energy Weapons Effects Studies - continued
   a. Nuclear Energy Civil Effects - continued

detection in a large area; (3) investigation of biological response of food sources and supplies to nuclear effects to define the requirements and time scale for the resumption of practical, large scale food production; and (4) analysis of preattack preparations and requirements essential to postattack productive operations.

Human Dosimetry Research

Most of the analysis and reporting for the High Energy Neutron Reactions Experiment (Operation HENRE) will be complete, and the data on elastic and nonelastic interactions of neutrons with air will be used in progressive interpretation of data which have a bearing on the dosimetry for Japanese survivors. Calculation of the yield for the Hiroshima bomb will have been completed by Los Alamos Scientific Laboratory for essential refinements of the neutron yield values. For Atomic Bomb Casualty Commission, effort will be required for coordinating the study of the combined effects of thermal radiation, ionizing radiation and blast. Active liaison with ABCC investigators will be maintained, and the research will include the cases of certain heavily-shielded survivors. There will be a continuation of the efforts to relate external radiation field measurements to the dose to specific loci in the body or in the bodies of large animals with practical new instruments. A study will be made of the feasibility of obtaining valuable data through the use of Weapons Spectrum Generator coupled with the HENRE neutron source when operated at heights up to 1500 feet above ground. The research in this category which leads to the correlation of biomedical data with the physical data, predominantly radiation dose, is essential for estimating the long-term hazards from peaceful uses of atomic energy, accidental release of large quantities of radioactive material, space exploration, and the planning of non-military defense.

Technical, scientific and logistic support will be provided for personnel engaged in biological and ecological research for the Division of Biology and Medicine.

   b. Biological and Environmental Consequences of Nuclear War ..... FY 1967: $90,226; FY 1968: $ -0-; FY 1969: $ -0-

Studies under this program, designed to evaluate the consequences of nuclear war as they should influence health and living environment, have been completed.

94-075 O-68-pt. 3—32

9. Cancer Research $6,020,000

Research objectives are to discover, develop and perfect new and unique applications of radioisotopes for the diagnosis and treatment of cancer, to explore the use of high energy radiation sources in therapy, and to understand the mechanisms of radiation in both the induction and treatment of cancer.

Program highlights	Increase in FY 1969
An attempt will be made to develop and perfect the diagnosis and treatment of cancer by studying the metabolic patterns of tumors. The increasing availability in variety and quantities of short-lived isotopes offers considerable promise in nuclear medicine. The present plan to provide several small cyclotrons during the next few years for the production of these isotopes at clinical research centers will permit expanded effort in this important area. Of particular interest is the availability of californium 252, which has the property of spontaneous fission, for clinical studies.	
Total	$+220,000

The cancer research program has three components each of which is intended to enhance understanding of cancer biology, to improve therapy, and as an ultimate goal, to prevent the onset of cancer.

Metabolic aberrations. Research within this subcategory is aimed at an understanding of those early events which distinguish the neoplastic cell from the normal. Biochemical, cytologic and immunologic studies of the tumor and of the host are aimed at an understanding of differences between the two which might explain the complexities of the carcinogenic process. Within the coming year, particular work will be expanded in the cytogenetics program at Oak Ridge Associated Universities. Under examination will be the relationship between radiation produced changes in the genetic mechanism to ultimate malignant change.

Diagnostic applications. This subcategory includes studies of new radioisotopes for both dynamic and localization studies in nuclear medicine. The majority of these procedures are of particular importance in early tumor diagnosis.

The installation of a small cyclotron at Argonne Cancer Research Hospital within the coming year will provide the opportunity to explore the use of this instrument in producing short-lived radioisotopes for clinical use. It is hoped that these new nuclides which cannot be produced by other means will also reduce the radiation exposure of the patient.

9. Cancer Research - continued

A new program at Oak Ridge Associated Universities will make a major contribution to the practice of nuclear medicine by collecting dose data in specific organs from standard and experimental radiopharmaceuticals.

Therapeutic applications. The third facet of the cancer program is aimed at the development of radiation techniques useful in cancer therapy. This may take the form of injected nuclides, implanted sources or external generated beams. Two potential sources of teletherapy, neutrons and pi mesons are currently attracting widespread interest and may represent therapeutic advantages in overcoming the radiation resistance of anoxic tumor cells. Although clinical therapy has not yet been undertaken, preliminary radiobiological studies are anticipated within the current year.

A new radiation source which may have application in the treatment of externally accessible tumors such as those of the oropharynx is californium 252 which has the property of spontaneous fission. Sources developed at Savannah River have already been delivered to Brookhaven National Laboratory for preliminary animal studies.

At Lawrence Radiation Laboratory, a new use for the computer is being found in cancer radiation therapy. Researchers are speeding and improving the localization and radiation of the proton beams to the area of the pituitary fossa by computer-aided calculations.

10. Selected Beneficial Applications $3,420,000

The objectives of this program are to develop new applications of radiation and radioisotopes for unique diagnosis and therapy in medicine; basic studies of organs and organ systems in health and disease; control and elimination of insects, weeds, and plant diseases, as well as improvement of farm animal productivity and an increase in knowledge of animal diseases.

Program highlights	Increase in FY 1969
Medical Research	$+ 80,000

Unique uses of radiations and newly available radioisotopes will be investigated for use in the diagnosis, characterization, treatment, and control of diseases other than cancer and for basic studies of organs and organ systems in health and disease.

10. Selected Beneficial Applications - continued

Increase in FY 1969

Medical Research - continued

An increase in research effort at Brookhaven National Laboratory will be directed to determining the role of trace metals and free radicals of irradiation origin on biological systems. In addition, studies will be intensified on the efficacy of Dopa and L-Dopa for therapy in Parkinsons disease.

Biological Research ..... $+ 40,000

Principal emphasis will be in the area of immunological aspects of parasitic infection.

Total ..... $+120,000

Continuing research effort will be directed to determining hematologic responses of patients following large doses of internally administered isotopes for therapy, and on studies of tagged iron 52 and fluorine 18 bone marrow transplants. An increase in effort will also be directed to development of a fast pulse Linac System designed to make available free radicals of biologic significance for study.

Emphasis in the medical area will be directed to the development of new diagnostic procedures for diseases other than cancer. Research effort will be increased in improving techniques for the evaluation of organ function, measurement of regional blood flow, studies of gastrointestinal absorption, and assessment of tissue damage, useful in diagnosis and treatment of diseases. Particular emphasis will be placed on the development of these nuclides for scanning, possible use in radiopharmaceuticals, and for studies of metabolism in normal and diseased states. Studies will be undertaken to exploit recent developments in radionuclide microdetectors that are used in determining regional blood flow, detecting hemorrhage in localized areas, and identifying metabolic abnormalities in internal organs.

Radioisotopes are used in biological and agricultural research in studying pest control, crop improvement and animal nutrition. In addition, work in this category is directed towards development of new techniques using radiation, nuclear by-products and concepts in solving agricultural problems.

Examples of the investigations included in this category are: the use of selected radiation-induced mutations in crop improvement, exploration of the potential use of radiation-induced aberrations in insects which might lead to possible insect control measures, use of radioactive labeled materials in studying the mechanism of action of insecticides and synergists, and the utilization of radiation and radioisotopes to elucidate metabolic, nutritional and disease situations of importance to agriculture.

11. Radiation Preservation of Foods $450,000

The objectives of this program are to determine the basic chemical changes, nutritional adequacy, wholesomeness, and microbiological safety of selected perishable foods which have been subjected to low-dose (below 1 Mrad) irradiation for the purpose(s) of storage-life extension and/or control of pathogenic microorganisms (e.g., Salmonellae). Studies in this category are required, directly or indirectly, to fulfill Food and Drug Administration (FDA) requirements pertaining to approval of such low-dose irradiated foods for public consumption.

Program highlights	Increase in FY 1969
The Food and Drug Administration has established a requirement for more lengthy and consequently more costly studies prior to approval of low-dose irradiated foods for public consumption.	
Total	$+10,000

The Division of Biology and Medicine's portion of the food irradiation program consists of four general areas: food chemistry, microbiology, wholesomeness, and cytogenetics.

Food Chemistry includes those studies concerned with the effects of radiation on naturally occurring tissue substrates and with the characterization of the changes (quantitative and qualitative) in terms of chemical, biochemical, and physiological parameters. Studies to be undertaken in FY 1969 will include detailed investigations of the pre- and post-irradiation composition of certain foods generally accepted as being closely related to each other. Data from these studies are needed in order to support requests that FDA allow extrapolation of feeding-study data between these foods.

Microbiology includes those studies concerned with the effect of radiation on the naturally occurring microbiological flora of the foods of interest to the program. Microorganisms of interest include both those of public health significance (Clostridia, Salmonellae, Staphylococci, Streptococci, certain viruses, etc.) as well as those which are entirely of economic (spoilage) significance. Studies will also be conducted to explore the ecological relationships existing between the two groups and to determine the effect of irradiation on those relationships.

11. Radiation Preservation of Foods - continued

Wholesomeness includes those studies conducted relative to nutritive value, possible carcinogenicity, and possible toxicity of low-dose irradiated foods. These studies consist primarily of long-term toxicity studies conducted in accordance with FDA-approved protocols and involving two-year feeding studies on three species of laboratory animals. Among the foods being considered for study are papayas and mangoes.

Cytogenetics includes those studies conducted to investigate possible effects of oral consumption of irradiated foods on cell survival and reproduction in appropriate mammalian species (e.g., rat, mouse, pig, etc.).

A companion program to determine radiation processing parameters, storage-life extension, and acceptability to the consumer and to develop suitable radiation source facilities for irradiation of foods is managed and budgeted within the Isotopes Development program.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

BIOLOGY AND MEDICINE - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$12,439,000
A Construction Projects	
A-1 Obligations for new projects	($ 950,000)
A-2 Obligations for prior year projects	($ 4,789,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 5,000,000)
B-2 Obligations from prior year appropriations .	($ 1,700,000)
Estimated Obligations FY 1968	$ 5,377,000
Actual Obligations FY 1967	$11,620,912

Obligations for the Biology and Medicine Program for FY 1969 are estimated at $12,439,000, of which:

a. $950,000 is for the construction projects justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $4,789,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $5,000,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $1,700,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION A-1

The projects comprising Section A-1, which are requested for authorization in FY 1969 are:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-8	General plant projects	$ 950,000	$ 0	$ 950,000	$ 0
	Total	$ 950,000	$ 0	$ 950,000	$ 0

EXPLANATION OF PROJECTS IN SECTION A-1

1. Project 69-8 General plant projects $950,000

The purpose of this project is to provide for miscellaneous alterations, improvements and minor additions to research facilities of the biomedical research program necessary to improve efficiency of operation, correct actual or potential operating hazards and facilitate advances in research. The estimate, based on past experience as to requirements, will cover the necessary improvements at Commission operated laboratories in the life sciences, as well as minor construction or alterations required by biology and medicine Commission supported research at universities and other research institutions. A tentative breakdown of the estimate by area is as follows:

Albuquerque	$225,000
Chicago	$ 20,000
New York	$105,000
Oak Ridge	$285,000
San Francisco	$245,000
Washington Headquarters.	$ 70,000

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-6	General plant projects	$1,000,000	$ 900,000	$ 100,000	$ 0
67-5-a	Biology laboratory, Pacific Northwest Laboratory, Richland, Washington	5,000,000	361,000	4,639,000	0
65-7-c	Biomedical and animal laboratory, Lawrence Radiation Laboratory, Livermore, California	3,500,000	3,450,000	50,000	0
	Total	$9,500,000	$4,711,000	$4,789,000	$ 0

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Total Biology and Medicine	$5,000,000

JUSTIFICATION

Biology and Medicine Capital Equipment Not Related to Construction $5,000,000

A budget for capital equipment not related to construction in the amount of $5,000,000 is requested to support the biomedical research program. Research in the life sciences is becoming increasingly more precise and consequently

SECTION B-1 - continued

requires more elaborate and sophisticated equipment. Radiations of a wide variety of intensity and of a diversity of type are being utilized in most laboratories conducting research in radiation biology, and this requires equipment of greater sensitivity and reliability than that presently available. In addition, as the complexity increases, the cost is higher. Major costly items such as electron microscopes, spectrometers, various types of accelerators and ultracentrifuges are becoming increasingly necessary in the biomedical research program. In addition to the normal needs commensurate with proposed levels of research, this budget includes several large items of significant cost, but with no single item costing $500,000 or more. A listing of major equipment acquisitions currently planned is presented. Final procurement actions are subject to the then existing demands of the programs and may vary from the itemization below:

Major Equipment Acquisitions

Lawrence Radiation Laboratory - Berkeley		$ 300,000
Additional stereotaxic apparatus for humans needed to irradiate any part of the human anatomy with high energy particles produced at the 184" cyclotron and other accelerator facilities at Berkeley	$150,000	
A high resolution (220 Mc Proton) NMR spectrometer for the Chemical Biodynamics group to pursue the detailed configurational changes of proteins and nucleic acids	150,000	
Lawrence Radiation Laboratory - Livermore		110,000
A mass spectrometer which will permit a systematic elemental analysis of particle samples over the whole mass range especially needed for those elements which cannot be determined by x-ray fluorescence.		
Oak Ridge National Laboratory		555,000
Liquid waste sterilization system required to decontaminate waste in Virus Control Laboratory	100,000	
X-ray diffraction supplementary equipment required by Biophysics Group for studies on protein structure	105,000	
Animal containment units required to house and provide germ-free facilities for maintaining animals	200,000	
Equipment for tissue culture laboratory	150,000	

SECTION B-1 - continued

Oak Ridge Associated Universities	$ 100,000
Array scanner to permit immediate collection and analysis of data while patient is undergoing scanning.	
Off-Site - Washington Designated Contracts	300,000
Cyclotron for production of short-lived isotopes at a location to be selected (contractors under consideration for these machines include University of California, Vanderbilt University, University of Alabama, and University of Missouri).	
Sub-total Major Items	1,365,000
In addition to the specific requirements identified above, the biomedical laboratories and major off-site research projects require funds for normal replacements and miscellaneous new equipment	3,635,000
Total Capital Equipment	$5,000,000

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Total Biology and Medicine	$1,700,000

MANDATORY INCREASES

Mr. MORRIS. The authorization bill has allowed $1,050,000 of the budgeted increase of $3,601,000. How much of this increase do you consider mandatory for fiscal year 1969?

Dr. TOTTER. It is difficult to answer that.

Mr. MORRIS. I know it is a hard question.

Dr. TOTTER. Estimates have been made recently of the cost of continuing scientists at a steady level without counting in escalation. These estimates run about 3½ percent per year, without any change in the price of the dollar. So, obviously, if our increase is only 1.2 percent, this means a reduction.

URANIUM MINERS STUDIES

A large part of the $1,050,000 would be used in intensifying the uranium miners' study, a subject which has received the attention of several committees of the Congress. It will make it much more difficult for us to do that, if any of the $1,050,000 is not forthcoming although we fully intend to pursue the studies.

Mr. MORRIS. Will you provide for the record the status of the program in reference to the problem of radiation exposure of uranium miners, which received a great deal of discussion last year?

Dr. TOTTER. Yes, I will.

(The information follows:)

U. S. ATOMIC ENERGY COMMISSION
DIVISION OF BIOLOGY AND MEDICINE
RESEARCH RELATED TO THE RADIATION EXPOSURE OF URANIUM MINERS

	FY 1967	FY 1968	FY 1969
1. Development of Samplers of Mine Air			
a. Rapid Detector for Radon and Radon Daughters in Mine Air			
Health and Safety Laboratory, New York, New York (J. H. Harley and A. J. Breslin)	$ 68,000	$ 70,000	$ 80,000
A scintillation-photomultiplier, two-filter device for spot sampling of both Rn and Rn-daughters in mine atmospheres is under development. The minimal sampling time is 10 minutes. A recent field test has been successful. It is portable, battery-powered and self-contained and could be set for repeat automatic cycling if line powered. It requires further development and ruggedizing.			
b. Monitor for Simultaneous Measurement of Radon and Radon Daughters			
Massachusetts Institute of Technology (R.D.Evans)	40,000	40,000	40,000
This is conceived of as a research tool for simultaneous measurement of concentrations of radon and attached and unattached radon daughters but could also be used for routine monitoring on a 30 minute cycle; it is not readily portable at present. A prototype was built in 1963; work has begun on re-evaluation, development and redesign with modern microcircuitry and a surface barrier silicon detector. Following lab tests there will be a test of its use in mines.			
	$108,000	$110,000	$120,000
2. Development and Evaluation of Personnel Dosimeters			
a. Dosimetry and Instrumentation Techniques in Applied Radioactivity			
Massachusetts Institute of Technology, Cambridge, Mass. (R.D.Evans)	99,129	133,919	140,000
This is a broad program investigating the late effects in man of internal exposures to radium in movement of radon from source; a			

	FY 1967	FY 1968	FY 1969
technique involving the creation of slight overpressures will, in some instances, impede the movement of radon from mine walls, thereby reducing the ambient radon concentration. The level of effort has been considerably increased in the development of a personnel dosimeter and a portable air monitor for radon daughter products. Four types of detectors are under investigation simultaneously for the miniature electronic counter. The air monitor will utilize a semiconductor detector.			
b. Personnel Dosimeter for Radon Daughters			
Eberline Instruments Corporation, Santa Fe, New Mexico	$ 0	$ 33,157	$ 0
The total Eberline program is devoted to the development of a radon daughter product, personnel dosimeter and a portable air monitor. A number of years ago, Eberline developed a film badge which depended on free diffusion of radon through the badge case. The badge was not a successful dosimeter for airborne daughter products so it was modified to admit radon only. A dosimeter now under development incorporates a miniature pump to load a filter which is in close proximity to a film. The dosimeter is intended to admit and detect daughter products. Eberline now markets a set of assemblies which can be used to monitor mine air. These assemblies are being engineered to a single package which will constitute a portable air monitor.			
c. Radon Daughter Products Inhalation Study: Correlation of Deposition and Retention in Human Lungs with Aerosol Characteristics and Exposure Conditions.			
Colorado State University, Fort Collins, Colorado (A.H. Dahl and K. J. Schiager)	70,189	55,000	60,000
This project under the direction of Drs. Dahl and Schiager involves field studies in a Colorado uranium mine for the evaluation and control of radon daughters inhalation exposure. These studies were initiated two years ago and have led to the determination of deposition and retention of radon daughters in humans. The objectives of this study have been threefold and are as follows:			

	FY 1967	FY 1968	FY 1969
1. To investigate the general relationships of the physical characteristics of mine aerosols and exposure conditions to the deposition, retention, and translocation of the radioactive materials. This includes use of the whole body counter which was provided eight years ago by DBM to the Colorado State Department of Public Health at Denver.			
2. To investigate various exposure surveillance methods.			
3. To investigate the effectiveness of various methods for controlling exposures to radon and its daughters in mine atmospheres. This includes both laboratory and field testing of the positive pressure air purifying respirator developed through a contract with Harvard School of Public Health and further improved by Mr. Burgess.			
d. New Research	0	0	51,000
	$169,318	$222,076	$251,000
3. Characterization of Mine Air			
Assessment and Control of Radioactive Air Contaminants			
Health and Safety Laboratory, New York, New York (A.J. Breslin)	32,000	35,000	85,000

A part of the Health Protection Engineering Division program is engaged in the development of apparatus and techniques for determination of aerosol concentrations and for the collection, counting and sizing of particles, both microscopic and sub-microscopic. They have the task of characterizing mine atmospheres with respect to radon daughter concentrations and the distribution in size of the particles to which they are attached. At the present time, they have no satisfactory way of determining both the size of a sub-microscopic particle and whether or not it previously had a radon daughter attached to it. One device under development at HASL may solve this problem.

	FY 1967	FY 1968	FY 1969
4. Basic Inhalation Studies			
a. Radiobiology of Radon and Inhalation Studies of Alpha Emitters			
University of Rochester - AEC Project (D.A. Morken and P.E. Morrow)	$194,000	$191,000	$198,000
The University of Rochester has had a continuing program over a number of years concerning the biological effects of various radionuclides including radon and its decay products in animals. Besides quantitating the radiation effects from these nuclides, the work also contributes to a firmer basis for estimating various factors needed for maximum permissible concentration calculations as employed by the ICRP and NCRP. Characterizations of inhaled radioactive dust and associated radioactivity in the handling of this dust by the body, especially by the lungs, are important in this regard.			
b. Inhalation Hazards to Uranium Miners			
Pacific Northwest Laboratory, Richland, Washington (B.O. Stuart)	100,000	195,000	200,000
An active program is underway at Pacific Northwest Laboratory to determine the tissue distribution of uranium and thorium following inhalation of uranium ores by rats and dogs and the possible relationship of these factors in the instance of lung cancers among uranium miners. In addition, specimens of lung tissue from miners are being studied by neutron activation analysis to detect any difference in selected metallic components that may be relatable to the induction of lung cancer.			
	$294,000	$386,000	$398,000

	FY 1967	FY 1968	FY 1969
5. Basic Studies on Aerosols			
a. The Electrical Charging of Small Particles			
University of Minnesota, Minneapolis, Minnesota (K.T. Whitby and B.Y.H. Liu)	$ 39,228	$ 40,000	$ 40,000
These investigators have studied the electrical charging of small aerosols at reduced pressures and in the course of their research have developed an electrostatic aerosol sampler based on the electrical mobility of charged aerosols in the range of 0.03 - 3.2 microns. The collected samples are amenable to both optical and electron microscopy.			
b. Fundamental Investigations of the Behavior of Aerosols			
California Institute of Technology, Pasadena, California (S.K. Friedlander)	17,992	0	20,000
Dr. Friedlander has developed a theory for the self-preserving particle-size distribution for coagulating sedimenting aerosol systems. He has also developed models for deposition processes in lung dynamics.			
c. Properties of Aerosols			
University of Rochester - AEC Project (T.T. Mercer)	117,000	145,000	150,000
The technical skills and theoretical knowledge available at the University of Rochester (Morken, Mercer, and Morrow) are at the disposal of the Uranium Miners Program. This group is especially skilled in characterizing physically the aerosols that may be found in the mines.			
d. Aerosol Technology			
Health and Safety Laboratory, New York, New York (A.J. Breslin)	54,000	68,000	72,000
The Laboratory studies the fundamental properties of aerosols and			

	FY 1967	FY 1968	FY 1969
develop methods of aerosol generation and measurement to advance the understanding of aerosol dispersion, to improve air cleaning and air sampling, and to provide techniques for use in studies of radioactive air contaminants.			
	$228,220	$253,000	$282,000
6. Basic Instrumentation Studies			
a. Contoured Semiconductor Radiation Detectors			
General Electric Company, Philadelphia, Pennsylvania (G.C. Huth)	91,128	105,000	115,000
This is a semiconductor detector and circuitry development program. A unique characteristic of one of the detectors is the ability to detect alpha particles without applying external voltage. There appears to be an excellent chance that this device can function effectively as the detector element in either a personnel dosimeter or an air monitor. This is under investigation.			
b. Investigations of the Application of Image Intensification Systems for Microscopic Observation			
Princeton University, Princeton, New Jersey (Geo. Reynolds)	52,500	44,000	46,000
The Princeton program is primarily for the development of image intensifier assisted light microscopy systems with which very low light level sources are studied, e.g., luminous bacteria. Very small concentrations of radioactivity, which with autoradiography would take perhaps a month to visualize, can be mapped with Reynolds' technique in a few seconds. It is often necessary to determine the sizes of submicron particles which were the light sources. There appears to be a reasonable chance that this system can be used to map the distribution of radon daughters collected on a filter and subsequently determine the particle size. The feasibility of this method will be determined in collaboration with HASL.			

	FY 1967	FY 1968	FY 1969
c. Radiation Detection Instrumentation			
Health and Safety Laboratory, New York, New York	$712,000	$688,000	$693,000
This laboratory has a broad capability in the design and evaluation of radiation detection equipment, personnel dosimeters, particle-size sampling devices, etc. It is heavily involved with the problems associated with uranium mining.			
	$855,628	$837,000	$854,000
7. Distribution of Radionuclides in Human Tissue			
a. Massachusetts Institute of Technology, Cambridge, Massachusetts (R.D. Evans)	245,706	291,474	320,000
This is a multi-lateral project associated with the epidemiology of radium in the watch-dial painters surviving from the 1920s. The project over the past 16 years has investigated many aspects of radium in the human body and its use as the benchmark for the toxicity of the internal emitter radioisotopes. The laboratory has an outstanding record in developing instrumentation for alpha emitters, whole body counting estimation of radon, etc. The origin and movement of radon in the biosphere has also been of special interest to this group.			
b. New Jersey State Department of Health (R.P. Kandle)	47,878	0	0
This study involves several hundred radium cases, many of them with relatively small body burdens. This program was undertaken to aid in the evaluation and determination of effects of long-term exposure to internal radioactive emitters, and to yield information required in the establishment of maximum permissible body burdens with greater statistical reliability than it was heretofore possible.			
Support of this project through the New Jersey State Department of Health has been terminated as of June 30, 1967. Follow-up of selected cases will be by Dr. Robley D. Evans of MIT.			

	FY 1967	FY 1968	FY 1969
c. New York University, Sterling Forest, New York (M. Eisenbud)	$ 38,068	$ 45,000	$ 50,000
This work supports the New Jersey Radium Dial Painter Project described above and is primarily involved in the radiochemical analysis of tissues and body burdens estimated by whole body counting techniques.			
d. Lovelace Foundation, Albuquerque, New Mexico	1,455,047	1,515,000	1,580,000
This project is studying the biological effects of several inhaled radionuclides. Isotopes of strontium, yttrium, cerium, cesium, ruthenium, iodine, barium and lanthanum have been administered to dogs and several smaller species. All of the isotopes are beta or gamma emitters and the main relevance of this work is the inhalation route of exposure. The organ deposition patterns, long-term toxicity and dosimetry estimates from this work may contribute to the general problem of inhaled radionuclides.			
e. University of Utah, Salt Lake City, Utah - AEC Project	682,087	750,000	770,000
Since 1954, this project has been studying the long-time biological effects of injected radium, barium and plutonium in dogs. Dosage levels were chosen to allow correlation with the human radium studies so that this project may form a link between the human exposure data and that for experimental animals. Information from this work on toxicity and dosimetry may be applicable to internally deposited uranium daughter products.			
f. Argonne National Laboratory, Argonne, Illinois, and Argonne Cancer Research Hospital, Chicago, Illinois	645,000	665,000	680,000
This group has been studying a large group of radium dial painters since 1937. This work has been important in the establishment of maximum permissible body burdens of radium nuclides based on radium. They are also doing uranium and thorium work which may relate to the problems with uranium daughters. The uranium portion of the study is concerned with the establishment of deposition patterns and their measurements.			

	FY 1967	FY 1968	FY 1969
g. Pacific Northwest Laboratory, Richland, Washington	$ 665,000	$ 695,000	$ 710,000
In addition to the studies described in item 4 above, there is a major program on the toxicity of inhaled radionuclides and factors modifying the clearance of particles from the lung. These studies may contribute to the understanding of the problems associated with uranium mining to the extent that they clarify some of the problems of aerosols and factors which modify clearance of inhaled material from the lungs.			
	$3,778,786	$3,961,474	$4,110,000
Total	$5,465,952	$5,804,550	$6,100,000

INCREASES BY ACTIVITY

Mr. MORRIS. Please provide for the record a breakdown by activity showing how the increase of $1,050,000 allowed in the authorization bill would be allocated.

Dr. TOTTER. Very well, sir.

(The information follows:)

U.S. ATOMIC ENERGY COMMISSION, DIVISION OF BIOLOGY AND MEDICINE, FISCAL YEAR 1969 BUDGET ESTIMATES

		Fiscal year 1968 estimate	Fiscal year 1969 authorization bill	Increase
06-01	Somatic effects of radiation:			
	06-01-01 Radiation effects, general	$16,100	$16,350	$250
	06-01-02 Toxicity of radioelements	9,950	10,110	160
	Total	26,050	26,460	410
06-02	Radiation genetics	7,330	7,420	90
06-03	Combating detrimental effects of radiation	1,950	1,960	10
06-04	Molecular and cellular level studies	16,300	16,400	100
06-05	Environmental radiation studies:			
	06-05-01 Terrestrial and fresh-water ecology	5,800	5,890	90
	06-05-02 Marine Sciences	3,900	3,900	0
	06-05-03 Atmospheric radioactivity and fallout	8,640	8,750	110
	Total	18,340	18,540	200
06-06	Radiological and health physics and instrumentation:			
	06-06-01 Radiological and health physics	4,200	4,250	50
	06-06-02 Radiation instruments	3,040	3,080	40
	Total	7,240	7,330	90
06-07	Chemical toxicity	600	600	0
06-08	Nuclear energy weapons effects studies:			
	06-08-01 Nuclear energy civil effects	1,100	1,100	0
	06-08-02 Biological and environmental consequences of nuclear war	0	0	0
	Total	1,100	1,100	0
06-09	Cancer research	5,800	5,900	100
06-10	Selected beneficial applications	3,300	3,350	50
06-11	Radiation perservation of foods	440	420	(20)
	Total, biology and medicine program	88,450	89,480	1,030

BIOLOGY LABORATORY, PACIFIC NORTHWEST LABORATORY

Mr. MORRIS. As outlined on page B & M 28, funds for construction of the biology laboratory for the Pacific Northwest Laboratory at Richland, Wash., have been deferred from the current fiscal year until fiscal year 1969.

Could you tell us the present status of the project, and why it would not be possible to defer the laboratory beyond 1969, considering the current fiscal situation?

Dr. TOTTER. A study was made a few years ago of the actual cost to us of having the work divided into two locations at Hanford. I do not remember the exact figures now, but there would be considerable extra cost to us if we did not consolidate in one building all the work of the biology division at Hanford.

This is one of the main reasons for going ahead with the building.

Mr. MORRIS. Provide for the record the precise figures from that study, if you will.

Dr. TOTTER. I will be glad to do that.

(The information follows:)

BIOLOGY LABORATORY, PACIFIC NORTHWEST LABORATORY, RICHLAND, WASH.

The need for a biology laboratory at PNL, Richland, has been pressing for a number of years and $5 million for its construction was appropriated by the Congress in fiscal year 1967. Since that time, engineering studies have been completed and it is hoped that actual construction can begin soon after July 1, 1968.

The laboratory is planned for performance of a wide variety of biological research studies. It will provide facilities in which to conduct research in radiation biology; it will contain quarters for housing and caring for colonies of large and small animals. Special facilities will be provided for performing inhalation toxicology, large animal radionuclide metabolism and toxicity, physiology, pathology, ecology, and aquatic biology studies primarily related to the effects of specific radionuclides and radiation on living systems.

Present laboratory buildings are entirely inadequate for the important studies being undertaken at Richland. The main buildings are vacated process buildings and were constructed nearly 20 years ago. The need for the new laboratory became even more acute when all other AEC operations in the vicinity of the biology laboratory were terminated. This meant that an entire area of the Hanford reservation had to be maintained for the relatively small biology operation. It is located more than 20 miles from the rest of the PNL which imposes operational as well as scientific problems. In 1964, the aquatic biology laboratory was destroyed by fire and this program has been maintained in makeshift quarters in anticipation of new facilities.

Apart from the urgent scientific need for a building, probably one of the most significant reasons for early completion of the project is the $300,000 annual cost saving which will accrue from using the new facility. These savings result from reduced maintenance costs, reduced utilities costs, and the termination of isolation pay and excess transportation costs. In addition, normal maintenance of the present facility has been deferred because of the realization that the building would be deactivated. A recent check of needed facilities repairs indicated that a minimum of $175,000 will have to be spent in fiscal year 1969 to bring the facilities to a reasonable performance level if construction of the new laboratory is not started promptly.

In summary, the need for the new biology laboratory has become more urgent than in the past and the proposed facilities will be more economical and more productive. Approximately $25,000 will be saved for every month which construction can be advanced.

CAPITAL EQUIPMENT

Mr. MORRIS. A total of $6,700,000 is budgeted for capital equipment for the biology and medicine program in fiscal year 1969, including a carryover of $1.7 million.

What type of inventory control system does the Commission maintain over the biology and medicine program to assure full utilization of equipment and to prevent stockpiling of unnecessary quantities?

Dr. TOTTER. In our program this is done in the regular process of evaluating the results of the program. We do have a system of identifying and reporting as excess any equipment when it becomes unneeded.

As I recall, there is very little equipment from the B. & M. program that has been declared surplus, indicating rather complete utilization of most of the material that we have.

Mr. ABBADESSA. Mr. Chairman, we have a contracts division which looks at this from a broad administrative viewpoint in addition to the programmatic review. Among the things they do is receive reports of the inventory level of various classes of equipment, using the GSA breakdown. They review those periodically to determine that the amounts of equipment on hand do not become disproportionate to the level of operation.

They also have issued guidance related to economic ordering quantities.

I believe this is under reasonable administrative control, and we could have a brief writeup placed in the record to explain this activity in more detail.

Mr. MORRIS. The committee would like you to do that, if you will.

(The information follows:)

The information requested is set forth on page 664 in response to the question: "What assurance do you have that there is not surplus equipment in the current inventory?"

Dr. TAPE. I can add one further remark, Mr. Chairman, as a man who once had responsibilities in a laboratory; namely, these funds are not adequate to satisfy the needs of the scientists, and they scrounge equipment from the other fellow whenever they find it.

MARINE RESEARCH VESSEL

Dr. TOTTER. If I may, Mr. Chairman, I might mention one piece of equipment which is very important to us at the Puerto Rico Nuclear Center—this is the research vessel requested. I do not know whether you have a question on that.

Mr. MORRIS. Yes. I planned to ask what is involved in this $300,000 request and why is it essential in fiscal year 1969?

Dr. TOTTER. I might answer this best by saying that the request did not appear in our regular budget this year because our friends at Puerto Rico were frantically trying to locate another ship of the same sort as this one. It was obtained from the Department of Defense several years ago without cost to AEC and modified at a cost of about $40,000 to make it seaworthy for their purposes. It has now deteriorated to the point that it is not too safe to take out.

After checking with all the possible sources for another vessel, it was found that the Department of Defense have all their seaworthy vessels tied up, either employed or frozen for their use, as one might expect. It is only recently that we have come to a dead end in attempting to get another vessel of the sort we had.

(Off the record.)

Mr. MORRIS The gentleman from Tennessee.

Mr. EVINS. I have no questions. I wish to commend Dr. Totter for his great effort. We have emphasized in this committee over the years the importance of moving forward in the peaceful uses of atomic energy, including your field of biology and medicine.

I want to suggest again that the percentage of effort is very low at this time in this field as compared to the weapons program.

RADIATION PRESERVATION OF FOODS

Dr. TOTTER. I might comment that in our food preservation program we are running into the fact that we do not have enough basic research completed, so we start out trying to make applications on an inadequate foundation of fundamental knowledge. This has really caused us difficulty.

RESEARCH PROGRAM, BIOLOGY DIVISION, ORNL

Mr. EVINS. Would you supply a statement for the record elaborating on the achievements and accomplishments of the Oak Ridge Laboratory in the field of biology and medicine?

Dr. TOTTER. I shall be glad to.

Mr. EVINS. Thank you, Mr. Chairman.

(The information follows:)

RESEARCH PROGRAM OF BIOLOGY DIVISION, OAK RIDGE NATIONAL LABORATORY

The Biology Division of the Oak Ridge National Laboratory as well as other biomedical laboratories supported by the Division of Biology and Medicine is an excellent example of a laboratory that has achieved a reputation for excellence in both basic and applied biological research. On initiation of this laboratory in 1947, it was understood by the director and his staff that it was essential to carry out programmatic research to obtain data needed for estimation of radiation hazards. As a result, the large-scale programmatic studies were initiated in mammalian genetics and in radiation physiology and pathology. In accepting this responsibility, however, it was emphasized that a broadly based program in basic research was also essential to provide fundamental information for interpretation of radiation effects on living organisms at the molecular and cellular levels of organization.

As a result of this approach to laboratory research, many important contributions in both basic and programmatic research have been made and effective interaction between investigators in the basic and applied areas of research has been maintained.

The important work of Dr. W. L. Russell and his coworkers in mammalian genetics continues to provide information needed for more precise estimation of the genetic hazards of radiation to man. The results obtained in this work over the years have demonstrated that the frequency of mutations induced by radiation in the mouse varies significantly with changes in dose level, dose rate, type of radiation used, as well as sex of the mouse exposed. Results of these studies have not only provided information on levels of radiation effect but also indicate that mechanisms exist in the young germ cells (early oocytes) of female mice which may repair the initial genetic lesions induced by radiation. Because of the importance and interest of other groups in the Division in knowing the types of changes induced in the genetic material at the molecular level, as well as the potential for repair of such damage, considerable information and experimental techniques are readily available for use in the mouse to study such repair systems. In addition interaction of the microbial, insect, and mammalian geneticists have led to an organized program of research in comparative chemical mutagenesis (a program which is of considerable programmatic interest) and as a result a small joint research effort between the AEC and the National Institutes of Health has been initiated.

Because of the need to know more precisely the effects of radiation on individual organisms that are irradiated, as opposed to their progeny (genetic studies), investigations were started early to determine the effects of acute and chronic exposures on both early and late effects of moderate to high doses of radiation (for example: lifespan shortening, carcinogenesis). In addition, related investigations to identify the sensitive systems contributing to the end effects and to determine mechanisms for the repair and protection of irradiated individuals were carried out simultaneously. Results of these experiments have provided important information on the type and degree of somatic effects induced by radiation and have led to the development of extensive, environmentally controlled animal quarters necessary for studies of very *low dose*, lifetime studies for which little or no information is available. Such studies are important because it is in this dose level range that most of man's exposures now and in the future fall. Through the scientific interaction of a geneticist with physiologists at Oak Ridge, it was shown that the recovery of lethally irradiated animals was dependent on the successful transplantation of red blood cell precursors from an unirradiated donor to irradiated host. Because of the importance of the immune response systems in successful and permanent transplantation, basic information has been obtained in this laboratory which has contributed significantly to our understand-

ing of the processes and effects of transplantation of cells and tissues in animals and humans following irradiation or as the result of disease. Continued efforts in these areas of research (both basic and applied) have demonstrated the potential importance of the immune-response system on aging as a result of radiation. It would appear that the immune response system becomes less effective or completely incompetent with increasing age. Thus, it is possible that transplantation of immune-competent cells from young donors into older hosts may lead to better defense against disease in the aged.

Because of the considerable need to know the effects of radiation at the molecular and cellular levels to interpret basic mechanisms involved in damage to both the somatic and genetic materials, emphasis was placed on experimental work in this area. To carry out such studies, isolation and purification of subcellular particulates such as nuclei, mitochondria, ribosomes, etc., was necessary. Improved centrifuge systems for separations of cell particulates and biological molecules were designed, built and tested in the Biology Division. This small beginning in development of improved instruments for research has led to a large-scale, interdivisional, biomedical instrument development program, the Molecular Anatomy Program (MAN), that is jointly funded by the AEC and NIH. In this program centrifuges have been developed which increase the scientist's ability to isolate and concentrate materials needed in both applied and basic research. Development of a centrifuge which can isolate and purify influenza viruses from large quantities of materials has been realized, and an improved influenza vaccine from which contaminating proteins have been removed has been produced and placed on the market by the Eli Lilly Pharmaceutical Co. Other instruments of importance in clinical practices are in various stages of development. This is another and most important example of how interest in basic research has lead ultimately to the development of hardware for investigations in both basic and applied biological and medical fields.

There has been a long standing interest in cancer as a result of the well established cancer-producing effects of radiation. The outstanding facilities for large scale, long term animal studies made the Biology Division an obvious place for a cooperative effort between the AEC and National Cancer Institute in studies of co-carcinogenesis. As a result a program was initiated involving both applied and basic studies in carcinogenesis. The effects of radiation, viruses and long term inhalation of chemicals and smog alone and in combination on the production of tumors are being studied. In one of the supporting projects associated with this program, it has been shown recently that a specific virus-induced tumor in rabbits which requires a specific amino acid, arginine, for proliferation is markedly reduced by extra-corporeal dialysis of the blood of the animal in an articial kidney type of structure which contains an enzyme, arginase, that may reduce the level of the compound necessary for growth of the tumor. Success of such a system in general would mean that treatment of similar tumors or other inherited metabolic disorders, such as pheynlketonuria, which arise as the result of increased amounts of toxic materials might be easily controlled. As a consequence, formerly incapacitated individuals could be returned to useful lives.

The presence of the large number of research scientists in the Biology Division and their interest in training young scientists at both the predoctoral and postdoctoral level has naturally led to the incorporaion of these individuals in the graduate training program of the University of Tennessee. Thus a new approach to graduate training was initiated by the University of Tennessee and the Biology Division of the Oak Ridge National Laboratory involving the establishment of a University of Tennessee-Oak Ridge Graduate School of Biomedical Sciences at Oak Ridge. This establishment insures the utilization of the scientific staff of the laboratory in training new scientists for their role in research as well as teaching.

The results or the last 21 years' experience since the Biology Division was started have demonstrated that the several large-scale mission-oriented projects organized here in connection with radiation effects prospered exceedingly well, and in large measure because of the closely interwoven and strong support from the many basic fields discussed above. As a matter of fact, this successful interplay of practical problems supported by a very broad program in basic science has elicited the strong interest of other Government agencies, in particular the NIH, to add within our structure investigations on additional major biomedical problems facing this country today. It appears now to be well established that the successful elucidation of the large-scale and long term

difficult biological problems, which have been discussed briefly in this section, depends upon the very strong and tightly interwoven basic programs; hence, these latter need to be continually strengthened and kept vital for the success of the overall program. The continued success of both the AEC and the interagency programs also depends upon an updating and expansion of the physical laboratory facilities of the Biology Division, a matter presently under consideration.

Mr. MORRIS. The gentleman from New York.

ECOLOGICAL STUDIES

Mr. ROBISON. Doctor, why is the Commission working in the area of ecology? Also, on page B & M–11 some reference is made to study in soils, plants, and soil-plant relationships.

Dr. TOTTER. The study of ecology is required to determine the effects of radioisotopes on the environment. There are two locations where we are studying arid land ecology. One is close to the test site in Nevada, and the other is at Richland.

Mr. ROBISON. The question is, What is the relationship of this to the overall mission of the Commission?

Dr. TOTTER. I think the Commission has to know what happens to any kind of landscape which will ever see the possible release, either accidentally or not accidentally, of radioisotopes, sources of radiation.

The particular value of arid lands and Arctic, also, in this study is that their ecology is much simpler than mid-U.S. ecology and, therefore, the effects can be seen more quickly and evaluated much more easily. This then provides us with a basis to go into a more complex ecology and study the same sort of thing.

I think it will have very great usefulness and foundation for studies of other matters than radioisotopes.

Mr. ROBISON. You are not getting into competition with the Department of Agriculture in this field?

Dr. TOTTER. No, sir, I think not at all.

Dr. TAPE. I would be happy to put in a little plug here, that while the work which has gone on under the Atomic Energy Commission aegis is directed at these radiation stimuli and the ecological problems have been studied because of our interest in what the radiation effects may be, the experience we have gained puts us pretty high in this general field of ecological understanding and the way in which one can go about determining the effects of other pollutants, as Dr. Totter has said.

At the end of the session yesterday, we were talking a bit about the question you raised for Lake Cayuga. The work he is talking about is not specifically directed to that sort of study, but there are a lot of common elements in the two.

THERMAL EFFECTS

Mr. ROBISON. Let us talk on the record, for just a moment, about the problem we discussed off the record yesterday.

Doctor, yesterday I had a conversation, after the hearing ended, with Commissioner Tape and some of the others who were here, about the concern being expressed by some of the residents along Cayuga Lake, one of the "Finger Lakes" in upstate New York, by virtue of the planned location on that lake of a New York State Electric & Gas Corp. nuclear powerplant.

On pages B&M 12 and 13 of your presentation, reference is made to the work you want to do in the field of marine sciences, and also in the field of thermal pollution. In the latter case, you talk about a "pilot effort" which you would like to undertake. Has this any relation to the concern of some of the people in the "Finger Lakes" area over to the effects of this powerplant on the ecology of the lake itself?

Dr. TOTTER It would certainly help provide a foundation for specific studies in any place where there may be the release of radioisotopes; yes, sir.

Mr. ROBISON. The problem would not be release of radioisotopes so much as it would be heat?

Dr. TOTTER. We have not in the past engaged in any research in thermal pollution outside of AEC sites but, as you mentioned, we are now starting to do some. I do not know exactly the extent to which thermal studies will become a proper part of our mission.

Dr. TAPE. It is related to the health and safety aspects, which we can certainly look at this way.

Mr. ROBISON. It is just beginning?

Dr TAPE. Yes.

Mr. ROBISON. I might state, Dr. Totter, the specific aspects of the Cayuga Lake situation. It is a deep lake with very cold water at the bottom of the lake. I can understand the power company's interest in having that source. The Cornell people are indicating some interest in wanting to look at the situation from the scientific point of view. They are not trying to become involved in the licensing procedures or involved in that aspect with the power company, but they would be interested in studying the environmental affect on the lake. This is what we were discussing yesterday.

Now, can we look forward to some cooperation, insofar as the Commission could give it, with the local people and the company regarding this problem?

Dr. TOTTER. You cartainly can.

One of the difficulties we run into in this sort of thing is that many people regard any change as being a deleterious change when in fact it may be an improvement. One has to study it to make sure whether there has been harm or actually some improvement in the situation.

BIOLOGICAL AND ENVIRONMENTAL CONSEQUENCES OF NUCLEAR WAR

Mr. ROBISON. The Commission is no longer studying—this being in a totally different field—the biological and environmental consequences of nuclear war? I am glad to hear that; if so. Is it because you think there will not be a nuclear war, or do you know all you need to know about it?

Dr. TOTTER. No, sir. I think what has actually happened is that the main customer for those studies has found another source for his information.

Mr. ROBISON. Who was the main customer? The Department of Defense?

Dr. TOTTER. Part of the Department of Defense. I am sorry I cannot answer exactly which part. I do not recall.

Mr. ROBISON. Who is their new supplier?

Dr. TOTTER. I presume they have within their own shop a source of information.

Mr. ROBISON. This means another Federal agency or department or bureau is continuing to study this particularly complex and unhappy field?

Dr. TOTTER. There are several studies. I cannot name them precisely to you now, but I would be glad to look into it and furnish that, if you wish.

Mr. ROBISON. I would be happy to have you do so.

(The information follows:)

TERMINATION OF THE ATOMIC ENERGY COMMISSION'S PROGRAM TO STUDY THE LONG-TERM BIOLOGICAL AND ENVIRONMENTAL CONSEQUENCES OF NUCLEAR WAR

On February 8, 1962, Chairman Seaborg wrote Congressman Chet Holifield to acquaint him with a recent action of the Commission with regard to studies of the effects of nuclear war. Part of the letter, quoted below, gave a brief history of the action:

"From time to time over the past 6 years the Atomic Energy Commission has responded to special requests to provide evaluations of the biological and environmental consequences of nuclear warfare. The Commission's responses to these requests have been prepared on an ad hoc basis by various combinations of its staff under tight deadlines for completion of the work requested, and without the benefit of full liaison with the scientific staffs of other Government agencies."

The letter then went on to say that the Commission had decided to conduct continuing studies. The letter also said that this decision had been communicated to the Secretary of Defense, the National Security Council, the Director, Office of Emergency Planning, the Special Assistant to the President for Science and Technology, the Special Assistant to the President for National Security Affairs, and the Director, Bureau of the Budget, with an invitation to comment and make suggestions concerning scope, and so forth.

By 1966 and early 1967 it had become clear that the specific nature and direction of the interests in the consequences of nuclear war, within the executive branch, had changed considerably and also that alternative ways of meeting the original interests were being developed, particularly in the Department of Defense. Meanwhile, the most important general conclusion of the AEC's own studies was becoming clear: that no remotely adequate study of the long-term biological consequences of nuclear war could, as a practical matter, be carried out unless the major agencies of the Government concerned with applied biology, health, agriculture, land management, management of living resources, and so forth, become directly involved—probably under some sort of overall direction from the Executive Office. Under these circumstances, the study announced in Chairman Seaborg's letter was ended.

It is our understanding that Defense Research and Engineering, Defense Atomic Support Agency, Office of Civil Defense, to name three agencies within the Department of Defense, are all carrying out studies, at least from time to time.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Mr. ROBISON. Finally, somewhere in your presentation or in the justifications there is mention of a decrease in hazards from nuclear fallout. What is the status of this now, in your opinion, or that of anyone else who cares to answer, insofar as the United States is concerned?

Dr. TOTTER. The nuclear fallout, as I mentioned, of strontium-90, which is one of the main problems, was lower at the end of 1967 than it was at the beginning of the year. Our ability to predict the fallout is quite good.

I have a statement here, if you would like me to read it.

Mr. MORRIS. Please include it in the record.

(The information follows:)

STATUS OF FALLOUT, APRIL 1968

Reasonable agreement has been maintained through 1967 between predicted and observed levels of global fallout deposition. Less strontium-90 was present on the ground at the end of 1967 than at the beginning of the year because the loss of strontium-90 due to radioactive decay exceeded new fallout during 1967.

Measurements by the Defense Atomic Support Agency aircraft sampling program, Project Stardust, its successor, the AEC supported Project Airstream, and the AEC high altitude ballon sampling program indicated the total atmospheric inventory of strontium-90 to be 0.75 megacurie in January 1966. The atmospheric inventory decreased to 0.3 megacurie by January 1967; and in January 1968 about 0.1 megacurie of strontium-90 from pre-1967 nuclear tests was estimated to be still aloft with an additional 0.1 to 0.3 megacuries present from foreign nuclear tests of which the sixth Chinese nuclear explosion in June 1967 was the primary contributor. Thus, the total atmospheric inventories are essentially the same at the beginnings of 1967 and 1968, hence we may expect comparable amounts of fallout in these 2 years.

The deposition of strontium-90 in 1966 was found to be 5.5 and 2.2 millicuries per square mile in the wet and dry areas of the United States respectively, with an average worldwide deposition of 2.0 millicuries per square mile. In 1967 measurements of strontium-90 deposition showed 3.4 millicuries per square mile in wet areas, 1.4 in dry regions, and 1.3 millicuries per square mile for the worldwide average.

The atmosphere injection of a new source of strontium-90 during 1967 introduces uncertainties into predicted future fallout levels. The best current estimates indicate the following strontium-90 deposition (in millicuries per square mile) during the next few years; neglecting any contributions from possible future foreign tests:

	"Wet" United States	"Dry" United States
1968	3.4	1.4
1969	1.7	.7
1970	.9	.4
1971	.5	.2

The AEC Health and Safety Laboratory has studied the relation of fallout deposition rate and accumulated deposition of strontium–90 to subsequent levels in the diet and bone. The Health and Safety Laboratory predicted 19 picocuries of strontium–90 per gram of calcium in the New York City diet in 1967, and 17 picocuries of strontium–90 per gram of calcium was actually observed. With the nearly constant level of strontium–90 on the ground, the dietary level in New York City is expected to remain about 17 picocuries per gram calcium for the next few years. The average strontium–90 intake in the United States is about two-thirds that in New York City. Thus the average United States intake is expected to be about 12 picocuries per gram calcium. Such an intake of strontium–90 will lead to levels in bone of about 5.0 picocuries per gram calcium in children less than 4 years old, decreasing with age to about 1.0 picocurie strontium–90 per gram calcium in adults.

The observations have thus confirmed the general magnitude of the fallout risk anticipated by the Federal Radiation Council in 1964, and have, in fact, been running somewhat below the predictions. Contributions to the radiation exposure of the general public due to other radionuclides such as strontium–89, cesium–137, iodine–131, and carbon–14 are also near or below the predicted levels. Thus the following conclusion reiterated and confirmed in that report from FRC Report No. 4 (May 1963) can be accepted as still valid: "that the health risk from radioactivity in foods anticipated over the next several years would be too small to justify protective actions to limit the intake of these radionuclides by altering the normal production, processing and distribution of food, particularly milk and dairy products."

Mr. ROBISON. What have been the effects of the French tests or the Chinese tests, to date, on fallout over the United States, if any?

Dr. TOTTER. Let me see if I can find it here.

Dr. TAPE. Let me make a general comment first.

The French tests are in the Southern Hemisphere, and as such we do not really see much. The South Americans are the ones who would be asking this question.

The Chinese tests in the atmosphere have injected material into the atmosphere which one can see has resulted in some increase in background. The number of tests has been pretty small. With the exception of one test, the individual tests have been small. We can see slight changes in the background, but these are more of a technical achievement than they are anything related to health.

Would you agree with that?

Dr. TOTTER. Yes. The actual figures show that the injection into the stratosphere from the recent foreign tests just about replaced the amount which deposited on the earth the preceding year.

Mr. ROBISON. Thank you very much.

Thank you, Mr. Chairman.

Mr. MORRIS. I thank the gentleman.

Thank you, Dr. Totter, for your statement.

The committee will recess until 1:30 o'clock.

ISOTOPES DEVELOPMENT

Mr. MORRIS. We will now proceed with isotopes development.

Mr. FOWLER. I have an introductory statement which I can either submit for the record or present at this time.

Mr. MORRIS. You may submit it for the record.

(Mr. Fowler's statement follows:)

INTRODUCTION

The Atomic Energy Commission's budget request for the isotopes development program for fiscal year 1969 is for $7,185,000, a decrease of $190,000 from the estimated fiscal year 1968 costs. It also provides for $1 million for equipment required to support the planned research and development work which is approximately the same as the fiscal year 1968 estimate, $990,000.

No request is being made for construction of new facilities.

Program plans and requirements for funds in fiscal year 1969 have been greatly tightened and are directed only to work showing greatest national need and interest.

I was pleased to observe that the report of the Joint Committee on Atomic Energy on authorizing appropriations for fiscal year 1969, views the budget request for the isotopes development program as an austere one in which initiation of all but the most urgent and promising research efforts have been deferred.

At this point, it should be stated, as the subcommitee is aware, that the report of the Joint Committee recommends authorization of $7,985,000 in operating funds, an increase of $800,000 over the President's budget, to provide for initiation of second phase program work directed to development of an implantable radioisotope heat engine for powering heart devices.

A major portion of the operating funds being requested for fiscal year 1969 will be used in support of research and development in areas of major national concern and benefit. These include: health, pollution control, water resources management, crime, national security, preservation of foods, nuclear safety, and research on new production technology for radioisotopes for medical and other use.

With the chairman's permission, I will quickly discuss major program funding requests for fiscal year 1969, and will emphasize particularly the radioisotope engine work for heart devices and the need for continuing this development on a priority basis along with selected other projects.

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT ($2.325 MILLION)

The planned operating costs in fiscal year 1969 for radioisotopes production and materials development is $2.325 million, a decrease of $175,000 from fiscal year 1968.

This category of work is one of the most basic and important activities carried out by the Atomic Energy Commission; therefore, any reduction in expenditure is at the expense of not doing required materials research.

The work undergirds the AEC's program for commercial production and distribution of radioisotopes to meet the changing needs of science and technology in the United States.

To put a dimension on the value and importance of this work, one has only to look at the use of radioisotopes in medicine for the diagnosis and treatment of disease and their application in searching out modes of body processes and the causes of diseases.

In diagnosis and therapy, between 3 and 4 million patients each year are receiving radioisotopes.

All this work, in one way or another, has been made possible by the availability of the wide variety of radioisotopes developed and produced through funding under this program.

It might be worth taking a minute to identify new radioisotopes for medical use which we are developing production processes for and the type of medical application. These include:

1. Zinc-69^{m} (14 hr/440 kev) for prostate scanning to detect tumor.
2. Rubidium-83 (83 d/530 kev) for study of muscular dystrophy.
3. Gallium-67 (78 hr/180 kev) for bone marrow scanning to detect tumor.
4. Potassium-43 (22 hr/180 kev) for heart scanning to study circulation and heart muscle health.
5. Yttrium-90 (64 hr/1.75 Mev) for treatment of the pitutiary gland.

We are using all the unique production facilities of the AEC, both reactors and cyclotrons, to produce radioisotopes in ultrapure form—purities which have never been achieved before and are vital to medical usage.

If I may be permitted a personal observation, I would make the flat statement that of the money spent on the isotopes development program, to date, it can be justified fully based upon the benefits which have been, and are, accruing in the use of the radioisotopes which we have researched and produced for medical purpose.

Approximately $300,000 of the requested funds in fiscal year 1969, under this category, will be directed to materials characterization research on thulium-170, a fuel having potential application for space isotope-electric power systems.

Lastly, $190,000 will be directed to nuclear safety research and development on radioisotope devices, sealed sources and other equipment using radioisotopes which is in direct support of the AEC's regulatory program to provide a better scientific and technical basis for developing standards and regulations governing the use of radioisotopes.

THERMAL APPLICATIONS ($900,000 PLUS JCAE $800,000 EQUALS $1.7 MILLION)

In this research and development program, we are directly concerned with development of technology for the use of the heat liberated by radioisotope decay.

Major funding (approximately $500,000) under this program, as presented in the President's budget, is directed to fuels development for radioisotope engines for heart devices, as well as for manufacture of radiation sources to be used for heat and radiation effects studies in animals.

Radioisotopes to be worked on in fiscal year 1969 include plutonium-238 and promethium-147. Critical studies completed in fiscal year 1968 have shown that another candidate radioisotope, thulium-171, while having desirable radiation characteristics for implantation within the body, is severely limited in amounts which can be produced; additionally, costs associated with such production are considered to be prohibitive. Accordingly, further work on this radioisotope is being terminated.

The AEC completed in December, conceptual studies on radioisotope powered engines for heart devices. These studies were jointly funded by the AEC and the National Heart Institute.

The four conceptual design contractors, Thermo Electron Corp., McDonnell Douglas Corp., Aerojet General Corp., and Westinghouse Electric Corp., were called to Washington in mid-December to report on the results and conclusions of their studies.

Results of the design studies show all four concepts to be feasible—it is considered that they can be developed within the current state of the art and meet specifications required for such a power source.

At the same time, the studies show a number of difficult engineering problems—however, none of these appear to be unmanageable.

Primary problems include optimization of the engine to result in minimum heat rejection to the body. The higher the engine conversion efficiency of heat to mechanical energy, the lower the excess heat level to the body (the blood) from the implanted source. With a high engine efficiency, we would also be able to reduce the amount of radioisotope fuel required for the engine, thereby lowering the radiation level to the body. Another type of problem, which we will be directing our attention to, will be minimum engine weight and volume to assure that an isotopically powered heart device will be clinically acceptable.

As the chairman himself remarked in a speech he made in San Francisco on April 1, and perhaps so stated on Tuesday, that the "problems associated with the development of an artificial heart are so complex and severe that one cannot give full assurance that such a device will be available in any predictable time period, and yet there is reason for optimism * * *" "* * * The reason for the optimism is that one of the very few known possibilities for furnishing power to a completely implantable artificial heart lies in the radioisotope heat source."

Certainly the death of nearly three quarters of a million Americans each year from heart disease is a matter of national concern deserving high priority in the Government's research and development efforts.

If the Congress appropriates the additional $800,000, recommended by the Joint Committee report, we would proceed into phase II work which would result in the building of model engines directed to establishing whether or not predicted efficiencies of converting heat to mechanical energy can indeed be achieved, as well as concerning ourselves with other problems such as sizing, configuration, and materials. If we obtain positive results, then we would be requesting funding to proceed into phase III work, which would involve selection of a specific engine type for design, fabrication, and testing of a prototype—this would require the expenditure of approximately $3 million and between 3 and 4 years' work.

I wish to make clear, at this point, that successful completion of the phase III work would not yield an integrated system including the radioisotope engine, fully qualified, for reliable operation over a 10-year period, which would be the ultimate objective.

RADIOISOTOPE APPLICATIONS DEVELOPMENT (FISCAL YEAR 1969 $1.350 MILLION)

Total planned expenditures in the radioisotope applications development category for fiscal year 1969 are $1.350 million which is down slightly from the fiscal year 1968 level of $1.375 million.

We are continuing to give increasing emphasis in this category on research and development leading to isotopes and nuclear techniques for pollution control, water resources management, criminalistics, national security problems, as well as medical problems.

Of the total $1.350 million, just over $900,000 will be programed in research for pollution, water resources, and national security—$485,000, $150,000, and $275,000, respectively.

The reasons for this are straightforward—the urgency associated with controlling pollution of our environment, seriously increasing crime rates, cleaning our water supplies, and the unique ability of isotopes and nuclear techniques to assist in the solution of some of these problems.

For example, it is estimated that the national bill for air pollution damage to buildings, agricultural commodities, etc., is $12 billion per year—or about $60 for every man, woman, and child in the country.

Sulfur dioxide is one of the major contributors to air pollution in the United States—approximately 100 tons per day are being dumped into our air.

94-075 O—68—pt. 3——34

Since appearing before this subcommittee last year, considerable progress has been made on the project to determine dispersion of sulfur compounds from electric powerplants using fossil fuels. Results to date have demonstrated the technical feasibility of the isotope method for study of atmospheric sulfur pollution by determining the difference between the ratio of two of the naturally occurring stable isotopes of sulfur, sulfur-32 to sulfur-34 in sulfur dioxide emitted from a stack and that in the atmosphere surrounding the stack.

The program plan for fiscal year 1969 includes field experiments using the stable sulfur isotope ratio method for mapping the movement and deposition of sulfur dioxide emitted from electric powerplants in two cities; New York (Con Ed Arthur Kill plant) and New Haven (United Illuminating Co.), and a rural location in western Pennsylvania, using the Keystone Electric powerplants (a combine including Penn Electric and others), which are mine-mouth plants.

The project is a cooperative effort between the AEC and the Bureau of Disease Prevention and Environmental Control of the Health, Education, and Welfare.

The program will be funded by AEC in fiscal year 1969 at a level of $200,000. It is expected the HEW will also financially contribute to the work. During the current fiscal year, HEW has made available $50,000 for this work along side our funding of $125,000

RADIATION PROCESSING APPLICATIONS DEVELOPMENT (FISCAL YEAR 1969, $1.425 MILLION)

The planned operating costs in fiscal year 1969 for process radiation development are $1.425 million, essentially, the same as the fiscal year 1968 estimate of $1.415.

RADIATION PRESERVATION OF FOOD (FISCAL YEAR 1969, $1.185 MILLION)

In the radiation preservation of foods program, the requested operation funding is $1.185 million which is down from the fiscal year 1968 estimated level of $1.435.

Mr. MORRIS. In your opinion is this an austere budget?

Mr. FOWLER. I certainly agree with that.

Mr. MORRIS. We shall insert ID–1 through ID–14 covering the request for the isotopes development program.

(The pages follow:)

U.S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

ISOTOPES DEVELOPMENT PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$ 7,185,000
Estimate FY 1968	7,375,000
Decrease	$ -190,000

The purpose of this program is to develop technology and demonstrate applications of radioisotopes and radiation important to the national economy and welfare. The program objectives include:

(a) Development and demonstration of applications of radioisotopes and radiation, and incorporation of these applications into the national economy.

(b) Production and distribution of isotopes at levels necessary to insure that national requirements are satisfied.

(c) Development of technology for the production, separation, purification, and encapsulation of radioisotopes, utilizing resources of both the Atomic Energy Commission and industry.

Major emphasis in FY 1969 will be on: development of ultra-pure fuels for an isotopically powered circulatory support system; development of isotopic methods for identifying the origin of atmospheric pollutants; determination of the properties of thulium-170 fuel forms; and initiation of development efforts on new radiation processing applications. Efforts on radiation preservation of foods and research and development on radioisotope production and materials will continue.

The overall reduction of $190,000 results from phasing out a number of individual projects, and from deferring initiation of all but the most urgent and promising research efforts.

ISOTOPES DEVELOPMENT PROGRAM - continued

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
ID-2	1. Radioisotope Production & Materials Development.....	$2,275,394	$2,500,000	$2,325,000
ID-4	2. Thermal Applications Development	433,102	650,000	900,000
ID-6	3. Radioisotope Applications Development	1,237,401	1,375,000	1,350,000
ID-7	4. Radiation Processing Applications Development	1,502,002	1,415,000	1,425,000
ID-9	5. Radiation Preservation of Foods	1,432,666	1,435,000	1,185,000
	Total Isotopes Development Program	$6,880,565	$7,375,000	$7,185,000

JUSTIFICATION OF CATEGORIES

1. Radioisotope Production & Materials Development 2,325,000

The Radioisotope Production and Materials Development category is concerned with defining the production of radionuclides in reactors and accelerators, developing separations and purification processes, characterizing radioisotope products, developing encapsulation methods and safety criteria for radioisotope sources, and analyzing the state-of-the-technology. This category also provides management and technological support to the AEC's radioisotopes production, distribution, and sales program. The work under this category includes the following activities: Neutron Products, Cyclotron Products, Fission Products, Source Development, and Technology Utilization.

The FY 1969 budget request provides for the following:

Neutron Products ..... FY 1967: $ 628,624 FY 1968: $ 800,000 FY 1969: $ 650,000

Continued efforts on the development of preparation techniques for unusual or especially important radionuclide research material. In FY 1969, emphasis will be on determining the properties of thulium-170 fuel forms, containment materials, and experimental sources. This effort will provide the basic fuels technology needed for assessing the merits of thulium-170 as a potential space fuel. The decrease in funds requested is attributable to the completion of efforts to characterize fuel forms of cobalt-60 capable of sustained operation at temperatures up to 850°C.

Cyclotron Products ..... FY 1967: $ 90,201 FY 1968: $ 120,000 FY 1969: $ 120,000

Continued level effort in support of the production of neutron deficient radioisotopes in the 86-inch cyclotron at the Oak Ridge National Laboratory (ORNL), primarily for medical use. During FY 1969, research efforts will continue at the FY 1968 level with emphasis on the development of reactions to yield short half-life isotopes.

Fission Products ..... FY 1967: $ 791,948 FY 1968: $ 600,000 FY 1969: $ 575,000

Continued effort to develop production technology and to characterize product materials in support of radiation and thermal applications development activities. Emphasis in FY 1969 will be on completing most of the basic fuels technology at Pacific Northwest Laboratory for promethium oxide at temperatures up to 1500°C. Work at ORNL will continue on defining the properties of radiation source compounds and on investigating methods of producing enriched krypton-85.

Source Development ..... FY 1967: $ 512,373 FY 1968: $ 670,000 FY 1969: $ 675,000

Continued efforts on development of source materials and fabrication technology, and improvement of operational safety and reliability. Work will continue on defining methods to reduce the cost of source fabrication, to upgrade the level of quality control, and to continually improve source safety assurance. Development of evaluation data on source and shipping container designs for use by regulatory agencies and manufacturers will continue.

Technology Utilization ..... FY 1967: $ 252,248 FY 1968: $ 310,000 FY 1969: $ 305,000

Continuing effort mainly at the Oak Ridge Isotopes Information Center, consisting mainly of preparing scientific and technical analyses in support of the Isotopes Development Program. Compilation of radioisotope export-import data by the Bureau of Census is also supported under this category as well as a study (Pacific Northwest Laboratory) of the potential availability of radioisotopes from discharged power reactor fuels.

2. Thermal Applications Development ..... $ 900,000

The Thermal Applications Development category is concerned with research and development related to applications using the thermal energy of radioisotopic decay as heat, or for conversion to mechanical energy. The FY 1969 program requires an increase of $250,000 for development of ultra-pure radioisotopic fuels for circulatory support systems, fabrication and test of an integrated life support device, and development of component heater systems.

Circulatory Support Systems .... FY 1967: $ 151,568 FY 1968: $ 486,000 FY 1969: $ 500,000

Conceptual design studies for a radioisotopic powered engine will be completed in mid FY 1968 with follow-on efforts on the engine development to be funded by the National Heart Institute.

The programs initiated at Los Alamos Scientific Laboratory and Pacific Northwest Laboratory in FY 1968 to investigate production methods and purification techniques for ultra-pure fuel forms of plutonium-238 and promethium-147, respectively, will require a higher level of support as they proceed into the experimental and materials phase of the effort. The evaluation of an electro-refining process for preparation of ultra-pure plutonium-238 metal will be essentially completed in FY 1968. During FY 1969, the evaluation of plutonium nitrides and oxide depleted in oxygen-18 will continue. The evaluation of promethium-146 burnout by re-exposure to a neutron flux will continue in FY 1969. Targets fabricated from promethium having a promethium-146 content typical of that from power reactor spent fuels will be analyzed with regard to isotopic content.

Characterization of the radiation properties of promethium-147 fuel forms will be completed in FY 1969. Determination of the radiation field in and around a man-equivalent phantom for implanted plutonium-238 and promethium-147 heat sources will be made in FY 1969. Parametric shielding calculations for promethium-147 and plutonium-238 heat sources will continue. Development of heat sources qualified to withstand all foreseeable accidents and having sufficient durability for the expected lifetime of a circulatory support system under normal operating conditions will be started in FY 1969.

Life Support Systems ..... FY 1967: $ 96,000 FY 1968: $ 88,000 FY 1969: $ 190,000

This is a jointly funded AEC-Department of the Air Force project to provide life support for long duration manned spacecraft flights. AEC efforts are directed principally to development of radioisotope heat sources and heat exchangers to satisfy thermal energy requirements of the system. Engineering assessment, preliminary design and successful testing of a plutonium-238 isotopically heated laboratory system for water recovery was accomplished during FY 1967. An evaluation is being conducted in FY 1968 of an integrated system which would encompass various life support functions such as waste conversion and incineration, and carbon dioxide removal. Detailed design, fabrication, and test of such a model is planned for initiation in FY 1969.

Swimsuit Heater System ..... FY 1967: $ 80,178 FY 1968: $ 17,000 FY 1969: $ -0-

A 420 watt swimsuit heater utilizing plutonium-238 has been developed and is being turned over to the Navy for evaluation under operational conditions in the Sea Lab. III.

Component Heater Systems ..... FY 1967: $ 105,356 FY 1968: $ 59,000 FY 1969: $ 210,000

A promethium-147 source was designed in FY 1967 and fabricated in FY 1968 for the Department of the Air Force for use in evaluating its performance in thermal conditioning of a key component in an advanced strategic aircraft. Fabrication of an advanced design of this source, a source for a battery heater, and development efforts on other potential applications will require increased funding in FY 1969.

3. Radioisotope Applications Development ..... $ 1,350,000

The objective of this category is the development of new radioisotope technologies and the demonstration of their use as instrumented systems for the solution of problems where the isotopic approach offers definite advantages over competitive methods. In FY 1969 efforts to identify the origins of atmospheric sulfur pollutants will continue to receive emphasis.

Basic Technology Development FY 1967: $ 357,418 FY 1968: $ 292,000 FY 1969: $ 260,000

This activity is aimed at the development of new concepts and methods. Generally, projects are supported which will be of benefit to all phases of the Isotopes Development Program or which have a high potential for subsequent development as definite isotope systems. This includes projects which make possible the safer and more technically effective and economic use of isotopes or provide for new capabilities, such as Mossbauer analytical techniques, radioisotope activated luminescence techniques and solid state detector development.

Systems Engineering Applications FY 1967: $ 879,983 FY 1968: $ 1,083,000 FY 1969: $ 1,090,000

This activity provides for development and performance evaluation of radioisotope techniques and related nuclear systems which are applicable to specific problems and requirements of major economic or national importance. These activities have been grouped under the following general areas of application:

Environmental Systems

Includes the development of improved techniques for helping to measure and combat environmental pollution. Because of the extreme sensitivity and specificity of isotope techniques, they offer much potential for aiding in control measures. Major projects will be the continued development of a tracer technique to determine the dispersion of sulfur compounds from a given stack and to

determine the contribution of emissions from that stack to ambient air quality, a gauge for continuously monitoring the sulfur dioxide content of stacks so that control measures can be optimally applied, and completion of a rating technique for high-head turbines in the water-short western region of the United States.

Marine Systems

The project on coastal sand movement will continue through FY 1969 which is the terminal year. Additionally, a project will be initiated to study the use of nuclear techniques for locating and measuring undersea ore deposits.

National Security Systems

A sustained research and development effort will be continued on applications of radioisotope systems and nuclear techniques for detection and abatement of crime and subversive activities, improvement in physical security systems, and other problem areas of concern to national security.

Aerospace Systems

The effort to develop a solid state fuel gauge in conjunction with the U.S. Air Force will be completed.

4. Radiation Processing Applications Development ..... $ 1,425,000

Process Radiation is concerned with the production or processing of materials employing radiation as a source of energy to effect chemical, physical or biological change. The primary objective of this category is the development of technology necessary to advance the productive large scale use of radiation. Two major activities constitute this category:

Basic Technology Development .. FY 1967: $ 1,178,965 FY 1968: $ 995,000 FY 1969: $ 1,355,000

Major efforts in radiation engineering and radiation chemical processing at Brookhaven National Laboratory (BNL) constitute over half of this activity. This work is directed to development of engineering process data and materials, radiation source and facility design, large radiation safety data, and basic radiation processing applications.

The increase in funding for this activity is for offsite contractor work on basic radiation technology mainly for the following potentially beneficial applications: concrete-polymer materials, pollution and waste treatment and radiation initiated ionic reactions.

Specific Process Applications .. FY 1967: $ 323,037 FY 1968: $ 420,000 FY 1969: $ 70,000

Specific projects, for which basic technology development has been completed and which offer potential for widespread demonstration of radiation processing techniques, and ultimate adoption by industry, are further developed under this activity. These projects, and the funds required in FY 1969, are as follows:

Polyethylene & Copolymer Production ..... FY 1967: $ 85,094 FY 1968: $ 85,000 FY 1969: $ -0-

Studies on polyethylene production at BNL were concluded in FY 1967 and the program emphasis directed in FY 1968 to ethylene copolymer systems in which radiation initiation exercises a greater control over product composition and quality.

Wood-Plastics Material Production ..... FY 1967: $ 133,916 FY 1968: $ 109,000 FY 1969: $ -0-

Final efforts to develop wood-plastic materials are being brought to a close.

Emulsion Polymerization of Vinyl Acetate and Related Copolymers FY 1967: $ 67,975 FY 1968: $ 85,000 FY 1969: $ 40,000

Technological work including product evaluation and process economic analysis will be completed for selected monomers in FY 1968-1969.

Semi-Conductor Fabrication FY 1967: $ 36,052 FY 1968: $ 77,000 FY 1969: $ -0-

This project is planned for completion in FY 1968.

Microbiological Inhibition System FY 1967: $ -0- FY 1968: $ 64,000 FY 1969: $ 30,000

This project initiated in late FY 1967 is to demonstrate a promising application of radiation for use in controlling bacterial growth in industrial cutting fluids. The initial project, expected to be completed in mid FY 1969, will include evaluation of the irradiation process in an industrial plant and cost-benefit data accumulation. If this is successful, one additional demonstration on military jet fuels will be considered for initiation in FY 1969.

5. Radiation Preservation of Foods ..... $ 1,185,000

The funds requested for FY 1969 for this category represent a net decrease of $250,000 from the FY 1968 funding level. Effectively, this is a decrease of $435,000 in operating level since the FY 1969 estimates include an extraordinary one-time cost of $185,000 noted below. This decrease is to be accomplished principally by reductions and deferrals in individual projects where final cost-benefit determinations of products for full demonstration-commercialization efforts are underway.

Activities in this category in FY 1969 will consist of:

Technology and Product Development

Technology development of the six to ten products or product groups which will be selected for final demonstration and commercialization development. Two of these, fin fish and Hawaiian fruit, have already been selected. A cost-benefit study by the U.S. Department of Agriculture initiated in late

FY 1967 will be completed in FY 1969. It will provide the basis for selection of the remaining products. Separate consideration is being given to red meats to determine the potential of radiation processing as applicable to centralized meat cutting. Program emphasis in FY 1969 will continue on development of petition data for selected products. This involves tasks such as large scale shipping studies and determination of maximum extension of product shelf life under commercial conditions.

Irradiator Engineering and Maintenance

Irradiator engineering, including irradiator design, dosimetry calibrations, source modifications and field trials. This work is performed principally at BNL. The research and demonstration units in use in the AEC program require periodic inspection and maintenance by a service contractor.

Funds are also requested for costs to be incurred for the radiation source for the Pilot Plant Meat Irradiator originally budgeted for FY 1967. Consistent with contractual arrangements finalized in early FY 1968, it is estimated that approximately $185,000 will be costed in FY 1969.

The continued program to determine the chemical changes, nutritional adequacy, wholesomeness, and microbiological safety of selected foods which have been subjected to irradiation is conducted under the Biology and Medicine program.

U.S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

ISOTOPES DEVELOPMENT - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$1,410,000
A Construction Projects	
A-1 Obligations for new projects	($ -0-)
A-2 Obligations for prior year projects	($ -0-)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($1,000,000)
B-2 Obligations from prior year appropriations	($ 410,000)
Estimated Obligations FY 1968	$ 990,000
Actual Obligations FY 1967	$ 1,361,443

Obligations for the Isotopes Development Program for FY 1969 are estimated at $1,410,000, of which:

a. $1,000,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $410,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

ISOTOPES DEVELOPMENT PROGRAM - continued

Activity	Estimated Obligations FY 1969
1. Radioisotope Production & Materials Development	$ 490,000
2. Thermal Applications Development	45,000
3. Radioisotope Applications Development	140,000
4. Radiation Processing Applications Development	150,000
5. Radiation Preservation of Foods	175,000
Total	$1,000,000

JUSTIFICATION OF CATEGORIES

1. Radioisotope Production & Materials Development ..... $ 490,000

Funds requested for this category support radioisotope production and distribution funded through the radioisotope inventory account as well as research and development on production technology and materials development in the Isotopes Development Program.

Funding requested is to provide for routine laboratory equipment requirements in support of research, development, and production activities at the Oak Ridge National Laboratory and Pacific Northwest Laboratory ($290,000) plus extraordinary requirements anticipated for FY 1969 as follows:

(a) Purchase and fabrication of improved radioisotopes and radiation source shipping containers to comply with more stringent requirements prescribed in 10 CFR 71 (31 FR 9941) ($150,000).

(b) Equipment support for thulium-170 fuel development program ($50,000).

2. Thermal Applications Development ..... $ 45,000

FY 1969 funding requirements are for equipment needed by Los Alamos Scientific Laboratory and Pacific Northwest Laboratory in conduct of the Circulatory Support System fuel development projects at these sites.

3. Radioisotope Applications Development ..... $ 140,000

Funding of $85,000 requested for FY 1969 is to provide equipment required for the Atmospheric Sulfur Pollutants Analysis project at BNL. The remaining requirement of $55,000 is to provide a continuing level of specialized and unique equipment items in support of R&D efforts by offsite contractors.

4. Radiation Processing Applications Development ..... $ 150,000

Requirements in this category are: for BNL equipment to support radiation engineering and chemical processing R&D ($100,000), and specialized and unique items in support of offsite R&D projects ($50,000).

5. Radiation Preservation of Foods ..... $ 175,000

FY 1969 funding is required for normal equipment support for offsite contracts ($100,000) and for procurement of an advanced on-ship irradiator for fishery products in direct support of shipboard irradiation studies ($75,000).

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
1. Radioisotope Production & Materials Development	$ 133,000
2. Thermal Applications Development	94,000
3. Radioisotope Applications Development	75,000
4. Radiation Processing Applications Development	108,000
5. Radiation Preservation of Foods	0
Total	$ 410,000

IMPLANTABLE RADIOISOTOPE HEAT ENGINE FOR POWERING HEART PUMP

Mr. MORRIS. You mentioned the $800,000 to provide for the unbudgeted increase to provide for development of an implantable radioisotope heat engine for powering a heart pump.

Will you briefly outline what will be undertaken with this money?

Mr. FOWLER. In the second phase program, which follows on a first phase effort which were conceptual design studies carried on by four contractors concurrently, looking at various concepts of radioisotope engines for heart devices, we would contemplate the building of models of radioisotope engines to see whether or not we can actually achieve some of the technical goals which have been set forth in the conceptual design studies, such as conversion efficiencies of heat to mechanical energy which would drive a heart pump. This is purely an engineering analysis at this point and one can establish conditions such as conversions efficiencies only when you put together a piece of hardware and see whether it works in the fashion the engineers predict it will.

This will be a major aspect of the second phase work involved with the $800,000.

FUTURE COST

Mr. MORRIS. Can you give us an estimate of the future development program cost?

Mr. FOWLER. If we are successful in phase 2 we would plan to move into phase 3 development to design, fabricate, and test a prototype system. This would require some 3 to 4 years of work. We estimate some $3 million for that portion.

Mr. MORRIS. Through the 4-year period?

Mr. FOWLER. Yes. I should mention at this point——

Mr. MORRIS. This is an estimate and we realize it.

Mr. FOWLER. This is an estimate.

The point I wanted to bring out here is that these 3 years and $3 million do not provide for a fully qualified heart engine which would be capable of operating for 10 years without failure. The large expense in such a development, then, would come beyond that period of time when we are in the qualification stage, to have a system capable of being put into the human body for reliable operation over a 10-year period. This qualification stage would cost much more money.

SIZE OF ENGINE

Mr. MORRIS. Can you give us some feel for the size of the present conception? We understand that is one of the problems now.

Mr. FOWLER. We used criteria provided to us by the National Heart Institute which they felt were clinically acceptable. These were maximum conditions.

I think we and they both recognize that as we march down the road it would be highly desirable and perhaps even necessary to reduce the size and weight of the engine for implantation purposes, but nonetheless at the time we did the conceptual studies they were Heart Institute specifications and they said that they were clinically acceptable as maximums.

94-075 O—68—pt. 3——35

Currently in our conversations with the Director of the Heart Institute, Dr. Frederickson, he has expressed some concern about the size.

Mr. MORRIS. What is its size now?

Mr. FOWLER. We are talking about an engine that as a maximum would be 3 kilograms in weight and 2 liters in volume.

I can express it another way based upon the four conceptual studies. In the one case it would be an engine that is 4.75 inches by 8.5 inches long. In another case 5 inches in diameter by 6 inches long. In another case it would be 4 inches in diameter by 3.5 inches long. In still another case a 5-inch-diameter sphere.

Mr. MORRIS. What did you say it would weigh?

Mr. FOWLER. Three kilograms ma ximum.

Mr. MORRIS. Approximately 7 pounds?

Mr. FOWLER. That is correct.

Dr. ENGLISH. This would not necessarily have to be located in the exact spot where the heart is. It is thought that it could be implanted in the abdomen, for example.

Mr. MORRIS. You think you might be able to carry it around in your pocket?

Dr. ENGLISH. Not in your pocket. The leads would create problems.

With regard to the follow-on program, after the period of 3 to 4 years which Mr. Fowler talked about—that is, the phase after the development of a working model or prototype, will involve the construction of a unit for engine qualification and will extend beyond the 3- to 4-year period and will cost much more. This is the last step which would have to be taken in engine development.

Mr. FOWLER. Another important point here on the question of sizing is the fact that in medicine one frequently makes tradeoffs. If it is a matter of a man's life maybe 6 to 7 pounds is not too much to think about carrying around in his belly. These are the kinds of considerations that the medical people certainly would be taking into account.

We do think we can make the engine small but the only way we can really establish this is by doing it and building models and trying to optimize size and miniaturizaton of the engine complex.

FINANCIAL PARTICIPATION BY CONTRACTORS

Mr. MORRIS. It is noted that in its report the Joint Committee suggested that the Commission give consideration to contractors who would desire to participate in the funding of this research.

Do you have any indication of industrial organizations which would be interested in financial participation?

Mr. FOWLER. I have had preliminary conversations with all four conceptual design contractors. We have received varying responses. Certainly in two cases there was a statement of willingness to financially participate in the next stage of the work.

In another case there was pretty much of a statement they would not be willing because they could not see the payout to them immediately, since after phase 2 we will be selecting a single engine design and a single contractor so that those people who would invest in this next stage work would not have assurance that they would be continuing on; although the other way of looking at it would be that

this keeps them in the ball game and if we are successful in this kind of development there is a future large business; 700,000 Americans are dying each year of heart disease of one kind or another.

Mr. MORRIS. Did I understand from your statement that during phase 2 which would be the utilization of the $800,000 you do not have any anticipation of industrial participation?

Mr. FOWLER. On preliminary inquiry some companies have indicated they would financially participate, others have stated they would not.

Mr. MORRIS. Would this affect the $800,000? Would you be able to get along with less money if they did?

Mr. FOWLER. Actually our problem is this: We would like to continue with all four contractors through this next stage because it is in the early part of the game.

If we run at a level which we think is necessary with four contractors this would be at approximately $400,000 each a year or $1.6 million.

We are trying through this financial participation to make up the difference, or at least part of the difference, between the $800,000 and the $1.6 million which we think is necessary.

Dr. ENGLISH. Is it not true that the intimations you have had so far, even from those who might be willing to participate, are that the degree does not appear to be anything like the amount of money that the Government would have to put into this development?

Mr. FOWLER. In one case they have indicated they are spending a couple hundred thousand dollars a year and they would be willing to continue to spend at this rate through phase 2.

Another company has indicated, and I think truthfully, that they have already invested $1 million in small engine technology and they feel they have probably contributed as much as any company in the country toward this kind of a program, and therefore their past contributions should be taken into account in terms of future work under any kind of Government-industry participation activity.

Mr. MORRIS. All right.

Mr. FOWLER. I think the testing of the pulse as to whether or not they will put in money will come when we formally ask them.

BASIS FOR $800,000 ESTIMATE

Mr. MORRIS. The $800,000 figure is based on participation by outside industry?

Mr. ABBADESSA. That is not completely accurate, Mr. Chairman. I think the legislative history with the Joint Committee will substantiate this.

Four study contracts were awarded. The committee recommends going forward with at least two of the concepts studied and states that in selecting the contractor, the Commission may wish to give appropriate consideration to those industrial organizations interested in sharing in the funding.

My understanding of the intention of the Joint Committee was to give the Commission full flexibility here. The $800,000 would be for two studies. This authority would allow us to do two studies with no participation from industry.

In the event we were successful in getting participation from industry we could possibly go on with the third or even the fourth study.

I think Dr. English pointed out that current indications are we will not get the kind of money that would allow us to do the additional study.

I think Mr. Fowler's point is that we really won't know until we try. I am reasonably sure that these words and in the intention of the committee was to give us full flexibility to allow us to spend the $800,000 without any industry participation.

Mr. FOWLER. I was simply making the point that from a division standpoint we would like to continue with the four contractors, and to be able to do that would require financial participation on the part of industry.

Mr. ABBADESSA. This is the Joint Committee's thinking, also, but they didn't want to limit us in the event we could not get the financial participation.

Mr. FOWLER. That is right.

PARTICIPATION BY NATIONAL HEART INSTITUTE

Mr. MORRIS. What is the National Heart Institute's undertaking in regard to this program?

Mr. FOWLER. They have a wide spectrum of activities, Mr. Chairman, which go all the way from preventive medicine to eliminate heart disease to research and development on heart-lung machines, temporary assistor devices, and permanent assistor devices. The long-term objective is to develop a full mechanical device for the replacement of the biological heart.

Mr. MORRIS. We are speaking now about the heart pump?

Mr. FOWLER. That is correct. The temporary assistor pump is the sort of thing that Dr. De Bakey has received so much publicity about, and Dr. Kantrowitz in New York who used temporary assist devices on people who are critical coronary shock patients, to relieve the burden on the heart to bring them out of the shock and help rehabilitate them on a temporary basis.

Their next step is to try to develop an implantable permanent assistor device for the left ventricle of the heart which does 80 percent of the work of the heart and thereby help alleviate some of the heart disease problems.

What we are doing is looking to the long-term objective of a permanently implantable mechanical heart to replace the biological heart.

DESCRIPTION OF MECHANICAL HEART DEVICE

Mr. ROBISON. The Joint Committee's report continuously refers to a "heart pump." This is not the whole heart?

Mr. FOWLER. No.

Mr. ROBISON. Tell me what it is.

Mr. FOWLER. We are talking about three pieces of equipment really—the radioisotope engine which is the power source; a hydraulic system which is a means of transmitting the mechanical energy to the heart pump itself, which is a separate piece of equipment. The three parts make up a total system, a mechanical heart device.

Mr. ROBISON. Which would replace the human heart if and when you have it?

Mr. FOWLER. That is right, which would replace the biological heart.

Mr. ROBISON. And the Commission is working now on just the radioisotope heat engine for powering the pump?

Mr. FOWLER. That is correct.

Mr. ROBISON. You are now in phase 2 of this project?

Mr. FOWLER. If the Congress appropriates the money we will proceed with phase 2.

Mr. ROBISON. Phase 3 would be what?

Mr. FOWLER. Phase 3 would be the building of a prototype engine which would be coupled with a heart pump to test a system under that situation.

Mr. MORRIS. And hydraulic system?

Mr. FOWLER. And the hydraulic system.

ESTIMATE FOR PHASE 3 DEMONSTRATION

Mr. ROBISON. The Joint Committee's report suggests that the phase 3 demonstration of this prototype engine is estimated to cost $3 million and take 3 years to accomplish.

Mr. FOWLER. That is correct.

Mr. ROBISON. The 3 years would be 3 years regardless of the amount of money we put into this because of the technical difficulties involved and the nature of the problem?

Mr. FOWLER. I think it is very difficult to think about moving this program much faster than that even if we put twice the amount of money into it.

Mr. MORRIS. Whose responsibility will it be to fit together the system, the pump, and the isotope energy source?

Mr. FOWLER. Of course, the National Heart Institute has the overall responsibility for all heart device work. The AEC would be serving as a service arm to them by doing the bioengineering work associated with building an engine, and providing a coupling with the heart pump. Eventually after the qualification phases of the nuclear system, which are beyond the 3-year period we are talking about, integration into the body for studies would be the responsibility of the Heart Institute.

Dr. ENGLISH. There is one other AEC responsibility. We certainly would be looked to with respect to the effect of radiation from the isotopic heat source on the body itself since, of course, this part of the biological studies is really an integral part of the AEC's biology and medicine division responsibility. They would be assisting in this in that sense.

Mr. FOWLER. We would be doing another important aspect associated with this and that is the research and development on the radioisotope fuels, plutonium-238 and promethium-147, for the radioisotope engine. Both of these isotopes are being looked at as candidate fuels for such a radioisotope engine.

FINANCING BY TRANSFER FROM NATIONAL HEART INSTITUTE

Mr. MORRIS. Why would it not be appropriate to finance AEC's participation by transfer from the National Heart Institute appropriations?

Mr. FOWLER. We have had a number of conversations about this very question. As a matter of fact, Dr. Shannon has communicated with Chairman Seaborg as of April 22. He has indicated the budgetary situation which the Heart Institute has and the priorities which they have for expenditure of that money. They have indicated they would not be able to provide moneys for the nuclear power supply development.

At the same time Dr. Shannon recognizes that nuclear power development is important. It would be an important adjunct to the artificial heart programs.

Mr. MORRIS. Can you provide for the record any official communications pertaining to this which you have had with the Institute?

Mr. FOWLER. We can certainly provide that.

(Information requested follows:)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
NATIONAL INSTITUTES OF HEALTH,
Bethesda, Md., April 22, 1968.

Hon. GLENN T. SEABORG,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR DR. SEABORG: We are enclosing a communication to us from the Director of the National Heart Institute concerning the artificial heart program and specifically the relation to it of activities of the Atomic Energy Commission.

We have discussed these matters at length with Dr. Fredrickson and his staff and concur with the position expressed in the attached summary. Their position is a reasonable one and reflects their desire to meet the aspirations of both of our agencies during a period when our budgets are indeed stringently restricted.

In concurring with their opinion, we do wish to stress the desire of the National Institutes of Health to continue the closest cooperation with the Atomic Energy Commission in collaborative activity on the development of the artificial heart program.

I must apologize for my part of what appears to have been a communications break in the spring of 1967.

With my kindest regards,

Cordially,

JAMES A. SHANNON, M.D.,
Director.

MEMORANDUM—DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE, APRIL 15, 1968

To: Director, NIH.
From: Director, NHI.
Subject: The development of an artificial heart, with special reference to the use of nuclear power.

Careful examination of the current state of development of a permanently implantable artificial heart leads me to the following conclusions:

1. Such a device is feasible; there is ample reason to believe that it could totally rehabilitate patients with heart failure that is not complicated by major vascular disease and do so for a period of years. The number of potential recipients would be large (several thousand annually).

2. The time when such a device might be ready will be inversely related to the resources committed to the problem. That commitment is now considerably less than optimal and, at the current rate of expenditure, a practical device will not be available for perhaps 10 years.

3. The support of development of an artificial heart should be allocated with regard to support committed to parallel solutions of disease problems for which

the device is intended. Specifically, these are: (a) research aimed at prevention of premature heart disease, particularly atherosclerotic heart disease, (b) the development of short-term and partial mechanical cardiac assistance, (c) improved salvage in myocardial infarction by medical means, and (d) cardiac transplantation.

At present, National Heart Institute support is programed such that research on the artificial heart is of lower priority than research on prevention or development of short-term assistance and of roughly equal priority with research on medical treatment of infarction and transplantation. I believe these priorities must so remain for the present.

4. A suitable implantable source of energy and power has not yet been developed for permanent assistance devices or for a whole artificial heart. A variety of systems are under consideration:

(*a*) A thermal engine with an electrical heat source.

(*b*) A thermal engine with a radioisotope heat source.

(*c*) A piezoelectric system for converting electrical to mechanical energy.

(*d*) An electromagnetic system (for example, brushless d.c. motors) for conversion of electrical to hydraulic energy.

(*e*) A biological fuel cell.

Systems (a), (c), and (d) require an external source of electrical energy for periodic recharging of implanted batteries by percutaneous or transcutaneous transmission. Although the biological fuel cell (use of glucose and oxygen from blood as reactants) is an attractive concept, at the present developments in this area are substantially behind the other energy sources under consideration. If and when a biological fuel cell is available, both a piezoelectric and an electromagnetic system could be powered by it and would not require an external source of energy; until then, of course, an external source would be required.

The current state of development of any of these power systems does not now provide a basis for selecting one for preferential development. All require further study without which their relative capabilities for meeting requirements for driving the blood pump, control, efficiency, size suspension, and stability cannot be determined.

5. The nuclear-powered thermal engine proposed by the Atomic Energy Commission is the conceptual stage. Four contractors have presented designs for isotope-powered engines. AEC desires to proceed to the construction of working models of several of these designs (phase II). AEC is confident that sufficient purified plutonium-238 can be provided to meet the requirements imposed by such a power source.

These designs meet the upper limits of specifications provided by the National Heart Institute in 1966. There is inadequate information to assure that these specifications for that portion of the device to be implanted in the pelvis are reasonable as to size and tolerability. On the basis of available evidence, AEC believes that the total body radiation from the source will be tolerable to the bearer and probably to those about him; there is not sufficient informaion to assure that thermal, mechanical, and radiation effects in the locality of the source will be innocuous.

6. These questions can only be answered by further research and development. AEC clearly has the capabilities necessary for development of a nuclear energy source. It is not unreasonable that it desires to develop a thermal engine concomitantly. At the same time the National Heart Institute needs to pursue development of thermal engines using other energy sources as well as continue research on different forms of power. There are not now clearly defined areas where engineering and biological aspects of thermal engine development can be clearly separated. The arrival at optimal solutions to the presently foreseeable problems related to isotope-powered thermal engines will critically depend upon the degree of cooperation and interchange between AEC and NIH.

7. In the NIH budget for fiscal 1969 funds are not available to support the AEC phase II development of a nuclear-powered engine. According to the Institute's current program plan, which includes an evaluation of the capability of a thermal engine (powered electrically for this test) to meet the pumping and control requirements of an artificial heart, information should be obtained in fiscal 1969 which will facilitate a determination of the preferred path for energy development. This consideration does not imply that continuing collateral research by AEC on miniaturized nuclear power sources would not be of benefit to the artificial heart program.

I am attaching for your convenience a chronological summary of NIH-AEC interrelationships relating to the artificial heart program.

DONALD S. FREDRICKSON, M.D.

A SUMMARY OF NATIONAL HEART INSTITUTE—ATOMIC ENERGY COMMISSION ACTIVITIES RELATED TO THE DEVELOPMENT OF NUCLEAR-POWERED ENERGY SOURCES FOR PERMANENTLY IMPLANTED ASSIST DEVICES AND AN ARTIFICIAL HEART

On June 24, 1966, Dr. Robert P. Grant, then Director of the National Heart Institute, requested the support of the Atomic Energy Commission for developing and loaning to the National Heart Institute isotopes for experimental heat sources. This was to be part of the overall plan for research and development of the artificial heart. On July 21, 1966, Dr. Grant received a reply from Mr. Robert E. Hollingsworth, the General Manager of the Atomic Energy Commismission, indicating that the AEC was very interested and willing to assist the Institute in this development and that he had requested Mr. Eugene E. Fowler, Direcor of the AEC Division of Isotopes Development, to supervise delivery of the sources to the National Heart Institute. On September 29, 1966, AEC formally entered into an interagency agreement for development and fabrication of fuel pellets of plutonium-238. The pellets were to be used for the study of endogenous heat and radiation effects upon materials and animals.

On November 8, 1966, Dr. Frank W. Hastings, then Acting Chief, artificial heart program, NHI, replied to a formal request from Mr. William Mott, Assistant Director for Technical Programs, AEC, for information desired by the Commission to formulate an AEC request for proposals for conceptual design of a thermal engine for which radioisotopes would be the heat source. Dr. Hastings' reply included specifications for an artificial heart which he considered as adequate as he could compile at the time.

These specifications were used as a basis for a request for proposals issued by AEC on December 23, 1966. On January 5, 1967, Dr. Hastings participated in a conference with AEC representatives to discuss the request for proposals. He was subsequently kept abreast of the reviews, but he did not participate in selection of the proposals.

On May 10, 1967, AEC selected four firms for the conceptual studies: Aerojet General Corp., San Ramon, Calif.; Donald W. Douglas Laboratories, Richland, Wash.; Thermo-Electron Engineering Corp., Walton, Mass.; Westinghouse Astronuclear Laboratories, Pittsburgh, Pa.

The implementation of these conceptual studies was visualized by NIH as a collaborative effort between the AEC and the NHI. The Office of the General Counsel, HEW, had notified NIH (in a memorandum dated March 28, 1967), that the NHI could not transfer funds to AEC, but recognized no legal impediment to the NHI and the AEC jointly funding contract projects for which appropriations of each agency would be available. Upon this basis, the National Heart Institute signed a memorandum of agreement on April 24, 1967, which was signed by AEC May 1, 1967. Half of the cost of each contract was to be billed to each agency. The contribution of the Institute came to approximately $275,000. It was anticipated that these studies would require 6 months, and that they would involve determination of feasibility of the development of a radioisotope-powered thermal engine. During the next 6 months, there were informal conversations between Dr. Hastings and the representatives of AEC and the contractors concerning progress in the studies. Dr. Hastings indicated that according to the program plan of the Institute, it was unlikely that resources would be available for actual developmental studies on the radioisotope-powered engines in fiscal years 1968 and 1969.

In February 1967, the Atomic Energy Commission sought to clarify responsibilities for the total project and requested a memorandum of understanding from the Director of NIH to the Chairman of the Commission. The AEC draft delineating the responsibilities for overall program evolution was modified by the Heart Institute and referred to the Director, NIH. At this time, however, the artificial heart program was undergoing complete reevaluation, and an Associate Director to manage it was being recruited. For these reasons a reply was not transmitted to AEC.

During the beginning of fiscal year 1968, the procedures and priorities of the artificial heart program were revised to enhance a fuller program having as its goal the development of a family of mechanical circulatory assistance devices. Highest priority was assigned to the improvement of temporary support devices. The matching of priorities with available resources permitted the allocation of one-tenth of the total resources for energy development—$1.1 million—for fiscal 1968. Program analysis further indicated that evaluation of various modes for energy generation and utilization was required before a clear-cut priority could be assigned to either one engine type or implantable energy source. The

NHI work plan for fiscal 1969, therefore, now calls for an analysis and performance studies of various principles, including thermal energy. In the view of NHI, preliminary test of the thermal concept does not require the use of a radioisotope energy source. The acquisition of new knowledge over the past 2 years has also stimulated reappraisal of the original specifications.

In early 1968 the Director of the Heart Institute and the Chief of the Artificial Heart Branch were asked to discuss the overall program with Chairman Seaborg and the other members of the Atomic Energy Commission. Some division of opinion on the potentiality of the thermal engine was brought out in this meeting; it was also apparent that there had been a lapse in communications between the two agencies in regard to the development of the artificial heart.

A series of meetings were thereafter initiated between Institute personnel and the representatives of AEC to discuss candidly and thoroughly all aspects of the problem. The participants from the Heart Institute at various times have been Drs. Frederickson, Cooper, Hastings, and Harmison. The Atomic Energy Commission has been represented by Mr. Fowler, and Drs. Mott, Storer, Sang, Sagen, English, and Cole. There has been a frank discussion of the Institute's overall plan of development including the priorities in each program area, and the feasibility and the conceptual studies about to be completed for AEC. NHI indicated to AEC that all of the specifications provided by Dr. Hastings in 1966 have not yet been proved experimentally to be feasible, that the mechanical requirements for suspending the engine in the pelvis, for example, might limit the practicality and usefulness of any engine sources of this type; and that the experience thus far with a Stirling cycle engine has not yet demonstrated an efficiency which approaches that envisioned in the conceptual studies. It was also brought out that there are many other questions concerning design, radiation effects, and other mechanical problems that cannot be answered without further development, including mock up of conceptual models.

During this same period the NHI has discussed, at his invitation, all aspects of artificial heart development with Mr Fred Schuldt, of the Bureau of the Budget: This includes the analysis of NHI priorities, its interpretation of the current state of the art and the practicality of the utilization of devices as they were conceived in the studies funded last year. NHI has indicated to both AEC and to the Bureau of the Budget its desire to continue collaboration with the Atomic Energy Commission for work in this area. It has stated, however, that the fiscal 1968 and 1969 budgets do not permit it adequate resources to transfer funds from the artificial heart program budget to the Atomic Energy for the purposes of phase II development of the nuclear powered thermal engine.

Mr. Fowler and his associates attended the March 28, 1968, meeting of the Artificial Heart-Myocardial Infarction Program Advisory Committee, dealing with the current state of the art and the application of temporary devices for mechanical circulatory assistance to man. The Institute hopes to schedule time for discussion of engine development, including AEC presentation of its work, at an early meeting of this committee.

U.S. Atomic Energy Commission,
Washington, D.C., May 6, 1968.

Dr. James A. Shannon,
Director, National Institutes of Health,
Bethesda, Md.

Dear Jim: I greatly appreciate hearing from you and receiving the information provided in your letter of April 22, 1968.

I quite understand the priorities established by the National Heart Institute with respect to expenditure of research and development dollars for program activities associated with heart disease, and the importance of this work, I was also interested to see from Dr. Fredrickson's memorandum to you that while these priorities and the moneys available to the Heart Institute do not permit NHI funding for development of a nuclear power supply for heart devices, he feels that collateral research by the Atomic Energy Commission on miniaturized nuclear powered sources would be of benefit to the artificial heart program.

You will be interested to know that the report of the Joint Committee on Atomic Energy which accompanies the bill authorizing appropriations for the Atomic Energy Commission for fiscal year 1969 recommends authorization of $800,000 in operating funds over the budget submitted to Congress. These funds are to provide for initiation of second-phase work on development of an implantable radioisotope engine for heart devices The AEC authorization bill, which

includes the $800,000 has now been passed by both the House and Senate and signed by the President. We have also completed our hearings before the House Appropriations Subcommittee on Public Works this past week, during which committee members expressed considerable interest in this development program.

During the course of our hearings before the Joint Committee on Atomic Energy, as well as the House Appropriations Subcommittee, I stated the strong interest of the Commission in this effort and my personal view that isotopic power was clearly one of the most versatile and most feasible means of providing a long-term reliable power supply for implantable heart devices.

I share with you the desire and, indeed, recognize the necessity for the Atomic Energy Commission and the National Institutes of Health to continue the closest cooperation and collaboration in work directed to the development of isotopic power system for heart devices. I have been assured that Mr. Fowler, Director of our Division of Isotopes Development, is working closely with Dr. Fredrickson and Dr. Cooper, and I am encouraged that he has been invited to brief the National Heart Institute's Artificial Heart-Myocardial Infarction Program Advisory Committee in late June on radioisotope engine development for heart devices.

I will inform you as quickly as the Congress takes final action of the Atomic Energy Commission's fiscal year 1969 budget appropriations.

Cordially,

——— ———,
Chairman.

Mr. MORRIS. Also is it not true that the AEC under the statute has responsibility for development of isotopic power?

Mr. FOWLER. Isotopic power systems.

Mr. MORRIS. Which this is part of?

Mr. FOWLER. That is correct.

RADIATION PRESERVATION OF FOODS

Mr. MORRIS. $1,185,000 is budgeted to continue the program for radiation preservation of foods.

The Joint Committee in its report pointed out that one of the greatest difficulties in this program is the time and effort involved in the Food and Drug Administration petition process.

Please comment on this problem and its effects on the current program.

Mr. FOWLER. I can and perhaps Dr. Totter can add to it if I do not get the full story to you.

We have designed the AEC program, which started back in 1960, against protocols which we had established for clearance of radiation processed foods with the Food and Drug Administration.

Over the past year Dr. Goddard and the Food and Drug Administration have chosen to change those ground rules, which means that previously we were utilizing and taking benefit from the studies which were carried out by the Department of the Army under the radiation sterilization program, principally 2 years long-term animal feeding studies, and using these data as a basis for petitions, or consideration of petitions, by the Food and Drug Administration.

The FDA requested the AEC to perform on top of that work 90 days short-term animal studies.

This now has been changed and we are obligated to carry out 2-year animal feeding studies ourselves on the specific foods of interest to us.

The net effect of this means that the AEC's program is set back in terms of time from 2 to 3 years on any particular food product with which we are involved, with the possible exception of the petition which we now have standing before the Food and Drug Administration for marine products.

EFFECT OF CAPITAL EQUIPMENT DEFERRAL

Mr. MORRIS. $1 million is requested for new capital equipment together with planned expenditures of $410,000 deferred from the current year under the stretchout program.

What was the effect of the deferral of this $410,000 for the purchase of capital equipment during the current year?

Mr. FOWLER. The effect has been that we were confronted with a major problem, and that was the replacement of shipping casks for radioisotopes to meet new shipping regulations. These new regulations have required that we either modify or build and replace existing casks.

This deferral has had the effect that we have not been able to complete as much work in terms of building new casks in fiscal year 1968 as we would have liked.

Mr. ROBISON. Going back to the heart device, the original budget request was for $500,000 for fiscal 1969.

What was this originally asked for?

Mr. FOWLER. That was directed to the radioisotope fuels program for the radioisotopes engine.

Three hundred and fifty thousand dollars of this is directed to plutonium-238 fuels development, $77,000 directed to promethium-147 fuels development, another $73,000 directed to the manufacture of radiation sources for studies in animals and to understand the effects of radiation and heat on the animal system as it relates to the heat program.

Mr. ROBISON. This would be classed as basic research in this particular area?

Mr. FOWLER. Classed as research and developmental work from the standpoint of developing processes for manufacture of ultrapure medical grade fuels for the engine.

FOLLOW-ON EFFORTS IN ENGINE DEVELOPMENT

Mr. ROBISON. Look at page ID–4 of the justifications. There you talk about follow-on efforts on the engine development. This would be more in the field of applied research?

Mr. FOWLER. That is right.

Mr. ABBADESSA. The purpose of that sentence is to point out that in 1968 we complete our work on conceptual studies.

In this budget we contemplate that the follow-on efforts in the engine development would be funded by the National Heart Institute.

Mr. ROBISON. But it will not be.

Mr. ABBADESSA. That is correct. The Joint Committee, in adding $800,000, is providing for work not contemplated by our budget request. It is more a direct application or applied research.

PROGRAM OF NATIONAL HEART INSTITUTE

Mr. ROBISON. In a sense, what the National Heart Institute has decided to do is to go for a stepwise approach, as the Joint Committee says in its report, which means that the Institute will work on an intermediate device powered by an electric source of some kind, an outside device.

Mr. FOWLER. This is one of the means they are looking at. As a matter of fact, the Heart Institute requested proposals in February and received them in the middle of March, broadening the spectrum of activities they will look at in terms of power sources and the way they can get power into an animal body.

Their interest is to attempt to get a device into an animal body within 18 months.

This will probably be externally powered.

PRIORITY OF PROGRAM

Mr. ROBISON. That is the difference.

We are having all sorts of trouble with priorities this year. I have expressed my concern about priorities throughout these hearings.

But how do you feel about the priority of this particular project, and the $800,000 the Joint Committee has suggesed? Is it important? Can it be used to good purpose now? Is it necessary that we go forward with it?

Mr. FOWLER. First of all, I would say it is a very difficult technical problem. However, I would say heart disease certainly is a serious national problem; it is the No. 1 killer in the country.

If nuclear powered systems can be developed to provide a mechanical device to replace the biological heart, then, I think, as Chairman Seaborg himself has said, this would be one of the most dramatic developments in atomic energy in history.

In my terms it should have the highest priority.

PRESERVATION OF BACON BY RADIATION

Mr. ROBISON. You also mentioned troubles you have had with the Food and Drug Administration respecting the preservation of foods by radiation.

Is bacon one of the products which has been cleared? Can this be commercially used now despite Food and Drug's hesitance?

Mr. FOWLER. Bacon has been cleared by them.

Mr. ROBISON. You have to package it in tin cans under their regulations rather than in a wrapper?

Mr. FOWLER. Yes.

Mr. ROBISON. Which adds costs?

Mr. FOWLER. Yes. This has been approved; however, other type of wrapping materials have also been approved. As a matter of fact, at least one company in the country has indicated they contemplate carrying out test marketing during the current year of radiation-processed bacon.

Mr. ROBISON. In a tin can?

Mr. FOWLER. In a tin can.

It would be very similar to the canned bacon you see on shelves right now, the Danish bacon.

Mr. ROBISON. The difference from other bacon is that you can keep it in a tin can and not a refrigerator. Is that right?

Mr. FOWLER. Yes.

Mr. ROBISON. How is the Danish bacon preserved? Is it through some salt brine process?

Mr. FOWLER. It is cooked.

Mr. ROBISON. And the radiated bacon would not be cooked?

Mr. FOWLER. That is correct.

I might mention here, however, that the Department of the Army's petition for the radiation-sterilized canned ham has been rejected, or at least Dr. Goddard communicated with the Army and said they had 30 days either to appeal the rejection or withdraw the petition.

There is some hint they may be relooking at the approval they previously gave on bacon, so I don't know what the future brings on that particular problem.

PUBLIC ACCEPTANCE OF FOODS PRESERVED BY RADIATION

Mr. ROBISON. What evidence is there of public acceptance of food which has been preserved through the use of radiation?

Mr. FOWLER. There probably is some consumer concern about the use of radiation in processed foods. However, a small consumer attitude study has been carried out and nearly 70 percent of those queried did not express concern about using food processed by radiation. The sample included about 600 individuals representing a cross-section of our population.

WOOD PLASTICS

Mr. ROBISON. Have you dropped out of the wood plastics field altogether?

Mr. FOWLER. We are bringing to an orderly termination the development work this year on wood plastics, for the reason that industry is making progress in the commercialization of this technology, particularly the Atlantic Richfield Corp. recent entry into the field. This is a large company with a capacity to commercialize this product if it has commercial potential.

Mr. ROBISON. So you do not need to contribute further toward its development?

Mr. FOWLER. We feel we have done our job by developing the technology and having it accepted by industry.

Mr. ROBISON. That is a good example.

Mr. MORRIS. Thank you, Mr. Fowler, for your presentation.

CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES (PLOWSHARE)

Mr. MORRIS. We will hear next from Mr. Kelly and his associates on the civilian application of nuclear explosives (Plowshare).

The committee is happy to have you before it once again.

You may proceed in your own way.

CRATERING STUDIES IN CONNECTION WITH SEA-LEVEL CANAL

Mr. KELLY. I have with me today Col. James Tormey, who is with the U.S. Army Corps of Engineers. Particularly we are cooperating with them in the conduct of the engineering feasibility studies for a sea-level canal under the auspices of the Atlantic-Pacific Interoceanic Canal Study Commission. As you may know, we recently conducted two significant cratering experiments. I think the committee was shown the photographs of the two craters yesterday.

Mr. MORRIS. Yes; we were, Mr. Kelly.

RADIOACTIVITY REDUCTION

Mr. KELLY. I also have a drawing which shows the improvement we have made in the last few years in reducing the amount of radioactivity which might be released in cratering. The pattern on the left is the fallout pattern from the sedan experiments which we did in 1962. On the right is the fallout pattern we would expect if we did sedan with today's technology. In the intervening years this committee has given the Plowshare program funds for developing special explosives and emplacement techniques which we have used to accomplish this result. Part of the funds we are requesting in fiscal year 1969 would be to continue this kind of development.

The President's budget has some $7 million for nuclear excavation in fiscal 1969 and we would expect to use approximately half of that, a little over $3 million, for continuation of that sort of development testing.

PROJECT SCHOONER

In addition we would expect to do a large cratering experiment, one we have talked about before called Schooner, which hopefully would be approximately 100 kilotons and would advance the technology considerably.

Mr. MORRIS. Do you anticipate any problems with this project under the test ban treaty, referring now to Schooner?

Mr. KELLY. I would think we can do this under the limited test ban treaty.

PROJECT CABRIOLET

Mr. MORRIS. Cabriolet was the one which was delayed?

Mr. KELLY. That is right.

Mr. MORRIS. What was its total cost?

Mr. KELLY. I do not have the figures here. My recollection is that it was closer to $3 million. I can supply that for the record if you want it precisely.

Mr. ABBADESSA. His recollection is correct, it is closer to $3 million.

GASBUGGY

Mr. KELLY. The second major area of activity in the Plowshare program in fiscal year 1968 is underground engineering. We did the first experiment in this area in cooperation with the El Paso Natural Gas Company and the Department of Interior's Bureau of Mines in northern New Mexico last December. This is a picture of the Gasbuggy explosive being lowered down the emplacement hole.

Mr. MORRIS. Where is the explosive device physically located?

Mr. KELLY. In the cylinder which has the word "Gasbuggy" written on it.

The canister fits the hole. It is just a piece of pipe about 18 inches in diameter. The explosive is inside.

EMPLACEMENT HOLE GB–E

Mr. RHODES. Do you have facilities for keeping track of everything in that hole from time to time? You don't just drop things down there.

You have some fairly good idea of what will happen to it when it is all the way down?

Mr. KELLY. That is correct.

Mr. RHODES. I am glad to hear that.

Mr. KELLY. In this particular case we drilled a 28-inch hole and put a 20-inch casing into the drilled hole. We then lowered the explosive canister inside of the casing.

Mr. ROBISON. How deep is the hole?

Mr. KELLY. 4,240 feet.

Mr. MORRIS. A 26-kiloton device?

Mr. KELLY. Yes. It was fired on December 10, 1967. We are very optimistic about the outcome of it.

POST SHOT RESULTS

As you may know, we are still evaluating the results. We have achieved re-entry and we have recovered samples of the gas. There is considerably less tritium in the gas than we expected there would be.

The gas pressure is continuing to build up. It is now essentially at the original gas pressure, and we expect to start doing production drawdown tests within the next few months.

OTHER INDUSTRIAL PROJECTS

In fiscal year 1969 we have about one and a half million dollars in the underground engineering category, and we expect to spread this over several different projects. There has been a tremendous interest not only in gas stimulation (Projects Dragon Trail and Rulison) but also in copper leaching (Project Sloop) oil shale retorting (Project Bronco) and natural gas storage (Project Ketch).

Mr. MORRIS. Where will this copper leaching take place?

Mr. KELLY. The Safford ore deposit in Arizona.

LASL BECOMES TECHNICAL DIRECTOR

In order to meet the expanding demand for these kinds of experiments we recently appointed the Los Alamos Scientific Laboratory as the technical director for two of the proposed underground engineering projects—Rulison and Sloop—by this action we can now proceed in parallel on more of the underground engineering projects.

INCREASED INDUSTRIAL CONTRIBUTIONS

We are also expecting, and we have evidence based on informal discussions, that the industrial sponsors of the projects will pay a large share of the costs. As a matter of fact, we expect to spread the $1.5 million requested over at least two or three projects, and I would hope we can execute at least two of them in fiscal 1969.

We will work also to be prepared to conduct two more early in fiscal 1970.

WATER RESOURCES APPLICATION

Mr. RHODES. Would one of those projects have to do with the fracturing of the underground strata so that flow of water would be facilitated into the underground?

Mr. KELLY. That one is a little further down the line. We have had some discussions with the people from Arizona about that project. We really need to do a feasibility study on that particular application. This has not yet been done. We will probably engage in this feasibility study during fiscal 1969, or at least I hope to get started on it.

SCIENTIFIC EXPERIMENTS

The other category here is the scientific experiments, estimated at $500,000. We hope during fiscal year 1969 to do an experiment in conjunction with one of the weapons tests. I am not sure yet whether it will be a neutron physics experiment or a heavy element production experiment.

The funds in our research and development category go to the various laboratories to develop the necessary technical capabilities and to keep them available so that we can do the research needed to support the experiments that I have described, both in excavation and underground engineering applications.

The largest portion goes to the Lawrence Radiation Laboratory in Livermore, Calif., which is involved in all aspects of the Plowshare program. The other laboratories in the program are involved in only some of the aspects.

Mr. MORRIS. Thank you, Mr. Kelly.

BUDGET ESTIMATE CHANGES

The budget estimate provided for a decrease of $3,465,000 in the Plowshare operating program.

The Joint Committee, in the authorization bill, provided for an increase of $2.5 million over the President's budget request.

How would this unbudgeted increase be utilized?

SLOPE STABILITY EXPERIMENT

Mr. KELLY. It would primarily be used to support another cratering experiment. The development of the nuclear excavation technology is in a little bit of difficulty because we discovered within the past 12 months, actually about 6 months ago, I guess—that one of the proposed sea level canal routes now being investigated has substantial quantities of clay shales, a type of rock very difficult to work in.

As a consequence, in order to use nuclear excavation techniques to dig the canal through that route, we will have to learn how to dig craters with very flat slopes. This is a new technical problem we have just encountered which needs to be solved. If we get the additional funds they would be used to look at this new problem.

Colonel Tormey might wish to speak to that. He is also involved in the sea level canal study program.

Colonel TORMEY. This requirement for improved technology for excavating clay shales came about as a result of the explorations in Panama and Colombia where extensive reaches of this type of material were found.

A very distinguished board of civilian consultants from our leading universities and technical consultants declared that if we used the type crater which normally is associated with nuclear excavation, we

would be unsuccessful in having these canals stand indefinitely and steps to develop the new cratering method Mr. Kelly discusses and for which they have some hopes of success, are proceeding.

Mr. KELLY. This material is very soft, and the sides will tend to slide back into the canal unless they have flat and gentle slopes.

UNOBLIGATED BALANCE

Mr. MORRIS. What is the presently unobligated balance under this program? I refer to the current year.

Mr. CORSO. His costs are running close to the planned costs. It is problematical if there will be any under-run at all. He is running very close.

Mr. KELLY. That is right.

Mr. CORSO. As a matter of fact, I am watching it every month.

Mr. MORRIS. We may have a couple more questions which we will submit to you and ask you to answer them for the record.

What has been accomplished to date with the $17,965,000 available for the current fiscal year?

(Information requested follows:)

Chairman Seaborg spoke to the detailed accomplishments during fiscal year 1968 in his statement for the record. To briefly summarize the Plowshare program's accomplishments in fiscal year 1968, we have conducted two major cratering experiments, Projects Cabriolet and Buggy-I; and one nuclear experiment, named Marvel, which was directed toward developing emplacement techniques. In addition, Project Gasbuggy, the first joint Government-industry nuclear experiment to investigate a possible industrial application, was executed; and finally, Plowshare participated in the Pommard event, in which a number of cross-section measurements were made.

Mr. MORRIS. What is the present unobligated balance under the program?

(Information requested follows:)

The operating cost for the Plowshare program through March was $14,764,000. The remaining costs expected through June are $3,201,000. These funds are planned to support the initial preparation for the next major cratering experiment in fiscal year 1969 and also to continue post shot work on Project Gasbuggy. Supporting research and development is the remaining major cost effort supported by these funds.

RESEARCH AND DEVELOPMENT

Mr. MORRIS. Considering the large amounts being expended for research on nuclear explosive designs, why is it necessary to continue to expend $5,500,000 for research and development under this program?

(Information requested follows:)

While much has been accomplished in developing nuclear explosive designs, there are still a number of significant problems peculiar to peaceful applications which require either the development of new designs or modifications of existing designs. In the area of excavation, Plowshare research has been directed both at developing "cleaner" explosives, that is, explosive designs that will produce the least possible amount of radioactivity and special emplacement techniques to reduce the amount of radioactivity released to the atmosphere. As is evident in the drawing which was shown by Mr. Kelly in his testimony, the program has made considerable strides in achieving this objective. Future research in this area is aimed at improving explosive design and emplacement techniques to reduce even further the amount of radioactivity released to the atmosphere in creating explosions.

94-075 O—68—pt. 3——36

Underground engineering applications have their own particular problems which result in other design considerations. For example, in gas stimulation projects, the presence of tritium may prove to be a significant contamination problem. If tritium should prove to be a significant problem, it may be necessary to design an explosive which relies basically on the fission energy produced.

In applications such as copper recovery, other radionuclides may prove to be a problem from a product contamination standpoint, and the explosive would have to be designed accordingly.

Aside from radioactivity considerations, the diameter size of the explosive is also critical to the economics of underground engineering applications. While the shallower depths involved in cratering explosions do not make this a critical factor, many of the underground engineering applications require the emplacement of the explosive at very great depths, some as deep as 15,000 feet. To drill an emplacement hole to such depths, if the design of the explosive requires a large diameter hole, is extremely costly and could, in some instances, make the application uneconomic. Thus, if many potential applications in underground engineering are to be economical, the explosive must be designed with the smallest possible diameter. Other factors such as designing the explosive to withstand the high temperatures and pressures which occur at great depths must also be considered. Consequently, considerable effort is still required in the area of designing nuclear explosives for peaceful uses.

Explosive design, however, is only part of the effort that is included in the $5.5 million requested for fiscal year 1969. Research will also continue to develop a detailed understanding of the effects of nuclear explosions in a variety of environments; to develop an assessment and predictive capability for ground motion, airblast and radiological safety; to measure and evaluate physical data in support of these theoretical studies and to undertake feasibility studies and cooperative work with other groups on the use of nuclear explosives in promising applications. The last category of effort includes preliminary evaluation of concepts for using nuclear explosives and the early development of plans and designs for field events.

EXCAVATION EXPERIMENTS PLANNED IN FISCAL YEAR 1969

Mr. MORRIS. As outlined on page PNE–4, $7 million is requested for excavation experiments in fiscal year 1969.

Please outline the specific experiments planned under this request.

(Information requested follows:)

The $7 million requested supports two major lines of study which proceed concurrently. They are: (1) the cratering technology experiments (estimated at $3.9 million) and (2) the nuclear explosive development program to develop explosives and emplacement techniques for cratering experiments (estimated at $3.1 million). The Commission plans to use $3.7 million of the $3.9 million earmarked for cratering experiments for Project Schooner, a single charge cratering experiment in hard rock in the 100-kiloton range. Of the remaining $200,000, equal parts will be used (1) to conclude the Buggy-I experiment executed in fiscal year 1968, and (2) to begin preparations for a nuclear row-charge experiment now planned for execution in fiscal year 1970.

Two nuclear explosive development tests are now planned for fiscal year 1969 and will be supported by the $3.1 million requested for that purpose. Both events are aimed at reducing the total amount of fission products and neutron-induced radioactivity released from nuclear cratering experiments.

OPERATIONAL EQUIPMENT SYSTEM

Mr. MORRIS. As outlined on page PNE–12, $325,000 is budgeted for the initial development of a "New streamlined operational equipment system."

Why is it essential to establish this new equipment inventory in fiscal year 1969 rather than borrowing from other programs as has been the practice?

(Information requested follows:)

From the beginning, the Plowshare program has met practically all of its major equipment requirements by borrowing from other AEC programs. This practice continues today. A continuation of this policy in the post fiscal year 1968 period, however, will hinder the program's capability to move forward.

With the growth of the program, it has become increasingly difficult to obtain the necessary equipment items at the right time and in sufficient amounts. By selective scheduling, the borrowing arrangement has been marginally satisfactory. However, the movement of Plowshare projects off the Nevada Test Site (NTS) to other locations, in combination with the increased demands on the weapons and Vela programs and support requirements of the supplemental test sites, are creating severe equipment scheduling problems and in some cases, resulting in unavailability of certain equipment items. Moreover, such scheduling constraints cause field operations to become more costly, time is lost, and in general there are inefficiencies and less than optimum effectiveness in staging a field project.

Aside from scheduling considerations, current practices, both on and off the NTS, involve a number of separate equipment elements, each supporting a portion of the field operation. This multiplicity of equipment not only increases the costs of field operations, but also affects the mobility and efficiency of the operation. This is a problem even for those projects conducted on the NTS. It is even a greater problem for those projects that are conducted off the NTS.

In contrast, the proposed streamlined system considers the entire field operational system as a whole, and is designed as an integrated system to satisfy the total requirements. The objective of the proposed streamlined operational system is to provide, not only for equipment primarily for Plowshare activities, but also an improved and more efficient assemblage of equipment which would permit fielding the experiments at less cost and in less time. The system will be equally useful to both cratering and underground engineering projects; however, the primary programatic requirement in fiscal years 1969 and 1970 arises from joint Government-industry projects off the NTS which are in the latter category. If we are to encourage industry to pay for the larger part of the industrial experiments, we must be able to field experiments on a timely and economic basis. The streamlined system will permit us to do this.

Two characteristics of the planned system which illustrate the possible savings are the mobility of the system which makes it quickly and cheaply transported from one project to the next and the elimination of much of the expensive cabling presently required. For example, the cabling from ground zero to the control point for Project Gasbuggy, cabling which would not be required with the streamlined system, amounted to nearly $100,000. In addition, a principal feature of the system is that it is planned as a first step leading toward ultimate commercial utilization of the Plowshare nuclear explosion in which the number of men and the time in the field must be reduced to a minimum.

Should funds not be made available for this system, the immediate effect is that it will require that Plowshare field projects continue to be scheduled at the convenience of other programs, when their equipment can be borrowed, and at a higher cost. The long-term effect is much more serious. Since equipment for the streamlined system involves long leadtime items, the first steps to develop such a system should be taken during fiscal year 1969 in order to meet on a timely basis the increasing needs of the program as the technology approaches a commercial level.

USE OF TECHNOLOGY IN CONSTRUCTING INTEROCEANIC CANAL

Mr. RHODES. Is the perfection of this technology which you mentioned to provide a gradually shallow size necessary for the successful operation of nuclear explosives in digging the Interoceanic Sea Level Canal?

Mr. KELLY. Along Route 17 in the Darien region of Panama, yes. That is where this clay shale is found. We do not know of any other way to go through it.

Mr. RHODES. What about the other route?

Mr. KELLY. As far as we know, the route through Colombia does not have this kind of material. On the other hand, the test drillings of that route are not completed yet.

Colonel TORMEY. That is true. However, I expect that we will find some softer materials which might require the same type of shallow excavation in Colombia. The outlook is for some similar material, yes, sir.

Mr. RHODES. Have you any idea as to time frame in which you might have the answer to this problem?

COOPERATIVE STUDY

Mr. KELLY. In answering I would like to mention the cooperative program we have with the Corps of Engineers. A Corps of Engineers group that is physically located at the Lawrence Radiation Laboratory, Livermore, Calif., has done some low-yield experiments with chemical explosives. By "low yield," I mean about a pound. Through these experiments they have developed techniques and have, in fact, dug craters with sufficiently flat slopes to meet the clay shale requirements on that scale.

Within the AEC the Sandia Corporation is attempting right now to extend the work the corps has done with a series of 64-pound experiments. When the series is completed, the corps will do another scale-up at Fort Peck, Mont., at about a 1-ton—2,000-pound—level. I would guess that this 1-ton work should be completed by the first of August.

I would think after that it would be appropriate to consider designing a nuclear experiment and carrying it out. If we are successful in scaling up the technique that the corps has evolved at the 1-pound level, it should not take more than maybe one nuclear experiment to get an answer, at least in principle.

FISCAL YEAR 1968 UNOBLIGATED BALANCE

Mr. CORSO. May I clarify one point for the record. When I answered your question on Mr. Kelly's unobligated balance, I was referring to the amount in the financial plan and the amount in the 1968 column of the 1969 budget. However, in Operation Cutback, we did reduce the amount approved by Congress for the Plowshare program by $2,750,000, and that amount is in the approximately $70 million of carryover which has been applied to reduce the AEC's fiscal year 1969 budget.

I just wanted the record to be clear on that.

Mr. RHODES. Thank you very much.

You do feel, though, that this is a problem that can be handled?

Mr. KELLY. Yes, sir. I am optimistic about meeting the problem.

FALLOUT

Mr. RHODES. Will it increase the possibility that there will be radioactive fallout from such an excavation that might inhibit the use of nuclear explosives?

Mr. KELLY. The amount of radioactive fallout is roughly constant, about the same for each explosive. To dig the canal by the methods we have thought about originally; namely, just a single row all the way across the isthmus, would have taken, we estimated, approxi-

mately 300 explosives. Tailoring of the slopes of this 20-mile region to get it flat enough would probably increase the number of explosives by 50 or 60. So, instead of 300 explosives, it would be 350 or maybe 375. Of course, the total amount of radioactivity would go up by that proportion, which is about 15 to 20 percent.

I believe the amount is sufficiently small that a 15- or 20-percent increase would not affect the safety situation.

Mr. RHODES. In other words, the explosive still would be planted, and you would hope that there would be no appreciable amount of earth go into the atmosphere that might carry radioactivity with it.

Mr. KELLY. That is correct.

INDUSTRIAL EXPERIMENTS

Mr. RHODES. Mr. Robison.

Mr. ROBISON. Even though your overall budgetary request is down, the industrial experiments program, for which you asked $1,400,000, is a new program for fiscal year 1969?

Mr. KELLY. No. We had funds in that category in fiscal year 1968.

Mr. ROBISON. But you are calling it something else now? At least, looking at page PNE–8 of the justifications here, it shows no amount applied to this in 1967, nothing in 1968, and now $1.4 million?

Mr. KELLY. Last year we had just the item called Gasbuggy. We have expanded and broadened it to cover our other proposed industrial applications and are calling the whole category underground engineering. Really, Gasbuggy is a part of the underground engineering category.

INDUSTRIAL CONTRIBUTIONS

Mr. ROBISON. Maybe the chairman's questions covered this, but on this page it also says that industry proposes to pay most of the cost of these projects. Can you give us a dollar estimate as to what industry will contribute toward this, or is it still in the negotiating stage?

Mr. KELLY. We are still in the negotiating stage. The situation is a little bit different on each particular project.

For instance, in the oil shale project—Bronco—where there are some 15 or 20 companies involved, I think it would be relatively easy. I expect that we will be able to negotiate a situation where essentially the Government's only contribution would be the explosive service. This is because there are 15 or 20 companies, and the dollar amounts would be small enough not to hurt any of them.

Mr. ROBISON. Can they not write it off under the so-called oil-depletion-allowance loophole, anyway? You do not know?

Mr. KELLY. I do not know. That is out of my bailiwick.

Mr. ROBISON. What I am driving at is, is there not some way we could get at this on a reimbursable basis, perhaps? I know this will help develop engineering technology for the benefit of the whole Nation, but primarily it is for the benefit of the immediate industry, it seems to me.

Mr. KELLY. Of course, ultimately we do expect that it will become a paying proposition. However, during the time we are developing the explosives and the technology, and until we gain some experience in operating off the Nevada test site, we want to be extremely care-

ful, and some of the costs associated with this will be borne by the Government.

Mr. ROBISON. I can see why the Commission wants to control the experiments and be in charge of the explosives, all the procedures, and whatnot, but it seems to me that, somewhere along here, you might receive some reimbursement for the work AEC people do and the materials they provide.

Mr. KELLY. It is our goal to get to that position as quickly as we can. We are making, I think, very substantial progress in that direction.

In the case of Gasbuggy, the so-called Government-industry mix is about 60-percent Government and 40-percent industry. In the next one, whatever it is, I expect it will be at least 80-percent industry and 20-percent Government. I think we are going in the right direction, and it should not be too long before we get to the desired point.

Mr. ROBISON. Thank you, Mr. Chairman.

Mr. MORRIS. I thank the gentleman from New York.

INDUSTRY PARTICIPATION ENCOURAGED

The committee wants to do everything it can, Mr. Kelly, to help you encourage industry to participate in these experiments. We feel they are important to the country, but also they will have important industrial use applications from which the corporations will receive direct benefits.

I want to commend you on your statement and explanation.

We will insert justification pages PNE–1 through PNE–14 in the record at this point.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION

FY 1969 Budget Estimates
Appropriation - Operating Costs

CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES (PLOWSHARE) PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969.....$14,500,000
Estimate FY 1968.....$17,965,000
Decrease.....$-3,465,000

The Plowshare program supports the research, development, and experimental testing necessary to develop peaceful uses for nuclear explosives. All of the activities proposed in FY 1969 are directed toward developing technology for the safe application of nuclear explosives in various yield ranges to civil works (excavation), industrial (underground engineering), and scientific purposes. All field experiments to be undertaken in FY 1969 will be designed to meet the requirements of the Limited Nuclear Test Ban Treaty.

The nuclear excavation program for FY 1969 is an extension of the FY 1968 cratering experiments and projects and is aimed at developing a further understanding of cratering phenomenology and a capability for accurately predicting the size and shape of craters. In addition, it is planned to continue the development and testing of specially designed nuclear explosives and emplacement techniques which can substantially reduce the amount of radioactivity released from cratering explosions. The ultimate technological goal of the cratering work is to attain a capability to enable the United States to design and conduct the excavation portion of major civil works projects.

The underground engineering efforts in FY 1969 take advantage of strongly motivated interest on the part of private industry for the use of nuclear explosives in cooperative projects in such applications as copper and natural gas recovery, and as a construction tool for creating underground storage facilities for natural gas and petroleum, and in-place oil shale retorting.

Plowshare designed scientific experiments round out the operating program. These experiments--in conjunction with nuclear detonations conducted for other purposes--are the mechanisms for producing new isotopes and for further developing techniques for neutron physics measurements.

CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES (PLOWSHARE) PROGRAM - continued

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
PNE-2	1. Research and Development.....	$ 6,403,337	$ 6,415,000	$ 5,500,000
PNE-3	2. Excavation Experiments.....	5,601,142	8,421,000	7,000,000
PNE-7	3. Scientific Experiments.....	468,817	350,000	500,000
PNE-8	4. Underground Engineering Experiments.....	379,550	2,779,000	1,500,000
	Total Civilian Applications of Nuclear Explosives Program.....	$12,852,846	$17,965,000	$14,500,000

JUSTIFICATION OF CATEGORIES

1. Research and Development..... $5,500,000

These funds support the work of scientists, engineers, and technicians in various laboratories and also are used to procure necessary materials and services to support their research, both in the laboratory and in the field. This effort is directed at obtaining a fundamental understanding of nuclear explosive design, of nuclear explosion phenomenology, and of the application of this phenomenology to civil, industrial, and scientific purposes. This work is conducted chiefly at the E. O. Lawrence Radiation Laboratory (LRL) in Livermore, California. The program also draws upon the specialized talents and capabilities of the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; the Sandia Laboratory, Albuquerque, New Mexico; Los Alamos Scientific Laboratory (LASL), Los Alamos, New Mexico; and the laboratories of several other government agencies (e.g., United States Bureau of Mines, United States Geological Survey) and various private contractors whose efforts complement research by LRL.

To the extent possible, Plowshare research studies at LRL are supported at a relatively constant level of effort and provide for a continuation of scientific and technical investigations, both theoretical and experimental, in four major areas: (1) development of the theory of nuclear explosion effects in

a variety of environments; (2) development of an assessment and predictive capability for ground motion, air blast, and radiological safety; (3) measurement and evaluation of physical data to support the theoretical studies, and (4) feasibility studies and cooperative work with other groups on the use of nuclear explosives in promising applications. Included in this basic framework of technical effort is the preliminary evaluation of concepts for using nuclear explosives and the early development of plans and designs for field events. In addition, part of LRL's research effort is aimed at the design and development of cleaner and more economical nuclear explosives for peaceful uses.

Also provided for under this heading is support of field studies at the sites of past nuclear explosions and Plowshare participation in appropriate tests sponsored by other programs. Funds are included to provide for surveillance of the Plowshare site near Carlsbad, New Mexico.

In FY 1969, it is expected that the Commission will continue to receive a number of promising formal proposals from industry--six have been received through December 1967--for joint experiments with the government on the use of nuclear explosives in developing various applications. Funds are planned to support such work beyond the preliminary feasibility study stage, including the initiation of engineering and site evaluations.

2. Excavation Experiments.....$7,000,000

The Commission's nuclear excavation technology development program is based on the premise that the relatively inexpensive energy available from a thermonuclear explosive can safely break and simultaneously move large quantities of rock and earth at a small fraction of the cost and time required by conventional techniques. Accordingly, it is considered possible to perform--by nuclear means--the excavation required for large construction projects such as canals, harbors, cuts through mountain barriers for transportation routes, and certain mining operations that may not otherwise be done. It appears that the use of nuclear excavation in large-scale engineering projects would yield potential cost savings in the hundreds of millions of dollars. Time and cost factors become important because in many projects requiring large-scale earth moving, tremendous financial requirements extending over long periods of time now make their construction with conventional earth moving systems economically infeasible. The nuclear explosive, as a new excavation tool, could make many such projects possible.

It is planned to continue the joint AEC-Civil Works Division, U.S. Army Corps of Engineers program (commenced in 1962) to develop a nuclear excavation technology for large-scale excavation with an orderly series of nuclear explosive device development tests and nuclear cratering technology experiments so as to determine the technical feasibility of nuclear excavation. In this connection, the AEC's excavation program is oriented and timed to contribute to the Atlantic-Pacific Interoceanic Canal Study Commission's assessment of the feasibility (including costs) of excavating a sea-level canal across the American Isthmus employing nuclear explosives.

The exact distribution of these funds among the different elements of the excavation program, such as special nuclear explosive device testing, execution of cratering technology experiments, planning, design and preparation of future experiments, and completion of technical activities in the field from experiments executed in prior fiscal years will be planned to achieve optimum progress without crash effort or without excessive delays between experiments. Following is the current nuclear excavation program which reflects present planning. Developments during the remainder of FY 1968 could cause some changes to this plan.

SUMMARY OF CURRENT NUCLEAR EXCAVATION PROGRAM

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
a. Excavation Device Testing.....	$4,030,775	$3,400,000	$3,100,000
b. Cabriolet (Low Yield Point Charge).....	1,204,930	1,400,000	0
c. Buggy-I (Row Charge in Flat Terrain).....	346,251	3,400,000	100,000
d. Buggy-II (Row Charge to Join Ditches).....	0	121,000	100,000
e. 10's of KT to 100 KT Point Charge (e.g.,Schooner)	0	100,000	3,700,000
f. Flivver (Low Yield Point Charge).....	19,186	0	0
Total Excavation Experiments.....	$5,601,142	$8,421,000	$7,000,000

a. Excavation Device Testing....FY 1967: $4,030,775 FY 1968: $3,400,000 FY 1969: $3,100,000

The primary objective of the nuclear explosive device development program is to develop thermonuclear explosives with a variety of yields into the megaton range, but having no more than a few kilotons of fission yield per explosive. Some immediate technical goals include (1) a further reduction of the total amount of fission product and neutron-induced radioactivity, (2) a significant reduction in the complexity of the nuclear system to increase reliability and safety with optimum nuclear efficiency and performance, and (3) a substantial reduction in the cost of the explosives. In addition to work on these goals, which mainly involves physics design and development work, attention is also directed to development of emplacement techniques to reduce even further the amount of radioactivity that might be released to the atmosphere from future cratering projects.

Two device tests are planned for execution in FY 1969 to further the development of excavation explosives, with plans for one additional test directed toward development of emplacement techniques. These tests will be similar to, but with larger yields than those carried out in FY 1968. The specific yield will depend largely on the results and analysis of the FY 1968 events. All detonations in this activity are planned to be conducted deep underground at the Nevada Test Site (NTS). Each device test will involve a single nuclear explosive emplaced in a drilled hole between 36-48 inches in diameter at depths of up to 3,000 feet. Each event requires a normal diagnostic effort and instrumentation for obtaining other physical measurements taken at surface stations as well as from underground satellite holes usually drilled to the emplacement depth of the explosive. The field construction associated with each event accounts for the majority of costs. The balance of required funding relates to technical support (timing, firing, safety, etc.), logistical requirements, and the fabrication cost of the nuclear device and its ancillary hardware.

Cratering Technology Experiments

Major emphasis in FY 1969 will be directed toward the conduct of one full-scale cratering experiment which is part of the continuing sequence of field experiments for developing excavation technology. The experimental program using single explosive charges with increasing yields in a variety of geologic settings will be continued with the planned Schooner detonation. Development of nuclear excavation technology requires cratering experiments to obtain further data with which to develop the theories necessary to design and carry out nuclear excavation projects and to verify empirically the theories that are being developed. Also, only through nuclear cratering

experiments is it possible to produce craters in which the crucial engineering parameters of nuclear excavation can be studied. The development of the technology first requires an experimental program using single explosive charges with increasing yields in a variety of geologic settings to develop scaling laws, refine the predictive theory of cratering mechanics, and understand basic mechanisms of radioactivity distribution. Secondly, rows of nuclear explosives must be detonated simultaneously under varying conditions to develop an urgently required understanding of the characteristics of ditches and channels which would be created in complex geology and terrain.

b. Buggy-I (Row Charge in Flat Terrain)....FY 1967: $346,251 FY 1968:$3,400,000 FY 1969: $ 100,000

The execution in FY 1968 of the first nuclear row charge experiment, Buggy-I, at the Nevada Test Site will be a major step in the development of excavation technology by determining the dimensions and smoothness of a ditch produced in hard rock by simultaneously detonating a row of nuclear explosives. The funds requested in FY 1969 provide for normal post-shot activities to conclude the technical studies and then to deactivate the site.

c. Buggy-II (Row Charge to Join Ditches).. FY 1967: $ 0 FY 1968: $ 121,000 FY 1969: $ 100,000

Following Buggy-I, the second nuclear row charge project is presently planned for FY 1970. It will extend the prior knowledge of row charge dynamics to an understanding of how ditches may be connected and also reveal ditching characteristics under a somewhat more complex geometry. This project is known as Buggy-II and, as currently planned, will be joined with the channel of Buggy-I on the NTS. The experiment will probably involve the simultaneous detonation of five to seven nuclear explosives having yields somewhat higher than those employed in the Buggy-I experiment. Specific yield calculations and design of the Buggy-II project will depend heavily on the results from Buggy-I. The FY 1969 funds would support preliminary engineering activities to begin to acquire a readiness to execute Buggy-II in FY 1970.

d. 10's of KT to 100 KT Point Charge (e.g., Schooner)..FY 1967: $ 0 FY 1968: $100,000 FY 1969:$3,700,000

As now planned, the Schooner detonation at either the NTS or in the Bruneau Desert area of southwestern Idaho, will occur in a hard rock medium and the yield will be in the 10's of kiloton to 100 kiloton range. Site evaluation and preliminary safety studies were conducted in FY 1964 for the Idaho Site. Planned activities in FY 1968 will complete the final site selection and field work will commence at the site selected in order to achieve an FY 1969 readiness for execution. Principal technical programs of Project Schooner are studies of cratering effects, shock transmission, pressure and velocity history, gas generating properties of rock, and distribution of radioactivity. The nuclear explosive will be emplaced in a 36-inch drilled hole at optimum cratering depth. The emplacement hole, including casing as necessary, subsidiary underground and surface instrument stations, and the technical and logistical support elements of the project make up the major portion of the FY 1969 costs.

3. Scientific Experiments..... $500,000

The AEC has a continuing interest in using the nuclear explosion as a tool to conduct scientific research for peaceful purposes. One of the phenomena of particular interest is the very intense neutron flux which occurs in a nuclear explosion. This neutron flux is singularly effective for conducting physics experiments which could not otherwise be carried out in conventional laboratories, and in another way may be used to create new isotopes, and possibly new elements, of high mass number.

Device Testing.....FY 1967: $ 468,817 FY 1968: $ 350,000 FY 1969: $ 500,000

These funds are planned to support Plowshare designed experiments on the mechanisms of producing new isotopes and for further development of techniques for neutron physics measurements in conjunction with nuclear detonations conducted for other purposes. It is expected that the major emphasis will be given to the heavy element studies which require--among other things--the recovery of samples from the underground region in which the detonation occurs.

The precise degree of participation by LRL and the Los Alamos Scientific Laboratory (LASL) in this activity will depend on the evaluation of laboratory studies and related work conducted by both laboratories in FY 1968.

4. Underground Engineering Experiments.....$1,500,000

Underground engineering with nuclear explosives is one of the major segments of the Plowshare program and basically involves the use of nuclear explosions to aid in the recovery and utilization of various natural resources. These marginal resources have heretofore been uneconomic or impossible to exploit by conventional means. Underground engineering applications which are the most promising and in which industry has shown the greatest interest are natural gas stimulation, petroleum production, natural gas storage, recovery of valuable metals from low-grade ore-bodies, and oil recovery from oil shales.

The FY 1969 experimental program in underground engineering anticipates joint participation by private industry, the U. S. Bureau of Mines (USBM), and the AEC in carrying out particular experiments deemed desirable subsequent to joint government-industry studies of the technical feasibility of the particular application. For each project a formal proposal from industry has been received requesting participation by the Atomic Energy Commission and the Department of the Interior in the experiment. These proposals all involve commitments by industry to provide funds and services for portions of the experiment. A matter of considerable interest in Gasbuggy, the first such experiment which was successfully detonated on December 10, 1967, was the ratio of requested government expenditures to proposed industry expenditures. The Commission believes this ratio will necessarily vary with different applications and will include considerations such as the value of technical information, the structure of the industry, and non-financial aspects of the proposal, such as patents, economic value of the application to the public, industry generally, and the specific company. In the final analysis the exact ratio will depend upon the outcome of detailed contract negotiations.

a. Industrial Experiments.....FY 1967: $ 0 FY 1968: $ 0 FY 1969: $1,400,000

As expected, the execution of Gasbuggy on December 10, 1967, has served to actively stimulate industrial interest in Plowshare underground engineering applications.

In order to capitalize on this interest, the government now has an excellent opportunity to develop underground engineering technology for the benefit of the nation and the AEC is prepared to move forward in order to obtain from industry the maximum possible funding for these experiments, thereby minimizing the government's expenditures. Even though industry proposes to pay most of the cost of these projects, it will be necessary to the AEC to meet its responsibilities to provide the personnel, equipment, and basic development work on which

these projects must be founded. Industry's faith in the potential of Plowshare applications has already been demonstrated by the five formal proposals (summarized below) for joint projects received by the Commission in several areas of natural resources.

FORMAL PROPOSALS RECEIVED BY AEC THRU DECEMBER 1967 (EXCLUDING GASBUGGY)

Type of Application	Sponsor	Project Name	Proposed Site
Natural Gas Production Stimulation	1. Continental Oil Co., Houston, Texas	Dragon Trail	northwestern Colorado
	2. Austral Oil Co., Houston, Texas	Rulison	northwestern Colorado
Underground Storage for Natural Gas	Columbia Gas System Service Corporation, New York City	Ketch	north central Pennsylvania
In-Place Leaching of Copper	Kennecott Copper Corporation, New York City	Sloop	southeast Arizona
In-Place Retorting of Oil Shale	Consortium of over 15 oil companies represented by CER Geonuclear Corp., Las Vegas, Nevada	Bronco	northwest Colorado

These funds would be used to commence activities on one or more of these projects depending upon the final outcome of contractual arrangements.

b. Project Gasbuggy.....FY 1967: $ 379,550 FY 1968: $ 2,779,000 FY 1969: $ 100,000

On December 10, 1967, Project Gasbuggy was executed and is the first industrial application of a nuclear explosion for peaceful purposes undertaken by this country. Also, Gasbuggy was the first joint industry-government sponsored venture involving a nuclear explosion. Funds requested for FY 1969 provide for the completion of the project and include post-shot monitoring and evaluations.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES (PLOWSHARE) PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969..... $ 750,000

A-Construction Projects
A-1 Obligations for new projects.....($ 0)
A-2 Obligations for prior year projects.....($ 0)

B-Capital Equipment Not Related to Construction
B-1 Obligations from new appropriations.....($ 500,000)
B-2 Obligations from prior year appropriations...($ 250,000)
Estimated Obligations FY 1968..... $ 100,000
Actual Obligations FY 1967..... $ 497,102

Obligations for the Civilian Applications of Nuclear Explosives (PLOWSHARE) Program for FY 1969 are estimated at $750,000, of which:

$500,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

$250,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Capital Equipment Not Related to Construction.....	$ 500,000

JUSTIFICATION

These funds provide for equipment acquisitions to support research, development, and field projects in Plowshare's operating program. Plowshare's equipment needs normally fall into two main groups. First, and of very high priority, are major equipment items such as mobile timing and firing units, weather units, and downhole equipment for field projects planned in FY 1969 and beyond. This type of equipment is singularly crucial to the program's capability to move forward with the industrial underground engineering projects foreseen in increasing numbers during the FY 1969-1973 period. The second grouping of equipment is that which meets the program operating needs of the participating scientific and technical groups carrying out research and development activities in their laboratories and in the field. Equipment of this type is predominantly scientific instruments and includes a variety of items for the measurement, recording, and collection of technical data. A separate and more detailed discussion of the two groups follows.

	Estimated Obligations FY 1969
Streamlined Operational Equipment System.....	$325,000

Since FY 1959 the Plowshare program has, by necessity, met most of its major equipment requirements by borrowing from other programs. The growing Plowshare program, along with the increased demands of the weapons program, including support of Supplemental Weapon Test Sites and Advanced Research Project Agency (ARPA) events, are creating severe scheduling problems and, in some cases are resulting in the unavailability of certain equipment items. Additionally, under such constraints, field operations become significantly more costly, more time is lost and, in general, there are inefficiencies and less than optimum effectiveness in staging a field project. This situation manifests itself very acutely in Plowshare projects planned and scheduled for locations off the NTS, where rapid interchange of equipment items for multiple uses are easier.

To eliminate these problems so that scheduling and the actual fielding of Plowshare projects will not be in jeopardy, this estimate provides for the initial development and procurement of elements of a new streamlined operational equipment system which will ultimately permit the fielding of two Plowshare projects in a given year at locations other than the NTS. This system concept has as its objective the provision of an improved and more efficient integrated assemblage of equipment for use principally in underground engineering projects, thus enabling them to be done in much less time and at less cost.

94-075 O-68-pt. 3—37

Present practice involves a number of separate equipment elements, each supporting a portion of the field operation. The underlying feature of the new streamlined system is to consider the entire field operational system as a whole and then to design an integrated system to satisfy its total requirements.

While the streamlined operational system has a relatively high investment cost (total estimated cost including future requirements, of $2.7 million), it is expected that the major items of equipment can be used a number of times--in effect creating a low, amortized unit cost per project. It is also expected that this system will simplify major logistic and support requirements, such as signal cable which has in the past been procured for each project. A further principal advantage is that it is to be designed as a first step leading toward ultimate commercial utilization of the Plowshare explosions in which the number of men and the time in the field must be reduced to a bare minimum in order to make Plowshare's underground engineering applications economically competitive with conventional recovery techniques where they exist. A major feature of the new system is the elimination of the conventional hard wire connection between the emplacement hole and the control point. The major savings in this regard, for example, will be in the elimination of cost of installing instrument cabling, which for Project Gasbuggy amounted to over $100,000. The additional savings resulting from reducing time in the field are difficult to assess, but it is clear that they will be significant and real. Another major feature of the system will be the utilization of integrated cable and explosive handling equipment, which hopefully will greatly reduce the time and manpower requirements for going "downhole" with the nuclear explosive.

	Estimated Obligations FY 1969
Basic Laboratory Equipment.....	$ 175,000

The types of equipment to be procured for support of laboratory effort consist of specialized precision instruments, recording systems, cameras, oscilloscopes, counters and amplifiers, ultrasonic units, and similar electronic and mechanical equipment. This type of equipment will be acquired by the laboratory participants (LRL, LASL, ORNL) in connection with their Plowshare research programs, and will be used principally for radiochemical and geophysical analyses and investigations in the cratering, underground engineering, and scientific applications.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Capital Equipment Not Related to Construction.....	$ 250,000

Training, Education, and Information Program

Mr. Morris. We next have the training, education, and information program.

Dr. Poor. Mr. Morris and Members of the Committee:

This program is designed to help the universities to train the personnel needed in all the Commission's work as well as to help some of the atomic industry of this country. It is divided into two major categories. One is the physical and life sciences and engineering; and the other has to do with training of State and local government personnel in radiation control.

In the first category of physical and life sciences and engineering, we have an authorized sum of $9.5 million. In the training assistance to States and local governments, we have $160,000, which is a part of the Commission's regulatory program.

TRAINING AND EDUCATION IN THE PHYSICAL AND LIFE SCIENCES AND ENGINEERING

The training and education in the physical and life sciences and engineering program is divided into five categories. I will trace them briefly and then I have a short statement I can leave for the record.

Mr. Morris. That will be fine, Dr. Poor. It will be made a part of the record right after your discussion.

Dr. Poor. I will give a very brief breakdown of the five categories.

At Oak Ridge and at Argonne and a few other places, we conduct courses that are not possible in universities for the training of people handling isotopes and other radiation materials.

In the second category we offer a few fellowships and traineeships. The fellowships are selected by a national board, and the traineeships are selected by competent institutions. These total about 530 altogether. A few of them are medical people working in areas where there are considerable amounts of radiation.

The third category, assistance to schools, is the means whereby we make it possible for university faculty members, graduate students, and some undergraduate students to use various Commission laboratories where they have large, unique, and sophisticated equipment which is too big and too expensive for most universities to acquire.

We also operate the Puerto Rico Nuclear Center under a contract with the University of Puerto Rico.

We have a few other minor categories for the conduct of conferences, symposia, and other training aids.

I will submit this statement to the reporter and then, if you have any questions, I will be very glad to answer them.

(The statement follows:)

Training and Education

Two budget categories are involved in training and education: (1) training and education in the physical and life sciences and engineering; and (2) training assistance to State and local governments in radiation control. These categories are authorized for a total of $9,500,000 and $160,000, respectively, in fiscal year 1969.

TRAINING AND EDUCATION IN THE PHYSICAL AND LIFE SCIENCES AND ENGINEERING

(1) A continuing flow of scientists and engineers well versed in nuclear fields is of the utmost importance to the continuing advancement of the United States in national security and in peaceful utilization of the atom. There is a continuing need in all nuclear fields for a constant infusion of manpower educated or trained to the necessary levels for all the many kinds of activities in the nuclear powered utilities; fuel fabrication and recycling; reactor development; radiological safety; medical use of isotopes, accelerators, and reactors; physical, biological, and medical research; industrial use of isotopes; agriculture; water desalination and exploitation of natural resources. Figures based on Bureau of Labor Statistics data and other surveys indicate the need for over 6,000 new people per year with bachelor's or higher degrees, while about 4,000 such people are being graduated annually. A major effort of AEC's Division of Nuclear Education and Training (DNET) is to assist in filling a portion of this 2,000-man gap by placing seed money to spur those activities best calculated to alleviate the more urgent manpower needs and/or having the greatest impact per dollar spent in bringing people into nuclear fields. The most direct effort in helping to alleviate this gap is in the fellowship and traineeship programs which directly produce degrees in nuclear science and engineering.

Over 137,000 persons are employed in Government laboratories and facilities and in private industry working in nuclear fields. Forty-two percent are known to be in scientific, engineering, or technician categories. Requirements for trained personnel to satisfy attrition, growth in industry, and the needs in the educational, biological, and medical fields demand that a vigorous course be pursued. AEC's educational programs are designed to stimulate the universities to produce the additional 2,000 nuclear-oriented scientists and engineers who are required annually. The programs are also designed to motivate promising college and graduate students toward study in nuclear science and engineering or to acquire working knowledge of nuclear energy as it will relate to their chosen field. The methods used involve assistance to institutions of higher education in nuclear areas in the form of equipment grants, reactor fuel assistance, and use of facilities at AEC sites along with the cooperation of AEC contractor personnel in the programs of the higher education institutions. These methods also include encouragement of talented individuals to enter nuclear fields, for example: postdoctoral fellowships, graduate student fellowships, traineeships, and the strengthening of college and high school science faculty in nuclear areas by institutes, workshops, and conferences.

Mr. MORRIS. We shall hear the other statement, and then proceed with questions.

TECHNICAL AND PUBLIC INFORMATION AND INTERNATIONAL ADVISORY AND CONSULTANT SERVICES

Mr. BRUNENKANT. Mr. Chairman, three programs are involved in this budget category. Two, our technical and public information programs, fill the needs of the technical community for scientific and technical information, and encourage public understanding of nuclear science and its peaceful applications, while the third supports advisory and consultant services when such services will significantly promote AEC's international programs.

All three activities are now programed to operate at or below fiscal year 1968 funding levels.

With the chairman's permission, I would like to highlight just a few significant parts of the program.

Mr. MORRIS. You may proceed.

Mr. BRUNENKANT. There are more scientists and engineers constructively employed today than at any time in our history. Their intellectual output threatens to overwhelm our ability to efficiently and effectively transfer knowledge. Men's minds and men's time have finite absorption capability. This is why computers offer both a challenge and hope of assistance in creating more effective information transfer systems.

Specifically, they offer us a means of assuring that the same research is not performed twice under Government auspices, and a further means of providing scientists who are doing research with information about related work which has been or is being performed by others. A small portion of this budget is directed toward adapting computers to this transfer process.

NEW YORK HALL OF SCIENCE

Last year this committee approved AEC assistance to the New York Hall of Science. I am pleased to report that New York City has approved the funding of $10.8 million for the building which will house the nuclear demonstrations and educational activities. A contract has been signed with an outstanding firm of architects and, hopefully, foundation work will start this fall.

I believe that this unusual facility will enrich the education of tens of thousands of students and provide continuing intellectual stimulation and opportunity for their teachers.

TRAVELING LECTURE DEMONSTRATION UNITS

I can also report that encouraging progress has been made in our efforts to join forces with the States in the planning and operation of our traveling high school lecture demonstration units. Last year this cooperative program, which saved some Federal dollars, was in effect in four States: North Carolina, Georgia, New York, and Texas.

Oklahoma, Oregon, and Florida have already contracted to participate this year, and there is a strong indication they will be joined by South Carolina, Wisconsin, Kentucky, and Pennsylvania.

Last year more than 3½ million students viewed AEC films as part of their regular educational program. Two new films were shown by 112 TV stations in 39 States, reaching an estimated 20 million people.

I will be delighted to answer any questions the committee may have.

Mr. MORRIS. Thank you.

We will insert justification pages TE & I 1 through TE & I 39 in the record at this point.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

TRAINING, EDUCATION AND INFORMATION PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$17,009,000
Estimate FY 1968	16,422,000
Increase	$ 587,000

The objective of the Training, Education and Information Program is to broaden the base of nuclear knowledge and technology at home and abroad. Program efforts are directed toward providing assistance to colleges and universities in establishing nuclear curricula; conducting specialized courses, administration of cooperative programs between universities and AEC laboratories; offering graduate and post-doctoral fellowships in the nuclear energy field, including a traineeship program; operating the Puerto Rico Nuclear Center; providing special assistance to states for training in radiation control; presenting nuclear science demonstrations and exhibits to increase the understanding and application of nuclear developments for the betterment of mankind; and providing services to effectively organize and disseminate the results of AEC's growing research and development programs to the scientific and industrial communities.

The major increases requested for FY 1969 are as follows:

Training and Education in the Physical and Life Sciences and Engineering

The increase of $150,000 is necessary to continue the improvement in the quality and to increase the number of individuals educated in nuclear science technology. To this end an increase in the number of post-doctoral fellowships granted and traineeships awarded has been included in the estimate for FY 1969. The cooperative educational program between universities and AEC laboratories is planned to continue; the additional support planned in this area in FY 1969 will assist in the national effort to increase the educational potential and, therefore the economic potential, in all parts of the country by enabling universities in all regions to utilize AEC's scientific facilities. Provision has also been made for the utilization of existing university reactors to provide training opportunities for students of those institutions not having reactor facilities.

Technical Information Services

The increase of $442,000 is to enable the Atomic Energy Commission to carry out its responsibilities for the effective dissemination of scientific and technical information. The major portion of this increase is for

Technical Information Services - continued

the following: continuation of design and fabrication of the atomic energy demonstration exhibit for the New York Hall of Science; the development of computer applications to input information for storage purposes and search strategy for information retrieval and output such information in forms suitable for publication; and disseminating the increased amount of scientific and technical information generated by the research and development programs of the AEC.

The estimates by category are as follows:

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
TE&I-3	1. Training and Education in the Physical and Life Sciences and Engineering	$ 9,432,007	$ 9,500,000	$ 9,650,000
TE&I-19	2. International Advisory and Consultant Services	54,087	55,000	55,000
TE&I-20	3. Training Assistance to States and Local Governments in Radiation Control	100,541	165,000	160,000
TE&I-23	4. Technical Information Services	6,010,676	6,352,000	6,794,000
TE&I-34	5. Public Information Services	350,436	350,000	350,000
	Total Training, Education and Information Program	$15,947,747	$16,422,000	$17,009,000

TRAINING, EDUCATION AND INFORMATION - continued

1. Training and Education in the Physical and Life Sciences and Engineering $9,650,000

The objectives of this program are to assure the availability, on a national level, of the scientific and engineering manpower in the nuclear energy fields by assisting individuals and institutions in a variety of education and training opportunities. These efforts are directed toward the advancement of nuclear technology in the improvement of industrial potential, and the national welfare and security.

The total nuclear education and training effort breaks down into five broad functional areas as described below:

(1) Operation of Courses - This effort is concerned with training in the applications and handling techniques of radioactive materials and radiation, including instrumentation and measurement techniques.

(2) Fellowships and Traineeships - Provides for graduate level training and thesis work in the nuclear oriented sciences and engineering at selected universities, national laboratories and other AEC facilities.

(3) Assistance to Schools, Faculty and Students - Provides a broad spectrum of educational and training opportunities at AEC laboratories, contractor facilities and universities. These activities include Summer Student Training, faculty training and research participation; training institutes for college and high school teachers and grants for nuclear training equipment. The National Laboratories offer traveling lecturers and cooperative programs between various university associations and the laboratories for faculty and students; assistance is provided university reactors in the form of reactor fuel, radioactive sources and other materials and services.

(4) Operation of the Puerto Rico Nuclear Center - This activity makes available to Spanish speaking and other students a broad program of nuclear education, training and research in the engineering, life and physical sciences, with

considerable emphasis upon tropical environment specialization. The work of the Center is conducted at several locations on the island in collaboration with the University of Puerto Rico.

(5) Other Expenses of Training - This activity supports the development of nuclear oriented training aids and assistance to specialized conferences and seminars designed to enhance and supplement the base program of nuclear education and training.

The estimate for FY 1969 is made on the basis of continuing effort at all existing AEC sites at levels approximating those of the previous year. Certain minor changes are contemplated and include the following: (1) Mobile Isotopes Laboratory support will be reduced by about half that provided in FY 1968; (2) Increases in numbers of fellows to be appointed in the Nuclear Science and Engineering and Traineeship programs have been planned; (3) Increases in the University-AEC Laboratory Cooperative program and the assistance to university reactors have also been estimated.

SUMMARY OF ESTIMATES BY ACTIVITY

Training and Education in the Physical and Life Sciences and Engineering:

A. Operation of Courses.....	FY 1967: $ 436,903	FY 1968: $ 425,000	FY 1969: $ 370,000
B. Fellowships and Traineeships..	3,663,389	3,680,000	3,785,000
C. Assistance to Schools, Faculty and Students.....	3,925,158	3,940,000	4,040,000
D. Operation of Puerto Rico Nuclear Center.....	1,126,764	1,200,000	1,200,000
E. Other Expenses of Training....	279,793	255,000	255,000
Total Category.....	$9,432,007	$9,500,000	$9,650,000

JUSTIFICATION OF ACTIVITIES

A. Operation of Courses.....$370,000

Courses included under this activity are tabulated below:

1. Radioisotopes Techniques Courses..	FY 1967: $203,248	FY 1968: $210,000	FY 1969: $200,000
2. Medical Qualifications Courses....	70,589	75,000	95,000
3. Mobile Isotopes Laboratory.....	163,066	140,000	75,000
Total	$436,903	$425,000	$370,000

The general demand for specialized training is expected to remain at about the same as in FY 1968.

1. Radioisotopes Techniques Courses - Oak Ridge Associated Universities (ORAU) FY 1967: $203,248 FY 1968: $210,000 FY 1969: $200,000

These highly specialized courses are designed to develop proficiency in the use of radioisotopes and related analytical techniques by college and university faculty, practicing scientists, engineers and medical doctors. These are short, concentrated courses scheduled to meet the needs of individuals who cannot take time off from their normal duties to pursue full term academic work at colleges and universities. The demand in the form of well qualified applicants continues to exceed present course capacities. Courses offered cover research techniques, engineering applications and specialized work in activation analysis, geology, nuclear electronics and medical radioisotope technology.

Course Title Radioisotopes Techniques:	Course Weeks	Actual FY 1967 Students	Estimate FY 1968 Students	Estimate FY 1969 Students
Basic Courses:				
1. Research Courses	4	108	120	120
Special Courses:				
1. Activation Analysis	3	22	20	20
2. Nuclear Geology	3	-	12	-
3. Medical Technician Supervisors	4	8	20	20
Total Enrollments		138	172	160

The decreased estimate in enrollees in FY 1969 reflects the exclusion of the Nuclear Geology course, which is currently planned for alternate years.

2. Medical Qualifications Courses (ORAU) FY 1967: $70,589 FY 1968: $75,000 FY 1969: $95,000
   Student Enrollment 60 65 80

These courses are designed to prepare practicing physicians to use radioisotopes in diagnostic and therapeutic procedures. The courses are offered in three sequential sessions of one week each: a. Basic, b. Preclinical, c. Clinical. In addition to classroom study, laboratory work is given to provide demonstrations of both custom-made, and commercially available apparatus.

3. Mobile Isotopes Laboratory - ORAU FY 1967: $163,066 FY 1968: $140,000 FY 1969: $75,000

This program is designed to meet a need for instruction and experience in the use of radioactive materials by faculty and students at colleges with limited science faculty and facilities. The program consists of two weeks on campus and is presented by staff members of the Oak Ridge Institute of Nuclear Studies or university consultants serving in the local area. During FY 1967 attendance (including faculty, students and others) totaled 747, distributed among 18 states and included 53 institutional visits. The estimated support for FY 1969 has been set at approximately one half of FY 1968 level

as a result of a proposed arrangement with the National Science Foundation to share equally the cost of operating the Mobile Lab units.

B. Fellowships and Traineeships.....$3,785,000

A variety of specialized fellowships and traineeships in the physical and life sciences and engineering are included under this activity as shown in the following tabulation:

1.Nuclear Science and Engineering (NSE) Fellowships.....	FY 1967: $1,263,646	FY 1968: $1,270,000	FY 1969: $1,265,000
2.Laboratory Graduate Fellowships-NSE	633,058	650,000	650,000
3.Postdoctoral Fellowships-NSE.....	264,675	300,000	350,000
Subtotal NSE Fellowships.....	$2,161,379	$2,220,000	$2,265,000
4.Health Physics Fellowships.....	522,883	490,000	490,000
5.Industrial Medicine Fellowships....	138,229	140,000	140,000
6.Traineeships.....	840,898	830,000	890,000
Total Fellowships and Traineeships.....	$3,663,389	$3,680,000	$3,785,000

Manpower projections for the period 1967-1973* show an average annual need for 1,600 scientists at the M.S.-Ph.D. level and 1,100 at the B.S. level; 700 engineers at the M.S.-Ph.D. level and 3,500 at the B.S. level; and 4,100 technicians at the A.A.S. level. In order to assure such individuals over both short and long range time frames the AEC maintains fellowships in specialized areas to produce leaders in research and development work as well as teachers. The total program is administered in carefully tailored segments as shown below, and is designed to produce specialists in various areas, strengthen graduate level academic programs in institutions across the United States and make use of the special facilities and staff of various AEC sites.

*Based on Bureau of Labor Statistics surveys.

Payments to universities for tuition and fees and payments for stipends and dependency allowances are consistent with those of other Federal fellowship programs. Some variations are needed to permit maximum flexibility as related to special circumstances of the individual programs. Thus all predoctoral fellowships provide for payments to universities of $2,500 per academic year in lieu of tuition and fees during the periods that students are studying on the university campus. During appointments at AEC sites only required tuition and fees are paid in lieu of $2,500 payment. Appointments are made on a twelve month basis, and predoctoral fellows receive $2,400 for first year study, $2,600 for second year and $2,800 for terminal year.

1. Nuclear Science and Engineering
   (NSE) Fellowships..... FY 1967: $2,161,379 FY 1968: $2,220,000 FY 1969: $2,265,000

   The Nuclear Science and Engineering fellowship program includes education and training effort in three discrete areas, employing varying methods of approach as described in the following paragraphs:

   a. Nuclear Science and Engineering (NSE) Fellowships are provided to graduate students in the sciences and engineering. Awards are made on the basis of scholastic attainment by a national selection board review. The program is designed to provide assistance for graduate study at the master's and doctoral levels in nuclear physics, plasma physics, reactor engineering, radiochemistry and a variety of electives in related fields. During FY 1969 it is expected that assistance will be provided to approximately 202 fellows at sixty-eight participating universities. The predominant major is nuclear engineering.

      NSE Fellowships..... FY 1967: $1,263,646 FY 1968: $1,270,000 FY 1969: $1,265,000

   b. Laboratory Graduate Fellowships-NSE are offered to students in the basic sciences and engineering for performing their required thesis dissertation work at an AEC laboratory. This type of fellowship program is justified and supported only in those cases where the campus facilities are not adequate to the individual student's thesis needs. Assistance for both M.S. and Ph.D.

candidates may be provided on campus. The fellowship provides annual stipends of $2,600 for master's degree candidates and $2,800 for Ph.D. candidates. Selection depends on the compatibility of the applicant's dissertation work and the ongoing research program of the AEC laboratory. The number of laboratory fellows to be supported during FY 1969 is estimated to be 103 studying in approximately ten laboratories.

Laboratory Graduate Fellows..... FY 1967: $633,058 FY 1968: $650,000 FY 1969: $650,000

c. Postdoctoral Fellowships-NSE contribute directly to the supply of university faculty well versed in the specialized research and development work of the nation's atomic energy program. The program permits and encourages recent doctoral recipients of unusual ability to work on AEC problems during their early productive years. Fellowship applicants are permitted to select research projects of interest to the AEC at a variety of AEC laboratory sites or universities actively participating in AEC programs. Awards are made primarily for one year with a maximum extension of one additional year. Priority in appointments is given those applicants indicating their intention to enter or remain in the teaching field in areas of AEC special interest. Financial support includes a stipend of $9,000 per year plus an allowance of up to $1,000 per year for relocation expenses and professional travel. The estimate for FY 1969 is expected to support approximately 35 fellows.

Postdoctoral Fellowships-NSE.... FY 1967: $264,675 FY 1968: $300,000 FY 1969: $350,000

2. Health Physics Fellowships..... FY 1967: $522,883 FY 1968: $490,000 FY 1969: $490,000

The need for trained health physicists at varying academic levels and in several specialized areas continues to increase as industrial applications of atomic energy multiply. The estimate for FY 1969 reflects this continuing need not only in the industrial area but also in the academic and research areas. Approximately 60 fellows can be supported at the cost level planned for FY 1969.

Training in health physics is provided under this program to selected college graduates with degrees in the basic sciences or engineering. The program is designed to provide the necessary requirements for the M.S. or Ph.D. degrees. The curriculum includes the normal nine month academic study at the participating university plus three months practical training experience at an AEC facility. Second and third year extensions are granted to well qualified fellows. The curriculum offered at the participating universities and AEC laboratories includes fundamental theory and practical applications in the following areas. Courses are offered in radiation physics, biophysics, dosimetry, electronics and instfumentation, the principles of permissible exposure and the interaction of radiation and living systems.

3. Industrial Medicine Fellowships..... FY 1967: $138,229 FY 1968: $140,000 FY 1969: $140,000

A continuing demand exists for physicians trained in industrial hazards resulting from work associated with radiation and radioactive materials. Therefore, training in occupational health is offered by the AEC at several universities throughout the country. The program is administered by the University of Rochester, Atomic Energy Project. The basic curriculum provides for one year of university study; however, extensions for an additional year are granted in those cases where graduates need to satisfy special board requirements. All graduates are urged to take an additional year of work experience at an AEC plant site. Stipends of $7,500 and dependency allowances of $500 for wife and children, not to exceed $1,500, are provided, plus limited travel. No increase is planned for FY 1969. The requested level of support is estimated for approximately 11 fellowships.

4. Traineeships..... FY 1967: $840,898 FY 1968: $830,000 FY 1969 $890,000

In order to meet the known projected need during the next 4-5 years for highly trained nuclear scientists and engineers a diversified approach must be employed. The traineeship program is designed to assist universities as well as individuals by encouraging nuclear curricula development. This program differs from the various AEC fellowship programs in that the traineeship program is administered

through contracts with selected universities for the support of outstanding students chosen by the universities. Study is directed toward advanced degrees in disciplines relative to the national effort in atomic energy. Concurrent with the basic goal of assisting students is the need to assist institutions in becoming "centers of excellence". The long range goal of the program is to produce approximately 50 Ph.D.'s in nuclear science and engineering per year by FY 1972. In order to accomplish this goal, it is estimated that a "steady state" of 200 fellows should be achieved by FY 1972. The estimated level will support approximately 140 traineeships.

C. Assistance to Schools, Faculty and Students..... $4,040,000

In order to exploit a wide range of educational, training, and research opportunities of the AEC's national laboratories and contractor operated facilities, and to assist educational institutions in advancing their training capacities, assistance is being provided in the specific areas tabulated below:

(1) Nuclear Training Equipment Grants	FY 1967: $ 498,783	FY 1968: $ 500,000	FY 1969: $ 500,000
(2) Faculty Training Institutes.....	946,604	800,000	800,000
(3) University-AEC Lab Coop Program..	2,089,870	2,280,000	2,330,000
(4) Nuclear Materials & Services.....	389,901	360,000	410,000
Totals.....	$3,925,158	$3,940,000	$4,040,000

(1) Nuclear Training Equipment Grants FY 1967: $498,783 FY 1968: $500,000 FY 1969: $500,000

The objective of this program is to establish or strengthen nuclear education programs at those institutions endeavoring to offer qualified curriculum but lack the necessary equipment required of nuclear science and engineering courses. Grants are made for theppurchase of such items as multi-channel analyzers, scintillation counters and geiger counters. Emphasis is currently being placed at institutions awarding advanced degrees in the physical and life sciences and engineering. All grant proposals received are reviewed by committees composed of educators in nuclear science and engineering. Selec-

tions are based on criteria that include quality of curriculum to be offered, numbers of students and amount. During FY 1969 two groups of grants will be offered; one in the physical sciences and the other in the biological sciences. All grants are planned for graduate schools with the exception of a limited number of colleges that have demonstrated ability in producing graduates, a significant portion of whom continue on to the graduate level. The 50 percent matching feature instituted in FY 1967 will continue in FY 1969.

(2) Faculty Training Institutes..... FY 1967: $946,604 FY 1968: $800,000 FY 1969: $800,000

A program of nuclear oriented institutes will continue to be offered under the joint sponsorship of the AEC and the National Science Foundation. These institutes are designed expressly to meet the needs of college and high school teachers. Three types of institutes are sponsored: (a) summer sessions of six to eight weeks for high school and college teachers, (b) in-service (school year) sessions conducted weekday evenings or Saturdays for high school teachers, and (c) full academic year sessions of 36 weeks for college teachers. Institutes are offered in radiobiology and several radiation science courses for chemistry and physics teachers.

During FY 1969 sequential institutes will be continued on an experimental basis at several universities and laboratories. This is a result of efforts to encourage a flow of institute participants from basic to more advanced programs. A growing need exists for specialized and advanced institutes and an increased emphasis is needed on individualized training opportunities for college faculty requiring experience in nuclear research techniques. Further, it is planned to increase the number of short topical institutes in specialized nuclear subjects. The level of support will remain the same as FY 1968 and the number of institutes will approximate 40.

(3) University-AEC Lab Coop Program FY 1967: $2,089,870 FY 1968: $2,280,000 FY 1969: $2,330,000

The education and training potential available throughout the AEC laboratory and contractor operated complex makes it possible to pursue a varied program of

94-075 O-68-pt. 3—38

laboratory cooperative effort with university associations and individual institutions in the general area of the site.

In some respects the Commission's University-AEC Laboratory Cooperative Program is as old as the Commission itself. In the early days of the laboratories, experienced university faculty members who could contribute to ongoing laboratory research received temporary appointments to some of the major facilities. However, in its fullest sense, this cooperative activity is relatively young. A specific effort to organize and use the many existing educational resources of AEC Laboratories for all qualified colleges and universities did not come into existence until 1964.

The major effort for developing this Program has been exerted along two complementary lines. One is to increase the number of participating Laboratories and their geographical distribution, while the other is to inform and motivate the colleges and universities. The growth of college and university associations in working more efficiently and effectively with the Laboratories and each other, has been one of the results of this effort. However, it is only a first step. Through these university associations, the AEC has the means of effectively reaching many universities and colleges, and many more science and engineering students.

These associations, with the cooperation of the AEC Laboratory in their respective area, have been developing various training programs for their institutions' faculty and students. Support for these programs requires at least one year's advance planning. The level requested for FY 1969 will support slightly increased participation in some of the laboratories, making it possible for several new schools to increase their interest in nuclear science and engineering.

These specialized installations and staff developed over the years provide an unusual capacity to offer both students and faculty a wide range of nuclear science training and research activities. The number of participating sites continues to grow as new programs are introduced.

Arrangements between the requesting institution faculty or student and the particular laboratory are being made in most cases through the use of regional associations such as Associated Universities, Inc., Associated Midwest Universities, Oak Ridge Associated Universities and Associated Western Universities. The use of such groups makes possible a high degree of coordination which maximizes the benefits to participants and laboratory staff. The following list includes those activities typical of the effort being supported.

(a) Summer Student Trainees
(b) Faculty Research Participation
(c) Faculty Training and Workshops
(d) Student Thesis Research Assignments
(e) Traveling Lecturer Series
(f) Tele-Lectures
(g) Faculty Study Groups (Professional Activities for Continuing Education)
(h) Student Study Sessions

(4) Nuclear Materials and Services..... FY 1967: $389,901 FY 1968: $360,000 FY 1969: $410,000

This program has been established to provide special assistance to university reactors to assure uninterrupted use of these facilities at institutions that are offering advanced curricula in the nuclear science and engineering disciplines. A breakdown of the estimated support planned for FY 1969 is provided in the following tabulation:

(a) University Reactor Assistance (Fuel Cycle).....	FY 1967: $349,411	FY 1968: $280,000	FY 1969: $280,000
(b) Radioactive Sources.....	30,770	40,000	40,000
(c) Other Materials.....	9,720	40,000	40,000
(d) Reactor Sharing.....	0	0	50,000
Totals.....	$389,901	$360,000	$410,000

This program includes support of the costs associated with refueling university reactors. Loans are made of special nuclear materials for such items as neutron sources, graphite and heavy water. These materials are also provided commercially when availability is deemed appropriate from such sources. The estimate for reactor fuel assistance in FY 1969 of $280,000 is considered minimal to meet the needs of 3-4 universities scheduled for refueling or initial fueling. This latter requirement stems from a long term understanding between the National Science Foundation and the AEC that the AEC would provide initial fueling, after careful screening of proposals by AEC review committees.

The estimates of $40,000 each for Radioactive Sources and Other Materials for FY 1969 is based on currently available information that such requirements will remain at present levels as a result of new or expanding curriculum at many universities and colleges.

A further augmentation in this general area of university reactor use for undergraduate and graduate training assistance is the sharing concept by which time is made available to students from one school on another school's reactor. The estimate of $50,000 for FY 1969 is considered appropriate for the initial year of operation and is based upon use of 3-4 reactors at host institutions being visited by 8-10 sharing institutions. Support is planned to assist in defraying transportation charges for the visiting students and incidental or time charges by the host university as the result of operating the reactor for additional periods.

D. Operation of Puerto Rico Nuclear Center..... $1,200,000

The Puerto Rico Nuclear Center is providing a program in nuclear education and training in the life and physical sciences and engineering which is being pursued at several sites. The program is being conducted and supported through a contract between the AEC and the University of Puerto Rico. Training and research are being conducted at Rio Piedras, Mayaguez, and El Verde. The total program includes graduate study in agri-

cultural, biological, medical and terrestrial sciences in the life science area, and in the physical sciences field study is offered in nuclear science and engineering and health physics. Classroom and other study is almost entirely at the graduate level and particular effort is made to assist the thesis research projects of students earning their M.S. or Ph.D. degrees. Emphasis is placed on subjects of special interest to Puerto Ricans and Latin Americans, and in research of particular application to the tropical environment.

The following tabulation provides an indication of the respective levels of effort in each of the training areas represented in the overall program:

1.Nuclear Science and Technology....	FY 1967: $ 131,074	FY 1968: $ 139,000	FY 1969: $ 140,000
2.Reactor Operations and Training...	88,092	89,700	89,000
3.Health Physics Training.....	31,781	32,400	33,000
4.Agricultural Bio-Science.....	189,978	200,400	200,000
5.Radioisotope Applications.....	129,588	137,800	138,000
6.Clinical Radioisotope Applications	178,212	179,000	179,000
7.Radiotherapy and Cancer.....	158,698	189,800	189,000
8.Medical Sciences and Radiobiology.	146,854	151,500	152,000
9.Nuclear Engineering.....	72,487	80,400	80,000
Totals.....	$1,126,764	$1,200,000	$1,200,000

The requested level for FY 1969 is unchanged from FY 1968 and is essential to continue the process of strengthening the program in several areas as indicated in the following paragraphs:

As a result of the reactor power upgrading it will be possible to develop a project in neutron scattering. It will be necessary to appoint a physicist and research associate to conduct the work and supervise the predoctoral research assistants in the Nuclear Science Division.

The Division of Radioisotope Applications is expected to intensify its research training projects in organic reaction mechanisms and organic radiolysis. This expansion is necessary to meet the increasing numbers of advanced students in nuclear related organic and inorganic chemistry.

An increased training load of both American radiotherapists and Latin American candidates for advanced radiotherapy training is planned for FY 1969. This will require three additional staff to meet this expanded teaching requirement in the Division of Radiotherapy and Cancer.

The Division of Agricultural Bio-Sciences is expected to give special emphasis to its program in graduate degree training during FY 1968. As a result of the rising level of education in Puerto Rico and the Americas, a growing need for graduate studies is being realized. A new program leading to the Ph.D. in Biology at the University of Puerto Rico is being developed. One scientist and one additional technician are planned for late FY 1969 to meet the needs of the expanding program.

E. Other Expenses of Training.....$255,000

This activity includes a variety of support functions designed to strengthen the overall nuclear education and training program. These functions fall into two general groupings explained in the two following paragraphs:

(1) Development of Training Aids..... FY 1967: $137,073 FY 1968: $120,000 FY 1969: $120,000

This functional area includes support for the production and rental of training films, lecture slides, script development and photography of films on various training aspects relating to nuclear energy; and the preparation of a variety of orientation and training media needed to adequately supplement the overall program. The estimate for FY 1969 is expected to support those data gathering and reporting costs needed to be responsive to a variety of government-wide requests for information from both the executive and legislative branches of government. The normal level of training aid support at the various participating laboratories and universities is expected to remain about the same level as FY 1968.

(2) Domestic Conferences, Symposia and Seminars..... FY 1967: $142,720 FY 1968: $135,000 FY 1969: $135,000

This functional area provides assistance to conferences and seminars on a range of subjects relating to nuclear science and engineering. This support also provides for the costs of participating in domestic educational exhibits in a number of scientific and technical areas. Support is normally provided for the costs of technical, logistical and managerial services. The estimate for FY 1969 is principally for special topical conferences in several technology areas that are presenting new training problems, e.g., water resources, plasma physics, and nuclear engineering.

TRAINING, EDUCATION AND INFORMATION PROGRAM - continued

2. International Advisory and Consultant Services $55,000

Justification of Activity

International Advisory and Consultant Services - FY 1967: $54,087 FY 1968: $55,000 FY 1969: $55,000

This activity provides for advisory and consultant services and attendance at conferences and symposia for the purpose of assisting in the evaluation and development of atomic energy programs of regional groups of countries and economically developed countries. Examples of projects supported under this activity are technical assistance to the Eurochemic facility at Mol, Belgium, laboratory-to-laboratory assistance to the Greek Democritus Nuclear Center near Athens and attendance at various international conferences.

Such advisory and consultant services will continue during FY 1969. The assignment of a U.S. advisor to the Eurochemic program will continue through mid-FY 1969 in part to insure that the U.S. will receive timely information on Eurochemic processing experience. During this period the plant will be obtaining important initial operating experience which is of interest to the U.S. programs and represents a return on the technical assistance we have provided during design and construction phases of the project. Occasional visits by U.S. experts to that facility thereafter is anticipated to assure the exchange of new information and technical data as they are generated. The laboratory-to-laboratory assistance programs between Greece and Brookhaven will continue through FY 1969. Additional sister laboratory arrangements are anticipated with Venezuela and Iran involving other AEC laboratories, and it is expected that travel by other advisors and consultants will occur from time to time in connection with such matters as nuclear power feasibility studies, water desalination programs, food irradiation investigations and insect and pest control measures. Also, increased emphasis is expected to be placed upon efforts to promote the marketing of U.S. reactors and nuclear equipment abroad through the attendance of experts and consultants at trade fairs and their participation in symposia and other meetings providing opportunity for U.S. participants to effectively discuss the extent of U.S. efforts and experience gained in the nuclear field and to emphasize the availability of U.S. materials, equipment and services.

3. Training Assistance to States and Local Governments in Radiation Control $160,000

There are presently 17 states which have assumed responsibility under Section 274 of the Atomic Energy Act of 1954, as amended, for regulating atomic energy activities. It is expected that by the end of FY 1969 there will be approximately 25 agreement states. It is anticipated that approximately four agreements will be signed in FY 1968 and four more in FY 1969. Considering Puerto Rico and the District of Columbia as states for this purpose, at the end of FY 1969 there will still be 27 non-agreement states. Of the present 33 non-agreement states, 27 currently have the necessary enabling legislation for an agreement and by FY 1970, more should have passed enabling legislation. As regulatory responsibility is transferred to the states, AEC must assure itself that state and local personnel who will administer the radiation control programs are competent to carry out the responsibilities under Section 274 above. The specific areas of radiation protection involved in the transfer of authority include byproduct materials, source materials, and special nuclear materials in quantities less than a critical mass. In an agreement state the quality of personnel is the most important requirement for maintaining an adequate and compatible program. The Commission provides training to states and local government personnel to keep them abreast of latest safety developments and procedures for radiation protection.

The reduction in the FY 1969 estimate will be made possible primarily by (1) elimination of the Three-Week Practical Health Physics Course and (2) substitution of new regional training courses in lieu of the Applied Health Physics Course in the field. This change in program planning is expected to result in a reduction in total program costs despite the increase in the number of agreement states and the emphasis on training as one of the means for maintaining and strengthening the technical quality of state personnel.

Justification of Activity

Training Assistance to States and Local Governments in Radiation Control ..... FY 1967: $100,541 FY 1968: $165,000 FY 1969: $160,000

The Ten-Week Course in Health Physics and Radiation Protection presented by Oak Ridge Associated Universities includes classroom lectures, laboratory exercises, and field trips. The optimum number of students for this program is 15 due primarily to physical accommodations. In FY 1967 the optimum number of students was exceeded for this course which had been given once each year. In FY 1968 and FY 1969, two Ten-Week courses are planned as approximately 30 students are expected to apply each year. The Ten-Week course is designed to supplement, in depth, the formal health physics and radiation safety education of state and local personnel responsible for radiation control. Costs for these courses are estimated at $116,000 for FY 1969.

The Three-Week Practical Health Physics Course has been given yearly at Oak Ridge Associated Universities to furnish additional field training for state personnel who have graduated from AEC's special university courses or who have received equivalent training, and who are now assuming greater responsibilities in state radiation control programs. In FY 1969 the Three-Week Course will not be given for the reasons given below.

The Applied Health Physics Course (Field) is presented at locations in the states to save transportation and per diem costs and make attendance easier. These short courses concentrate on specific areas, e.g., health safety aspects of industrial radiography. In FY 1969 a program of Regional Training Courses in Radiological Safety Aspects of Radiography, Medical, and Industrial Safety Aspects of the Uses of Radioisotopes will be offered in lieu of the applied field course. Approximately 54 students are anticipated at a cost of $16,000. Two of these Regional courses have already been presented on a trial basis and the consensus is that the Regional Program will be more effective in FY 1969 in training state personnel to cope with the specific problems they are now facing in the administration of their regulatory programs.

The Headquarters Regulatory Orientation Program is a two-fold approach designed to acquaint state personnel with the AEC's licensing and enforcement program and assure compatability of State-Federal Programs. It includes two orientation courses in regulatory and licensing practices and procedures and the annual meeting with agreement states and will cost $19,000 in FY 1969.

The need for one new course has become evident during recent months. The course entitled, "Field Training Assistance in Inspection Techniques and Practices", will be initiated in FY 1968 and continued in FY 1969 at a level of approximately $5,000 per year and will include about eight state personnel in both FY 1968 and FY 1969. The course will consist of class discussions to be presented by AEC Division of Compliance inspectors followed by a series of supervised inspections. In FY 1969 this course will replace the Three-Week Practical Health Physics Course so that more emphasis may be placed on the practical application of health physics theory in the conduct of the state regulatory program.

The exhibits program will be reduced from $5,000 in FY 1968 to $4,000 in FY 1969 and will consist of funds to develop one new exhibit in addition to routine equipment maintenance and exhibit presentation costs. Exhibits are used to describe the State Relations Program and to show the status of the program at professional meetings.

4. Technical Information Services $6,794,000

Consistent with AEC's statutory responsibility to disseminate scientific and technical information related to atomic energy, the Commission's technical information program communicates nuclear-related information to scientists and engineers, secondary school students and the general public of the United States - and the counterparts of these audiences abroad. Activities in this program are carried out so as to (1) increase the effectiveness of AEC's and other government agencies' research and development, (2) raise the level of literacy on nuclear-related subjects, (3) promote American industry's commercial use of innovations resulting from AEC-sponsored research and development, and (4) in foreign countries: stimulate interest and confidence in the peaceful uses of nuclear energy, demonstrate U. S. proficiency in nuclear science and its applications and increase sales of U. S. equipment.

SUMMARY OF ESTIMATES BY ACTIVITY

	FY 1967:	FY 1968:	FY 1969:
a. Nuclear Science Demonstrations and Exhibits	$1,972,348	$1,907,000	$2,151,000
b. Information Services and Materials	3,926,927	4,330,000	4,643,000
c. Scientific and Technical Conferences	111,401	115,000	0
Total Technical Information Services	$6,010,676	$6,352,000	$6,794,000

JUSTIFICATION OF ACTIVITIES

a. Nuclear Science Demonstrations and Exhibits

There is today an increased awareness among those responsible for science policy of the necessity to impress the general public with the very direct impact of science and technology on national progress. In the United States, where ultimate decisions rest with the electorate, the need for a high level of scientific literacy is most evident. Such literacy will enable the citizen not only to avail himself of technological opportunities, but will enlist his support of the prerequisite basic and applied research.

a. Nuclear Science Demonstrations and Exhibits - continued

Along with awareness of the need to educate has come the growing realization that methods of promoting scientific information must compete with a profusion of well-financed popular media to obtain the attention of the public. The role of exhibits and demonstrations is a particularly important one, not only for the information they provide but for their ability to arouse interest and create receptive attitudes which encourage viewers to seek additional information available through other media.

AEC's exhibits program utilizes Halls of Science, Domestic Traveling Presentations, and Overseas Atoms-in-Action Demonstration Centers - each of which is discussed below:

	FY 1967	FY 1968	FY 1969
(1) Halls of Science and Technology	$ 150,396	$ 217,000	$ 361,000
(2) Traveling Presentations			
(a) Domestic	662,672	700,000	700,000
(b) Overseas	1,159,280	990,000	1,090,000
Total Traveling Presentations	$1,821,952	$1,690,000	$1,790,000
Total Nuclear Science Demonstrations and Exhibits	$1,972,348	$1,907,000	$2,151,000

a. Nuclear Science Demonstrations and Exhibits - continued

(1) Halls of Science and Technology ..... FY 1967: $ 150,396 FY 1968: $ 217,000 FY 1969: $ 361,000

Halls of Science and Technology are designed to increase the public's interest and understanding of the beneficial uses of atomic energy. By promoting public confidence and allaying fears, they hasten acceptance of nuclear science applications. By giving students the opportunity to participate in real laboratory environments utilizing some of the newest nuclear-related tools and equipment, they motivate young Americans to qualify themselves for rewarding careers in science. They also serve as centers where teachers are provided training in the use of effective demonstration techniques and are introduced to new teaching tools. The FY 1969 estimate provides for: (a) operation of the American Museum of Atomic Energy at Oak Ridge ($100,000); (b) design and fabrication of one or two small topical displays demonstrating recent advances in nuclear technology for use in the AEC exhibit maintained in the Chicago Museum of Science and Industry ($30,000); (c) continued support of the Federal Science and Engineering Exhibit in which AEC participates with other Federal agencies ($6,000); and (d) continuation of design and fabrication of displays, demonstration equipment and facilities for the interior of the nuclear science center of the Hall of Science of the City of New York ($225,000).

(2) Traveling Presentations ..... FY 1967: $1,821,952 FY 1968: $1,690,000 FY 1969: $1,790,000

(a) Domestic ..... FY 1967: $ 662,672 FY 1968: $ 700,000 FY 1969: $ 700,000

The Domestic Traveling Presentations utilize a variety of exhibits and demonstration techniques to increase public understanding and interest in nuclear energy and its peaceful applications. Emphasis is placed on exhibits and demonstrations for young people which include a varied sampling of nuclear energy applications. The goal is to enrich students' understanding of science and technology and to stimulate their consideration of careers in science and engineering. Other presentations help visitors to fairs, expositions, and science museums increase their understanding of modern science and new advancements in nuclear technology. Still others serve the members of professional and civic organizations. Presentations are integrated with compatible activities of the community - school assembly programs and science classes, fairs, conferences, etc. - which attract receptive audiences at minimum expense to AEC.

a. Nuclear Science Demonstrations and Exhibits - continued

(2) Traveling Presentations - continued

(a) Domestic - continued

Presentations primarily for students ..... FY 1967: $ 384,567 FY 1968: $ 395,000 FY 1969: $ 412,000

An experimental cooperative venture was successfully begun in FY 1967 when a state-funded organization (Texas A&M University) operated one traveling high school lecture-demonstration unit. In FY 1968, state and non-profit organizations in Georgia, North Carolina, and New York are also operating units and it is anticipated that four more states will participate under similar arrangements in FY 1969. Joint AEC-state operation, because it involves greater local participation in the program, tends to increase its impact as well as to reduce the AEC unit operating cost. For example, in FY 1967 AEC's operating cost for the unit operated by Texas A&M was about $12,000, compared to an average unit cost of $28,000 for those operated by AEC. Our goal is to be able by 1972 to reach every secondary school graduate at least once during his school career. The FY 1968 estimate is based on Oak Ridge Associated Universities' (ORAU) operating 10 units while 4 are operated on an AEC-state cooperative basis, and in FY 1969 we expect to increase the number of cooperatively-operated units to 8. It is anticipated that in operating this larger number of units a further reduction in unit cost can be effected, thus requiring in FY 1969 a net increase of $17,000 in this activity.

Presentations primarily for general public, professional and industrial groups ..... FY 1967: $ 278,105 FY 1968: $ 305,000 FY 1969: $ 288,000

A variety of demonstrations and displays are used to fill the numerous requests received from museums, science and career fairs, and other civic and professional groups. Of these, "Radiation and Man", "Atomsville, U.S.A." and the Life Science Demonstration Laboratory are presentations which have been extremely well received by both young and adult audiences and will continue to be circulated and shown for several months each at major museums. In addition, a new unit offering laboratory demonstrations in physics entitled "Energy" is being developed for use in FY 1969.

a. Nuclear Science Demonstrations and Exhibits - continued

(2) Traveling Presentations - continued

(b) Overseas..... FY 1967: $1,159,280 FY 1968: $ 990,000 FY 1969: $1,090,000

The Overseas Traveling Presentations (Atoms-in-Action Demonstration Centers) promote international understanding and acceptance of atomic energy's many beneficial uses, and demonstrate U. S. accomplishments in peaceful applications of nuclear science. Tailored to the needs and interests of the host countries, the presentations also invite participation of responsible governmental leaders, teachers, research scientists, physicians and technicians in projects of their choosing. Previously unavailable opportunities to use modern research and teaching tools are provided them. In return, the demonstration of American equipment and services stimulates increased sales in foreign markets. Each Center involves in addition to the research projects utilizing U. S. equipment: classroom demonstrations for secondary school students and teachers; reference rooms for use of AEC and other U. S. publications and films; demonstration of nuclear techniques and equipment to local physicians, scientists and technicians; and lecture-demonstrations for the general public.

The FY 1968-1969 presentation schedule for the two Centers is shown below:

FY 1968

1. Latin America:

   Quito, Ecuador, November-December 1967
   Caracas, Venezuela, April-May 1968

2. Eurasia:

   Tehran, Iran, November-December 1967
   Taipei, Taiwan, April-May 1968

FY 1969 (tentative)

1. Latin America:

   Cordoba, Argentina, October-November 1968

2. Eurasia:

   Seoul, Korea, September-October 1968
   Manila, Philippines, February-March 1969

a. Nuclear Science Demonstrations and Exhibits - continued

(2) Traveling Presentations - continued

(b) Overseas - continued

In addition to the expositions above, AEC has been asked to provide exhibits for U. S. presentations to be made in connection with the Olympic Games at Mexico City in October-December 1968; the ANS-AIF International Conference and Exhibit in Washington, D. C. in November 1968; and the Water Desalination Congress in Rome, in the Spring of 1969. For programs of this nature, topical exhibits in such areas as advanced reactor concepts, desalting, plowshare, toll enrichment, food irradiation and space exploration are used to show U. S. nuclear accomplishments.

Wear and obsolescence of AEC's Latin American Demonstration Center will make it essential that the exhibits, the principal orientation film, and structural and interior walls be replaced in FY 1969. AEC is therefore reducing the operating schedule for the Latin American Center to one presentation in FY 1969 rather than the usual two. Inasmuch as the principal film used in the Eurasian Center, now seven years old, must also be replaced in FY 1969, a single orientation film depicting current U. S. accomplishments and technology advances is to be produced, suitable for use in both Centers.

In summary, the program effort in FY 1969 will comprise three major Science Demonstration Center presentations, three smaller topical presentations, refurbishment of the Latin American Center and production of a new orientation film.

94-075 O-68 pt. 3—39

TRAINING, EDUCATION AND INFORMATION PROGRAM - continued

b. Information Services and Materials $4,643,000

In this activity the primary objectives are (1) to further scientific and industrial progress by acquiring and organizing information on nuclear science and technology and communicating it to those engaged in research, development and production; and (2) to accelerate the transfer of AEC-developed technological innovations for faster and more effective use by the civilian sector of our economy. The components of this activity are as follows:

	FY 1967	FY 1968	FY 1969
(1) Technical Progress Reviews	$ 298,378	$ 310,000	$ 325,000
(2) Translations	36,015	0	0
(3) Printing	96,609	185,000	150,000
(4) Technical Information Extension - Oak Ridge	3,239,183	3,525,000	3,748,000
(5) Technological Spinoff	109,387	170,000	190,000
(6) Other Information Services	147,355	140,000	230,000
Total Information Services and Materials	$3,926,927	$4,330,000	$4,643,000

These components are discussed in greater detail below:

(1) Technical Progress Reviews .... FY 1967: $ 298,378 FY 1968: $ 310,000 FY 1969: $ 325,000

This series of journals on nuclear technology, compiled by specialists and recognized authorities, summarize, evaluate and reference the progress of development work in their respective fields. In FY 1967 the journal Reactor Fuel Processing was discontinued; the journal Reactor and Fuel-Processing Technology now incorporates coverage of that subject area. The other journals are Isotopes and Radiation Technology, Nuclear Safety, and Reactor Materials. The increase of $15,000 in FY 1969 reflects the increasing volume of nuclear information to be reviewed and evaluated.

(2) Translations ..... FY 1967: $ 36,015 FY 1968: $ 0 FY 1969: $ 0

Beginning with FY 1968, costs for translations are being charged to the scientific and technical programs involved.

b. Information Services and Materials - continued

(3) Printing..... FY 1967: $ 96,609 FY 1968: $ 185,000 FY 1969: $ 150,000

This activity provides for the printing of (1) Nuclear Science Abstracts (NSA), a semimonthly indexing and abstract journal which comprehensively covers the international literature on nuclear science and technology; (2) the Technical Progress Reviews; and (3) a small number of special reports and technical publications.

(4) Technical Information
Extension - Oak Ridge..... FY 1967: $3,239,183 FY 1968: $3,525,000 FY 1969: $3,748,000

The Technical Information Extension - Oak Ridge (DTIE), is the United States' major Federal nuclear science information service center. The Extension centralizes for AEC the publication, distribution and bibliographic control of scientific and technical literature. It prepares and publishes Nuclear Science Abstracts, other bibliographic tools, and semitechnical educational literature; and edits a variety of other nuclear science publications. It also conducts applied research in the development of advanced techniques and the use of newly developed equipment to improve AEC's information systems. DTIE is currently engaged in a major conversion from manual to computerized operations, a program in which AEC is collaborating with other Federal and international agencies to develop compatible computer networks for transferring science information.

The Extension's requirements by year are shown below:

Personal Services	FY 1967: $1,971,990	FY 1968: $2,126,000	FY 1969: $2,237,000
Other Objects	1,255,524	1,385,000	1,495,000
Travel	11,669	14,000	16,000
Total Technical Information Extension, Oak Ridge	$3,239,183	$3,525,000	$3,748,000

The increase for FY 1969 reflects (1) full year effect of the first step of the Federal Salary Act of 1967 and normal increases in salaries and personnel benefits; (2) a need for additional computer time and continuation of the effort to computerize AEC's technical information data base so as to make it fully compatible with other major science agencies' systems; (3) procurement of supplies to meet increased production requirements; and (4) a greater demand for microform products.

b. Information Services and Materials - continued

(5) Technological Spinoff..... FY 1967: $ 109,387 FY 1968: $ 170,000 FY 1969: $ 190,000

In the conduct of AEC-sponsored research and development numerous innovations are developed in processes, materials, equipment, techniques, etc., which have wide potential usefulness in non-nuclear industry. The effective transfer of such technology provides a bonus return for the public's investment in nuclear energy programs. The technological spinoff activity conducted in cooperation with other Federal agencies is designed to ferret out, publicize and facilitate the transfer of potentially useful innovations, with emphasis on finding commercial applications in smaller business enterprises. The activity is centered in Offices of Industrial Cooperation (OIC's) at major AEC laboratories. These offices provide mechanisms for contacts between industry representatives and laboratory scientists and engineers. The FY 1969 estimate contemplates continued operation of the OIC's at Argonne National Laboratory, Oak Ridge National Laboratory, and Sandia Laboratory.

(6) Other Information Services..... FY 1967: $ 147,355 FY 1968: $ 140,000 FY 1969: $ 230,000

(a) Specialized Information and Data Centers..... FY 1967: $ 75,352 FY 1968: $ 50,000 FY 1969: $ 45,000

The Specialized Information and Data Centers collect, organize and critically evaluate information in their respective subject areas. They provide advice and assistance to scientists, engineers and other information users to help them identify and obtain data and information relevant to their research, development and engineering program objectives. The FY 1969 estimate provides for continued joint funding with National Bureau of Standards of the Radiation Chemistry Data Center.

b. Information Services and Materials - continued

(6) Other Information Services - continued

(b) Selective Dissemination of Information (SDI)..... FY 1967: $ 34,700 FY 1968: $ 45,000 FY 1969: $ 60,000

This activity is a coordinated effort by Argonne National Laboratory, Lawrence Radiation Laboratory (LRL) and the Technical Information Extension, Oak Ridge, to develop machine-oriented systems to provide scientific and technical information to AEC researchers in accordance with their specialized needs. Successful development of such a system will facilitate the improvement of information systems utilizing computer technology throughout the National Laboratory complex. The FY 1969 estimate provides for continuation of the work at LRL with provision to add certain AEC Headquarters personnel to this SDI program.

(c) Information System Development Studies..... FY 1967: $ 37,303 FY 1968: $ 45,000 FY 1969: $ 95,000

The volume of research results has become so overwhelming that science workers are experiencing great difficulty in keeping informed of advances in their fields, which they must do to sustain scientific progress. Technical information systems capable of getting the right information to persons needing it are an urgent necessity. The FY 1969 estimate provides for studies to analyze and evaluate methods of data and information handling and continuation of the effort to measure the effectiveness of specific facets of AEC's technical information program.

(d) International Atomic Energy Agency (IAEA) Conferences FY 1967: $ 0 FY 1968: $ 0 FY 1969: $ 30,000

Conferences and symposia accelerate the transfer and encourage the use of new information among working scientists, engineers and others engaged in and responsible for nuclear science programs. The FY 1969 estimate provides for support of International Atomic Energy Agency conferences to be held in the United States. Costs for this activity are included under the Topical Scientific and Technical Conference activity in FY 1967 and FY 1968.

TRAINING, EDUCATION AND INFORMATION PROGRAM - continued

c. Scientific and Technical Conferences FY 1967: $ 111,401 FY 1968: $ 115,000 FY 1969: $ 0

(1) Major International Conferences FY 1967: $ 0 FY 1968: $ 0 FY 1969: $ 0

This estimate anticipates no major international conferences in FY 1970 for which costs would be incurred in FY 1969.

(2) Topical Scientific and Technical Conferences..... FY 1967: $ 111,401 FY 1968: $ 115,000 FY 1969: $ 0

After FY 1968, costs for topical scientific and technical conferences will be charged to the respective scientific and technical programs involved.

5. Public Information Services $350,000

The costs incurred under public information activity classify into two general areas: (1) contractor duplication of Commission informational materials designed to keep the news media, business concerns, and business and industrial publications informed about AEC policies and programs; and (2) production of motion pictures, securing of stock film footage, purchase of motion picture prints, procurement of duplicating, editing and laboratory services, etc. for the purposes of maintaining the Commission's still picture libraries at the New York Office and at Headquarters, providing films for distribution through the Commission's fifteen motion picture libraries in the United States and overseas, offering film footage at laboratory costs to private producers and AEC contractors to encourage production of motion pictures on atomic energy, and providing materials for use on educational and commercial television and radio nationwide.

SUMMARY OF ESTIMATES BY ACTIVITY

		FY 1967:	FY 1968:	FY 1969:
a.	Printing.....	$ 78,806	$ 80,000	$ 80,000
b.	Pictorial Materials.....	271,630	270,000	270,000
	Total Public Information Services..	$350,436	$350,000	$350,000

JUSTIFICATION OF ACTIVITIES

a. Printing ..... $ 80,000

This estimate provides for the duplication, by contractor, of Commission informational materials for distribution to the news media and to business and industrial publications and representatives of business concerns.

b. Pictorial Materials $270,000

This estimate provides for the conduct of the audio-visual portion of the Public Information activity, including production of films, procurement of film prints, and corollary costs in connection with the Commission's responsibility for disseminating information relative to atomic energy programs to educational assemblages, national, regional, state and local organizations, and the general public. The following requirements are included for FY 1969:

(1) Standard purchase of new and replacement prints of motion pictures on atomic energy subjects for distribution through the Commission's ten domestic, five overseas and four depository libraries $100,000

(2) Production of one or two lecture and two or three overall films, writing of scripts, and participation in AEC-wide film production 85,000

(3) Production and distribution of television news clips and radio news tapes covering important AEC events 26,000

(4) Assistance to the United States Information Agency in the distribution of atomic energy motion pictures throughout the world 12,000

(5) Motion picture film laboratory work and securing of stock film footage of research and development activities both for film production and for offer at laboratory cost to private producers, AEC contractors and other government agencies in order to encourage production of motion pictures on atomic energy 15,000

(6)	Still photos, slides and laboratory services, including materials for the newly-established AEC slide library	$ 10,000
(7)	Motion picture prints for high school depository libraries and for the educational film campaign being conducted by operations offices to increase use of atomic energy films in science-teaching programs	15,000
(8)	Miscellaneous requirements, including prints and footage for special educational television and motion picture work related to the State-AEC regulatory program and printing of catalogs listing atomic energy films available in AEC film libraries	7,000
TOTAL		$270,000

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U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

TRAINING, EDUCATION AND INFORMATION - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$1,435,000
A Construction Projects	
A-1 Obligations for new projects	($ 225,000)
A-2 Obligations for prior year projects	($ 475,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 595,000)
B-2 Obligations from prior year appropriations ...	($ 140,000)
Estimated Obligations FY 1968	$1,811,000
Actual Obligations FY 1967	$ 710,497

Obligations for the Training, Education and Information Program for FY 1969 are estimated at $1,435,000, of which:

a. $225,000 is for the construction project justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $475,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

c. $595,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

d. $140,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cut back."

SECTION A-1

The project included in Section A-1 requested for authorization in FY 1969 is:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-8	General plant projects - Puerto Rico Nuclear Center	$225,000	$ 0	$225,000	$ 0

EXPLANATION OF PROJECT IN SECTION A-1

1. Project 69-8 General plant projects - Puerto Rico Nuclear Center $225,000

This project provides for acquisition from the General Services Administration of the Cornelia Hill Annex Facility tract located near Mayaguez, Puerto Rico, for use in program assignments at the Puerto Rico Nuclear Center requiring an isolated location and other improvements, alterations and additions to facilities at Mayaguez, Rio Piedras and other locations in Puerto Rico as needed to meet requirements for technical and graduate training.

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
68-5-a	Addition to biomedical building, Rio Piedras, Puerto Rico	$1,400,000	$ 970,000	$430,000	$ 0
68-6	General plant projects, Puerto Rico Nuclear Center	450,000	405,000	45,000	0
	Total	$1,850,000	$1,375,000	$475,000	$ 0

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
a. Training and Education in the Physical and Life Sciences and Engineering	$300,000
b. Training Assistance to States and Local Governments in Radiation Control	30,000
c. Technical Information Services	265,000
Total Training, Education and Information	$595,000

JUSTIFICATION

Training, Education and Information	$595,000

The estimate provides for the necessary acquisition and replacement of equipment for the Training, Education and Information Program. Examples of types of specialized equipment include spectrometers, spectrophotometers, scalers, counters, analyzers, detection and other monitoring equipment at the Puerto Rico Nuclear Center, Oak Ridge Associated Universities (ORAU), the Oak Ridge and Argonne National Laboratories and the University of Rochester.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
a. Training and Education in the Physical and Life Sciences and Engineering	$ 71,000
b. Training Assistance to States and Local Governments in Radiation Control	7,000
c. Technical Information Services	62,000
Total Training, Education and Information	$140,000

Mr. MORRIS. What has been accomplished this year, 1968, with the increase of $342,000 available for technical information services?

Mr. BRUNENKANT. Approximately $75,000 of that was budgeted for the New York Hall of Science, and this is now, I think, a reality. Another portion was used for the computer program at Oak Ridge, our major documentation center.

A portion of it was required to defray increased payroll costs of our Oak Ridge facility, related to the Federal Salary Act of 1967.

CHARGE FOR TECHNICAL INFORMATION SENT OVERSEAS

Mr. MORRIS. The Joint Committee in its report on the authorization bill stated that it believed the program of sending technical information abroad should be reviewed, including a review of the desirability of imposing a reasonable charge for highly technical materials sent overseas. Would you like to comment on this?

Mr. BRUNENKANT. We are proposing to the Commission to reduce our free distribution of AEC reports to one institution per country. I think, however, it is important to note that a large percentage of the world's significant literature on nuclear science originates overseas. We would not want, by restricting the flow of U.S. information to deprive our scientists and technical people of the benefits they can obtain from the foreign literature.

We have not yet had the opportunity to assess the impact which the Joint Committee's recommendation might have in this connection. We hope during the coming year to make such an analysis.

Dr. TAPE. Although that particular point was raised in connection with the Atomic Energy Commission, this is a question which has been studied by the Government as a whole, and the people who are considering information and information exchanges in the international field have this under consideration.

It is my own view that the language of the report is a little too specific in the sense of talking about a charge. What we are looking for is an exchange of some kind, whether it be in information or services or moneys. These are things that we should look at.

Really, what we are all talking about is that it be a two-way street. We also recognize that some nations are in a better position to do this than others. We want to take that into consideration.

Mr. MORRIS. I think probably the Joint Committee was talking about a more or less quid pro quo arrangement.

Dr. TAPE. Of some kind.

Mr. MORRIS. You are exploring and will explore this?

Dr. TAPE. This is under consideration.

PUERTO RICO NUCLEAR CENTER

Mr. MORRIS. As indicated on page TE & I–38, $225,000 is budgeted under general plant projects for the Puerto Rico Nuclear Center. Could you tell the committee what is planned with this $225,000 estimate?

Dr. POOR. $135,000 of the $225,000 is for securing a location near the laboratory at Mayaguez at the western end of the island known as Cornelia Hill. This is an old installation that belonged to the Air

Force and was at one time a part of the tracking system. It has since been returned to GSA.

The $135,000 is a transfer of funds between agencies, as I understand it, to accomplish the purchase of this property. I can give you, either now or for the record, what uses we expect to make of this.

Mr. MORRIS. You might cover it briefly now.

Dr. POOR. We have a marine biology program under Dr. Lowman, and we have no adequate place to spread out and analyze collected specimens. This is for the purpose of determining the amount and kind of radioactive material deposited in the sea.

Secondly, the agricultural people have no place to work with their plants in that area.

Also, the dosimetry laboratory will be located there for processing badges for all project personnel in that part of the island.

Then there is proposed, in a little sheltered portion of the Cornelia Hill area, the construction of a dock that will accommodate the boats of the Puerto Rico Nuclear Center to take them out of an open portion of the bay, to bring them into the sheltered deep water area.

Also, we are offering to shelter the boats that belong to the National Science Foundation that are also unprotected.

This site is there and has been abandoned. We want to put it to use. Although I do not know the nature of the financing, it is my understanding this is simply an exchange of funds on the books.

Mr. MORRIS. I would appreciate it, Doctor, if you would provide a thorough explanation of this project for the record.

Dr. POOR. I can do that.

(The information follows:)

GENERAL PLANT PROJECTS, $225,000

1. Acquisition of Cornelia Hill Annex facility $135,000

In August 1966, GSA approved an AEC request for the conditional transfer, without reimbursement for a period of 4 years, of a tract of land near Mayaguez containing a building suitable for additional space required for PRNC program assignments. The tract containing approximately 20 acres is located at Point Guanajibo and before becoming excess was utilized as the Mayaguez Missile Guidance Annex, Puerto Rico Cornelia Hill Receiver Military Reservation. The main building on the site has an area of approximately 4,000 square feet and was originally designed to house electronic equipment. The Cornelia Hill Annex facilities are currently being used primarily for trace element analysis of samples collected under the PRNC sea level canal study.

A continuing need will exist for isolated facilities for PRNC and it is proposed that the Cornelia Hill Annex facility be acquired from GSA on a permanent transfer to fill this need. Operations which require a location isolated from PRNC reactor operations and work with radioactive materials include (1) nuclear accident dosimeter center, (2) low level counting program, (3) health physics film badge laboratory, (4) absolute dosimetry program, and (5) the trace element analysis laboratory. The tract would also provide land areas suitable for field plant studies. Before the necessary easements can be obtained for access between the dock area and the site, title to the annex must be obtained.

The acquisition arrangements are in accordance with the requirements of the Federal Property Management Regulations developed by GSA with the approval of the Bureau of the Budget pursuant to Public Law 152, 81st Congress (Federal Property and Administrative Services Act of 1949, as amended). These regulations provide that an agency which acquires excess real property from GSA must reimburse GSA for that property an amount equal to 50 percent of the appraised fair market value of the property. In the case of the Cornelia Hill Annex, the appraised value is $270,000 and AEC must under the above regulation reimburse GSA for 50 percent of that amount or $135,000.

2. Undesignated modifications and additions	$90,000
The changing program assignments to PRNC make it essential that provision be made in fiscal year 1969 for such modifications and additions to the PRNC facilities at Mayaguez and Rio Piedras and other locations in Puerto Rico as may be required to carry out new or revised program assignments without extensive delay.	
Total fiscal year 1969 general plant projects	225,000

Mr. MORRIS. The gentleman from New York, Mr. Robison.

HALL OF SCIENCE OF THE CITY OF NEW YORK

Mr. ROBISON. As outlined on page TE & I–25, $225,000 is budgeted for continuation of the design and fabrication of certain facilities in connection with the so-called "Hall of Science" of the city of New York.

Will you tell us what the status of this program is, and what is planned for fiscal year 1969?

Mr. BRUNENKANT. The city has approved the money, and the architects have been selected. Hopefully, they will start actual foundation work this fall.

In terms of the authorization of funds, $60,000 will have to be deducted from the original budget request of $225,000 as a result of the authorization reduction. So, we now have only $165,000 allocated for New York for fiscal year 1969.

We have been working with the New York people, although we have budgeted no money for this activity until fiscal year 1968. We believe that this will be one of the world's outstanding science facilities, particularly for its effect in enriching the secondary education capabilities of the New York metropolitan area.

It will house a reactor, a gamma facility, and many other nuclear facilities and will have the benefit of modern TV and computer educational aids. It will be operated as a nonprofit corporation. The new chairman of the board of trustees, recently appointed, is Dr. Piore, head of research for International Business Machines.

They will have the cooperation of the schools and universities, and, it is hoped, of a significant segment of industry of the New York area. We believed it would be beneficial to have institutions of this kind in other areas of the country.

Mr. ROBISON. It would have benefit, of course, to students outside of the city of New York, as well; to those who could travel from nearby States or areas or those who travel as part of their school junkets, if we may use that word in this connection, to New York, in the same way students come to Washington. They could go there and make use of the facilities and learn something from them?

Mr. BRUNENKANT. Yes.

Mr. ROBISON. Thank you, Mr. Chairman.

Mr. MORRIS. Thank you, gentlemen, for your very enlightening statements.

PROGRAM DIRECTION AND ADMINISTRATION

Mr. MORRIS. We shall proceed now with program direction and administration.

Mr. Vinciguerra, it is a pleasure to have you before the committee this afternoon. I have seen you sitting in the background for several days sending forth answers. We are happy to have you here.

Mr. VINCIGUERRA. I also have Mr. Henderson of the regulatory staff to answer any questions you may have in connection with the regulatory program.

I shall be very brief, Mr. Chairman.

The fiscal year 1969 budget provides for a staff of 5,952 at the end of the fiscal year 1969 for program direction and administration. This includes employees in the headquarters and field offices who are engaged in the direction and administration of AEC operating programs and the discharge of the regulatory functions.

Specifically, employees budgeted in this program are responsible for:

Planning and directing programs and evaluating technical performance of contractors who carry out the Commission's programs.

Negotiation and administration of such contracts.

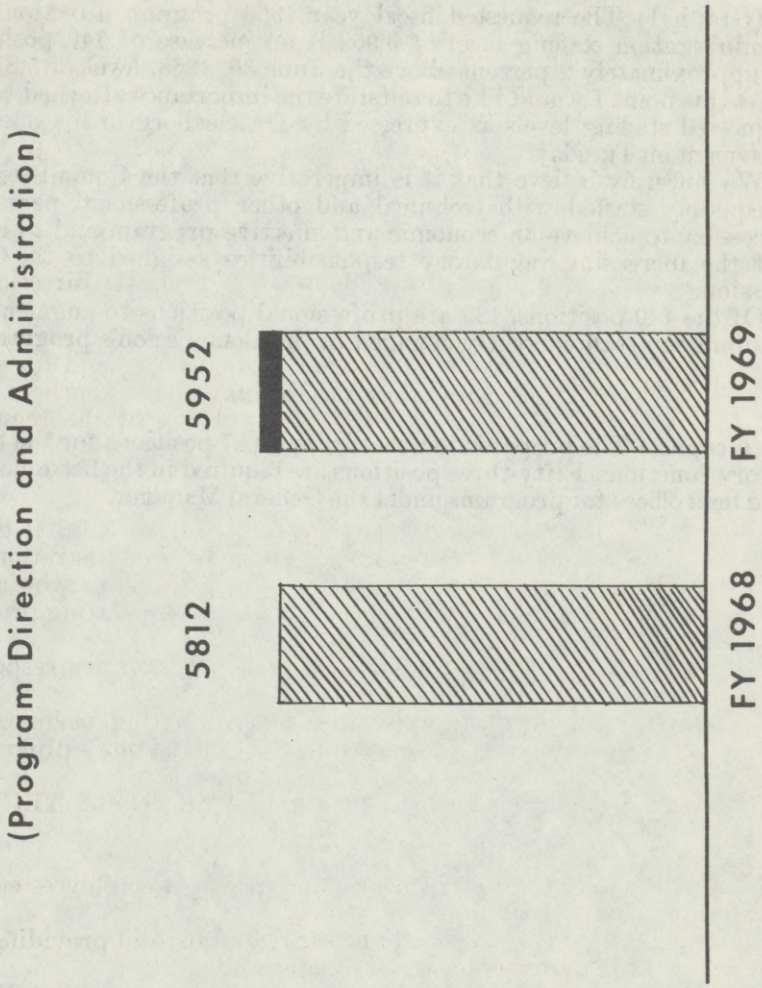
Managing fiscal and business management aspects of AEC's programs.

Licensing and regulatory activities.

Assuring the protection of health and safety of employees engaged in the program and of the general public.

Managing source and special nuclear materials, and providing safeguards to prevent diversion of these materials.

And other activities, including international cooperation, nuclear education and training, and program and administrative support.



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STAFFING LEVEL

(Graph 1) The requested fiscal year 1969 program direction and administration staffing level of 5,952 is an increase of 140 positions or approximately 2 percent above the June 30, 1968, level of 5,812.

At this point I would like to reiterate the importance attached to the requested staffing levels as expressed by Dr. Seaborg in his opening statement on Tuesday.

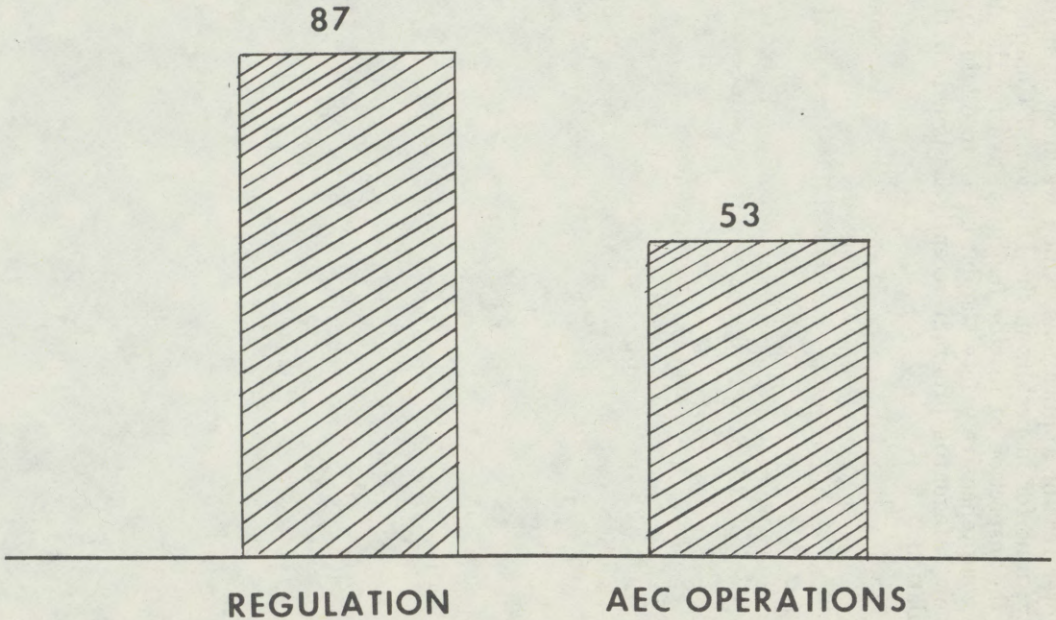
We sincerely believe that it is imperative that the Commission be adequately staffed with technical and other professional personnel necessary to achieve an economic and effective program and to carry out the increasing regulatory responsibilities assigned to the Commission.

Of the 140 positions, 125 are professional positions to augment the Commission staff currently engaged in the Commission's program.

REGULATORY FUNCTIONS

(Graph 2) The proposed increase includes 87 positions for the regulatory functions. Fifty-three positions are required in the headquarters and field offices for programs under the General Manager.

DISTRIBUTION OF FY 1969 REQUEST



(Graph 3) The 87 additional positions for the Director of Regulation are required in the following areas: 60 for review and evaluation of power reactor applications, which we know is increasing significantly; nine for inspectors in the Division of Compliance associated with the inspection of reactor facilities; five for the development of more comprehensive safety standards; 13 to establish and carry out the new safeguards program recently assigned to the Director of Regulation.

REGULATORY STAFFING REQUIREMENTS - FY 1969

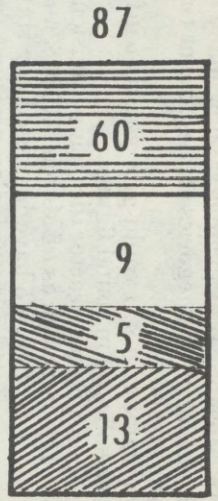
87 POSITIONS FOR:

Review and Evaluation of
Power Reactor Applications

Inspection of Reactor Facilities

Development of More Comprehensive
Safety Standards

Establish and Administer
New Safeguards Program



EMPLOYEE BREAKDOWN

Mr. MORRIS. Mr. Vinciguerra, how many employees do you have in each one of these categories at the present time, and how many vacancies do you have?

Mr. HENDERSON. I could give you that information. I can give it to you specifically in round figures.

In our present reactor licensing division, the first item, we have about 114 on board, as of March 31, 1968, and 16 commitments, bringing us up to 120. We have increased our staff in that area during the year and in fact had to redeploy positions from other regulatory divisions to accomplish this.

Our total compliance function, employs approximately 129. Of these, approximately 40 to 50 are engaged in the reactor inspection area.

We have on board 25 in our reactor standard division. This request would provide another 5 in that division.

In our safeguards program we presently have on board or committed by June 30 a total of 22 persons. Our fiscal year 1969 request includes an additional 13 positions which will enable us to assume full responsibility for this function. We are not really carrying it out now. We are getting staffed up to do it.

Mr. MORRIS. You may correct the figures for the record.

Mr. HENDERSON. I am giving round figures. I will correct them for the record. (The correct figures have been inserted.)

VACANCIES

Mr. MORRIS. Also, do you know how many vacancies you have in these categories under your authorization at the present time?

Mr. HENDERSON. Our present ceiling is 430, and we have on board 431. We are anticipating some turnover between now and June 30.

Mr. MORRIS. It sounds like you are one over.

Mr. HENDERSON. Yes, sir, I am afraid we are.

Mr. MORRIS. What are you doing? Is Mr. Abbadessa paying that one out of his own fund?

Mr. VINCIGUERRA. The ceiling we have is for the AEC as a whole. We are down on the General Manager's side, which permits us to allow the regulatory staff to be up one.

Mr. CORSO. For the record, we have always stayed within the employment approvals of the Congress. We have never exceeded them.

Mr. HENDERSON. I would like to correct that. Actually on board there were 425, as of March 31, 1968, but with commitments it will bring us up to 431 by June 30, 1968.

Mr. MORRIS. You are anticipating an increase of one.

Mr. HENDERSON. Yes.

ADDITIONAL POSITIONS

Mr. VINCIGUERRA. (Graph 4.) The 53 additional positions under the General Manager are required in the following areas:

Twenty-eight of the positions are in the headquarters, and 25 are in the field offices.

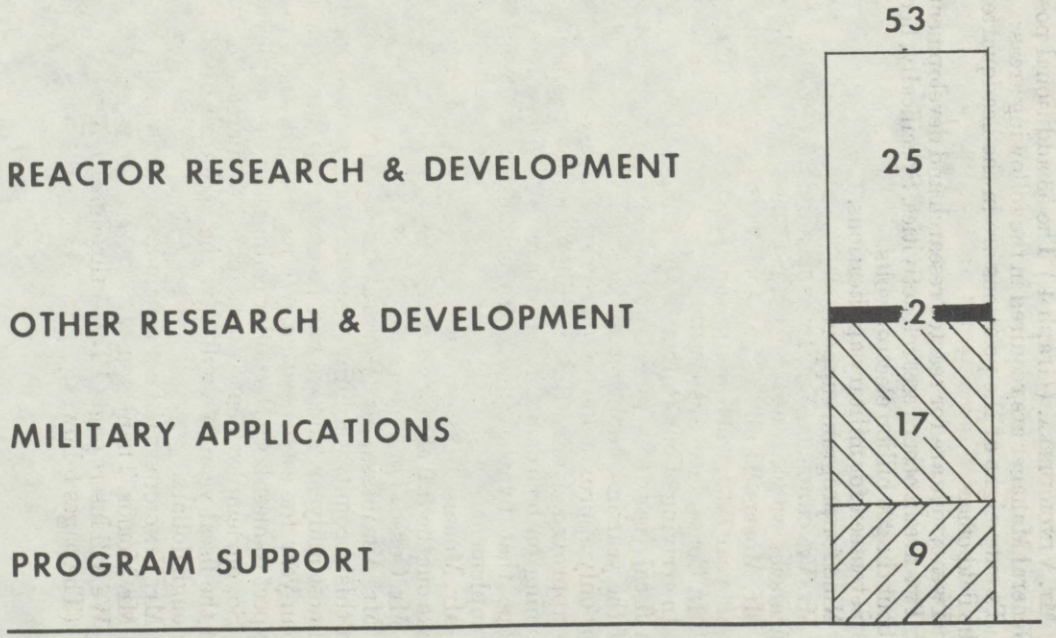
Twenty-five are for reactor research and development.

Two are in other research activities. Specifically, here we are talking about the 200 billion electron volts.

Seventeen for military applications.

Nine for program support.

GENERAL MANAGER STAFFING REQUIREMENTS



Mr. MORRIS. Does the General Manager have any vacancies at the present time?

Mr. VINCIGUERRA. Yes.

Mr. BOSTOCK. At the present time there are 102 vacancies throughout the Atomic Energy Commission.

In the reactor development area in the headquarters organization there are approximately 20 vacancies. There are commitments presently outstanding to fill those vacancies.

Mr. VINCIGUERRA. If funds permit, we expect to be at the authorized level by the end of the fiscal year.

Mr. MORRIS. By the end of fiscal year 1968?

Mr. VINCIGUERRA. Yes. I was speaking to your question of how many vacancies we have now as against the authorized level for 1968.

Mr. MORRIS. If all the positions were granted that you asked for in fiscal year 1969, when would you expect to have those people on board?

Mr. CORSO. I can answer that.

In arriving at our Bureau of the Budget allowance for new positions in fiscal year 1969, we factored a lapse of approximately two-thirds of the year in computing the dollars. We have enough money to pay for only approximately a quarter of a man-year for each position that is approved. Under this computation, the people will have to start coming on board in the latter part of the fiscal year, and we would hope that by the time we reach June we would have our full complement.

Mr. MORRIS. In other words, if the position is disallowed, you do not take out the full annual salary.

Mr. CORSO. That is correct.

Mr. ABBADESSA. Mr. Morris, while we have 102 vacancies right now in this account, we did not get our congressional appropriation until almost midyear, and we had factored into our request only one-third man-year for each position. We have a very tight dollar ceiling. We expect to meet both the dollar ceiling and the employment ceiling.

So, our employment is anticipated to increase in the last 3 months of the fiscal year. We will have the vacancies filled provided we have enough dollars.

Mr. VINCIGUERRA. That concludes my statement, Mr. Chairman.

Mr. MORRIS. Thank you.

We will insert pages PDA–1 through PDA–24.

(The pages follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

PROGRAM DIRECTION AND ADMINISTRATION - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$102,885,000
Estimate FY 1968	95,313,000
Increase	$ 7,572,000

This program covers the salaries, travel and other costs associated with both program direction and administration of AEC operations, and the discharge of regulatory functions of the Commission.

The following functions are performed by AEC employees budgeted under this program for AEC operations: (1) program planning and direction, (2) negotiation and administration of contracts, (3) accounting, auditing, property management, and other functions to assure adequate controls by AEC offices and contractors, (4) conducting a program of cooperation with other nations and international groups, (5) development and coordination of AEC's safeguards policies and programs for both domestic and international activity, and (6) normal management, administrative and supporting staff services required within the agency.

The regulatory functions of the Commission are discharged directly by AEC employees budgeted under this program and include: (1) all regulatory and licensing matters including development of regulatory and licensing policies and procedures, and administering licenses and regulations applicable to licensees, (2) inspection of licensees for compliance with license requirements and rules of the Commission, (3) investigation of licensee incidents, (4) development of reactor and radiation safety standards, (5) administration of the nuclear materials safeguards program for licensees, and (6) cooperation with states under Section 274 of the Atomic Energy Act.

The FY 1969 estimate is based on reaching a total employment of 5,952 regular full-time employees by the end of FY 1969 or an increase of 140 employees over the strength of 5,812 estimated at the end of FY 1968. Of the total increase of 140 employees, 53 are for AEC operations and 87 are for regulatory functions.

A summary of the budget estimate by category appears on the next page.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
PDA-3	1. Personal Services	$68,876,112	$73,741,000	$ 78,257,000
PDA-11	2. Personnel Benefits	5,474,437	5,852,000	6,457,000
PDA-13	3. Benefits to Former Personnel	24,617	24,000	79,000
PDA-13	4. Travel and Transportation of Persons	3,245,295	3,750,000	4,054,000
PDA-14	5. Contractual Services and Supplies	9,891,649	11,946,000	14,038,000
	Total	$87,512,110	$95,313,000	$102,885,000

The estimates include the following amounts for AEC Operations and Regulatory Functions, respectively:

SUMMARY OF ESTIMATES BY FUNCTION

Category	AEC Operations 1967	AEC Operations 1968	AEC Operations 1969	Regulatory Functions 1967	Regulatory Functions 1968	Regulatory Functions 1969
1. Personal Services	$64,170,235	$67,975,000	$71,434,000	$4,705,877	$5,766,000	$6,823,000
2. Personnel Benefits	5,118,939	5,422,000	5,938,000	355,498	430,000	519,000
3. Benefits to Former Personnel	24,617	24,000	79,000	-	-	-
4. Travel and Transportation of Persons	2,975,848	3,422,000	3,664,000	269,447	328,000	390,000
5. Contractual Services and Supplies	9,829,207	11,762,000	13,529,000	62,442	184,000	509,000
Grand Total	$82,118,846	$88,605,000	$94,644,000	$5,393,264	$6,708,000	$8,241,000

The estimated costs for Regulatory Functions include only the costs of personal services, personnel benefits and travel for personnel reporting to the Director of Regulation, and other costs clearly identified with specific activities of the regulatory function such as special contractual services. The costs of general supplies and other usual housekeeping services provided to Regulatory personnel are included in the estimates under AEC Operations.

JUSTIFICATION OF CATEGORIES

1. Personal Services $78,257,000

This category covers personnel compensation for: (1) an average employment of 5,859 regular full-time employees; (2) professional and management trainees for a six-month period; (3) advisory groups and individual professional and scientific consultants whose services are utilized intermittently for limited periods; (4) employees in temporary positions to meet special situations; (5) part-time employment of professional women; and (6) reimbursements to other Government agencies for personnel detailed to AEC for special purposes.

A breakdown of total personal services costs under this program follows:

Summary of Personal Services Costs

	FY 1967	FY 1968	FY 1969
a. Net cost of regular full-time employees, including terminal leave costs	$66,917,091	$72,094,000	$76,246,000
b. Costs of other employees	1,303,692	1,278,000	1,325,000
c. Pay above stated annual rate	257,153	-	292,000
d. Other personnel compensation	316,175	311,000	325,000
e. Payments to other agencies for reimbursable details	82,001	58,000	69,000
Total Personal Services	$68,876,112	$73,741,000	$78,257,000

a. Net cost of regular full-time employees, including terminal leave costs: FY 1967: $66,917,091 FY 1968: $72,094,000 FY 1969: $76,246,000

The estimates provide for employment at the beginning and end of the fiscal year as follows:

	FY 1967	FY 1968	FY 1969
Starting Employment	5,504	5,627	5,812
Ending Employment	5,627	5,812	5,952

Computation of the dollar estimate:

(1) Average employment	5,540	5,689	5,859
(2) Plus man-year equivalent for terminal leave costs	26	25	25
(3) Total regular full-time man-years	5,566	5,714	5,884
(4) Average man-year cost	$12,023	$12,617	$12,958
(5) Net cost of regular full-time employees, including terminal leave costs (Line 3 multiplied by Line 4)	$66,917,091	$72,094,000	$76,246,000

The above estimates are based on a strength of 5,952 regular, full-time employees at the end of FY 1969, an increase of 140 over the strength estimated for year-end FY 1968. Of this increase, 53 are required for direction and management of AEC operations and 87 are required to meet continued growth in responsibilities and workloads of the regulatory program. The cost estimates include the portion of the Pay Raise under P.L. 90-206 which became effective on October 8, 1967 only. No provision has been made in the estimates for the second phase of the Pay Raise which is to become effective in July 1968.

The need for increasing the AEC staff for maximum achievement of program objectives and economy in its contractor operations as well as to meet workload increases in the regulatory activities was recognized in the FY 1968 budget. Although partial relief was provided, a special review of manpower requirements for current operations and of staffing needs for FY 1969 reveals that a shortage of manpower still exists in AEC for (1) the technical direction and control of research and development projects and operations, (2) the impact of changes in weapons activities, (3) the increases in workload associated with essential and special administrative programs, and (4) the growth in regulatory activities.

The increases in staffing are discussed on the following pages.

REACTOR RESEARCH AND DEVELOPMENT 25

a. Reactor Development and Technology 20

An increase of 20 positions is needed in FY 1969 to build the technical capability essential for direction and control of the reactor development program. The need is for experienced engineers and scientists and for supporting clerical staff for the following major purposes:

(1) To significantly strengthen and augment the technical capability to provide guidance, direction, surveillance, and control of Reactor Development and Technology operations and programs in accordance with established priorities.

(2) To acquire the technical capability to place adequate emphasis on reactor and plant engineering and system design and to use this capability effectively in all phases of undertakings from establishment of design criteria through construction, testing, and operations in service during the plant lifetime.

(3) To develop, foster, and implement the policy of obtaining better planned, more disciplined, and concentrated programs of criteria, specifications, standards, inspection, and proof testing in all RDT programs, plants and facilities.

(4) To provide the additional capability for on-site technical surveillance and evaluation of reactor development operations.

(5) To utilize RDT capabilities to effect the necessary changes in laboratory and contractor organizations to assure effective technical management and the fullest use of available and planned resources on priority programs.

(6) To eliminate programs and projects of marginal utility and to redirect and reorient their associated resources, including facilities, in support of priority programs.

Substantial progress has already been made toward each of these objectives. The additional positions are required to maintain these efforts. They further reflect the substantial increase in the overall size and complexity of priority programs and projects in the reactor development program, after deletion of low priority programs and redeployment of the resources hitherto applied to them. The increases are primarily needed to further strengthen the capabilities to provide for augmented efforts on:

(a) The breeder reactor programs, particularly the liquid metal fast breeder,

(b) The nuclear safety program,

(c) The engineering standards, codes and specifications program and other quality assurance programs, and

(d) The nuclear desalting program.

b. Naval Reactors 5

The addition of five positions is the minimum required to effectively carry out the work on existing new projects planned during FY 1968 and FY 1969. A continuing increase in workload can be expected as a result of the growing number of active nuclear-powered ships, and the resultant overhaul, refueling and maintenance of their plants. In addition, projects such as the Deep Submergence Research and ocean engineering vehicle, the two-reactor carrier, the frigates, and others of a classified nature are important factors in the requested increase. The requested increases are for technical personnel who will be utilized on the new and existing projects.

OTHER RESEARCH ACTIVITIES 2

The 200-BEV accelerator project has been assigned to the Chicago Operations Office. The staffing requirements for this project since its inception have been met through redeployment of staff at that office. However, in FY 1969 two additional positions will be required to assist in the planning and review of the project.

MILITARY APPLICATION 17

Two additional positions in the Headquarters and 15 in field offices (primarily Nevada Operations Office) are required for workload increases in the weapons program which encompasses the design, development, and production of weapons; maintenance of stock piles in a state of constant readiness; underground testing; maintenance of readiness capability to resume atmospheric testing; and participation with Department of Defense in the development of test detection methods. Design, development, and testing of nuclear warheads for the Anti-Ballistic Missile and POSEIDON will have a particularly large impact on the workloads in this program over the next few years.

Five of the positions will be required for the overall management of the weapons program and in particular to expedite the early stages of weapons design and development and twelve positions will be required primarily to support the development and operation of the on and off continent Supplemental Test Sites.

PROGRAM SUPPORT 9

a. Management Information Systems 5

Five additional positions are required to support the computer-based, integrated AEC-wide Management Information System and the newly acquired third generation computer at Headquarters. As the productivity of the new AEC-MIS increases, affording additional and improved management information techniques and reduced costs of data, the demands upon the system continue to grow. As examples are the AEC-wide data banks being developed and implemented for contract data, financial and budget data, and special nuclear material transactions. The AEC is also participating in the Federal Council for Science and Technology government-wide, computer-prepared reports. In order to effectively utilize the investment to date, including the new third generation equipment, a larger analyst staff is needed to investigate proposed applications, to design new applications and to integrate information in existing data banks. In the area of implementation of approved applications, additional personnel are needed to control the mass volume of input/output data. These five positions will help to alleviate the critical shortage of computer-trained personnel in the Headquarters.

b. Other Program Support 4

An increase of four positions will be required in support of the increasing workloads in the areas of budget, safeguards, health and safety and legal. The specific needs are for: One budget examiner position primarily required to handle the increased workload requirements associated with the consolidation and preparation of research and development data for outside organizations, including the Congress, Bureau of the Budget and National Science Foundation; one position to support the strengthening of AEC safeguards and resident inspection controls of special nuclear materials; one position to assist in an expanding and more complex health and safety program; and one position as an absolute minimum to provide legal support for the very rapid expansion of AEC's regulatory activities.

REGULATORY FUNCTIONS 87

Programs assigned to the Director of Regulation will require a staff of 517 employees in FY 1969. This number reflects redeployment of 7 positions from other regulatory activities in order to meet workload increases in the licensing of reactor facilities. In spite of this redeployment, an increase of 87 positions over the estimated strength of 430 positions in FY 1968 will be necessary.

In FY 1969, the regulatory staff will receive applications to construct and/or operate approximately 46 major nuclear power plants. This compares to 21 applications received in FY 1967 and 36 anticipated in FY 1968. During FY 1967, two new regulatory divisions were established by the Commission. One of these divisions is

charged with maintaining a program to account for and protect nuclear materials held by licensees from diversion to unauthorized uses. The other division is responsible for focusing increasing attention on the reactor standards effort.

Sixty-nine of the new positions are related to the review and evaluation of power reactor applications and to the performance of necessary inspections of facilities. Five additional positions will be required in the development of more comprehensive facility safety standards, criteria, and guides. Thirteen additional positions will be required to establish and administer the new safeguards program for licensees.

Efforts to improve the utilization of manpower will continue in the current fiscal year and in FY 1969 with examination of organizational staffing requirements and agency-wide procedural requirements, and with the exercise of continuous controls within authorized employment levels. The increases discussed in this request represent existing and known future needs in excess of the capacity to redeploy staff to essential management functions in FY 1969.

AEC will continue its professional and management internship programs for recruiting outstanding college graduates for integration in the organization. These interns enter on duty shortly after graduation, and for the most part are placed on the rolls early in July.

Factors which will contribute to the FY 1969 increase in average salary include periodic within-grade salary increases which are not largely offset by savings due to turnover because of the extremely low turnover rate (13 percent compared to government-wide rates of 25 percent in FY 1966), the increase in high grade positions and the annualization of the Pay Raise which became effective on October 8, 1967.

94-075 O-68-pt. 3—41

The following table reflects by office the actual strength of regular full-time employees as of June 30, 1967, and estimated requirements at June 30, 1968, and June 30, 1969. All personnel performing regulatory functions are included under the caption, "Headquarters and Extension."

Estimated Year-End Employment

	Actual Strength 6/30/67	Estimated Strength 6/30/68	Estimated Strength 6/30/69
Albuquerque	680	691	694
Brookhaven	39	37	37
Chicago	257	250	252
Grand Junction	148	147	147
Idaho	195	193	193
Nevada	289	312	324
New York	202	206	206
Oak Ridge	497	499	499
Pittsburgh	91	99	99
Richland	312	310	315
San Francisco	276	274	275
Savannah River	180	179	179
Schenectady	79	84	86
SNPO-Cleveland	43	43	43
SNPO-Nevada	25	27	27
Total Field	3,313	3,351	3,376
Headquarters and Extension:			
AEC Operations	1,940	2,031	2,059
Regulatory Functions	374	430	517
Total Headquarters and Extension	2,314	2,461	2,576
Grand Total	5,627	5,812	5,952

b. Costs of other employees: FY 1967: $1,303,692 FY 1968: $1,278,000 FY 1969: $1,325,000

The estimates cover salaries of temporary, part-time and intermittent employees. The costs by types of employment are estimated as follows:

	FY 1967	FY 1968	FY 1969
Temporary Employment	$ 652,965	$ 594,000	$ 638,000
Part-time Employment	265,683	284,000	287,000
Intermittent Employment	385,044	400,000	400,000
Total	$1,303,692	$1,278,000	$1,325,000

The costs for temporary employment provide for (1) high school and business college graduates who are converted to permanent positions as vacancies occur beginning about four months after employment; (2) the summer employment of high school students under the Youth Opportunity Program; (3) foreign nationals hired under personal services contracts for overseas exhibit work; and (4) the summer employment of college students.

The part-time costs are predominately for the employment of professional women on a part-time basis.

The cost under intermittent employment is for salaries of personnel who are paid only when employed, such as, members of the General Advisory Committee, the Patent Compensation Board, the Advisory Committee for Reactor Safeguards, other boards, committees, panels and consultants and experts.

c. Pay above stated annual rate: FY 1967: $257,153 FY 1968: $ -0- FY 1969: $292,000

These costs are principally to cover salaries of employees for days of pay in excess of 260 days in the fiscal year. One extra day of pay is required in FY 1967 and FY 1969.

d. Other personnel compensation: FY 1967: $316,175 FY 1968: $311,000 FY 1969: $325,000

These costs cover payments for scheduled and emergency overtime, nightwork differential, Sunday premium pay, and authorized salary differentials for certain AEC employees stationed overseas. The increase of $14,000 in FY 1969 is primarily for increased overseas allowances and increased overtime and shift work predominately in the services activities.

e. Payments to other agencies for reimbursable details: FY 1967: $82,001 FY 1968: $58,000 FY 1969: $69,000

These costs in FY 1969 cover reimbursement to the Department of State for employees detailed to AEC foreign offices and payments to other agencies for reimbursable details to meet special requirements. The estimates for FY 1968 and FY 1969 include the reimbursement to the Department of Defense for the Assistant General Manager for Military Application beginning December 14, 1967, in accordance with Public Law 90-190.

2. Personnel Benefits $6,457,000

This category comprises payments to other funds for the benefit of employees, and certain cash allowances paid to employees. The items under this category are:

Personnel Benefits

Item	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
a. Payments to CSC Retirement Fund	$4,364,152	$4,681,000	$4,973,000
b. Payments to Employees Health Benefits Fund	426,421	438,000	451,000
c. Payments to CSC Employees Life Insurance Fund	212,386	227,000	236,000
d. Payments to Employees Compensation Fund	34,670	34,000	81,000
e. Agency's Share of FICA Taxes	51,637	44,000	50,000
f. Employee Overseas Allowances	49,463	60,000	68,000
g. Employee Domestic Quarters Allowance	3,900	2,000	2,000
h. Allowance for Duty at NTS and NRDS	101,597	130,000	144,000
i. Employee Incentive Awards	73,871	80,000	80,000
j. Moving Expenses	156,340	156,000	372,000
Total Personnel Benefits	$5,474,437	$5,852,000	$6,457,000

a. Payments to CSC Retirement Fund $4,973,000

This covers the estimated amounts to be paid by the agency into the Civil Service Retirement Fund, equal to amounts withheld from the basic salary of employees to whom the Civil Service Retirement Act applies. In accordance with law, requirements are computed at 6½% of basic salaries of such employees.

b. Payments to Employees Health Benefits Fund ..... $ 451,000

This covers the estimated contribution required of the Government under the Federal Employees Health Benefits Act of 1959. The estimate is based on current experience as to the extent of employee participation in the health benefit plans provided.

c. Payments to CSC Employees Life Insurance Fund ..... $ 236,000

This covers the estimated amounts to be paid by the agency to the CSC Employees Life Insurance Fund, equal to one-half of the amounts withheld from salaries of participating employees, in accordance with the rate established by the Civil Service Commission under the Federal Employees Group Life Insurance Act of 1954.

d. Payments to Employees Compensation Fund ..... $ 81,000

This covers payments to the Employees Compensation Fund under the provisions of P.L. 86-767. This amount budgeted for FY 1969 is the amount to be billed to AEC by the Bureau of Employees' Compensation for benefits paid by the Bureau in FY 1967 on account of injury or death of AEC employees.

e. Agency's Share of FICA Taxes ..... $ 50,000

This covers the agency's share of taxes on salaries of employees subject to the Federal Insurance Contributions Act, as provided by the Social Security Amendments of 1965.

f. Employee Overseas Allowances ..... $ 68,000

This covers special allowances for employees stationed overseas, as authorized by law.

g. Employee Domestic Quarters Allowance ..... $ 2,000

This covers the cost of domestic quarters allowances for a military employee on reimbursable detail to AEC.

h. Allowance for Duty at NTS and NRDS ..... $ 144,000

This covers the payments to employees assigned to duty at the Nevada Test Site and the Nuclear Rocket Development Station as authorized under Public Law 89-383 approved on March 31, 1966.

i. Employee Incentive Awards ..... $ 80,000

This covers cash awards to employees in recognition of suggestions, inventions, superior accomplishments and other acts as authorized by the Government Employees' Incentive Awards Act.

j. Moving Expenses ..... $ 372,000

This covers certain moving expenses related to transfers of employees as authorized under Public Law 89-516 approved July 21, 1966.

3. Benefits to Former Personnel ..... $ 79,000

This category covers the cost of Severance Pay to employees who are involuntarily separated as prescribed by Public Law 89-301, Federal Employees' Salary Act of 1965. Actual costs in FY 1967 amounted to $24,617. The estimate for FY 1968 of $24,000 represents the cost for severance payments currently in effect. The estimate for FY 1969 of $79,000 reflects the costs of severance payments based on planned organizational changes.

4. Travel and Transportation of Persons $4,054,000

This category consists of the following items:

Travel and Transportation of Persons

Item	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
a. Travel Subject to Travel Regulations	$3,132,070	$3,600,000	$3,900,000
b. Rental of Passenger Vehicles from Interagency Motor Pools	72,080	96,000	96,000
c. Contractual Local Transportation - (Headquarters only) .	41,145	54,000	58,000
Total	$3,245,295	$3,750,000	$4,054,000

a. Travel Subject to Travel Regulations $3,900,000

This estimate covers the cost of official domestic and foreign travel chargeable to Program Direction and Administration. The travel costs under this program include the travel of four principal classes of personnel: (1) AEC regular full-time employees; (2) AEC trainees; (3) AEC intermittent employees such as members of advisory groups and individual consultants; and (4) approximately 250 military personnel on duty with the AEC, whose salaries are paid by the Department of Defense, but whose duties require considerable travel on AEC business.

The FY 1969 estimate provides for travel at the rate of $644 per man-year of employment as compared to $613 in FY 1968 and $544 in FY 1967. The higher cost per man-year results from the increased travel required in the regulatory, weapons and research and development activities and the increased activity in the Western states.

b. Rental of Passenger Vehicles from Interagency Motor Pools ..... $ 96,000

This estimate covers reimbursement to the General Services Administration for use of passenger-carrying vehicles secured from GSA motor pools. These vehicles are used principally for local transportation.

c. Contractual Local Transportation - (Headquarters only) ..... $ 58,000

This estimate covers the net cost of shuttle bus operations between the Germantown Headquarters, the Bethesda Office and a terminal in downtown Washington, D. C. This bus operates on a regular schedule to transport employees on official business. Employees on personal business and the general public are authorized to use the bus by payment of a prescribed fare. The increase of $4,000 over the FY 1968 level is to cover a cost per trip increase as provided for in the existing contract.

5. Contractual Services and Supplies $14,038,000

This estimate covers all costs of operations at the Headquarters and in the field chargeable to this program except personal services, personnel benefits, payments to former personnel, and travel and transportation of persons.

The breakdown of costs by activity for the three years follows:

Contractual Services and Supplies by Activity

	FY 1967	FY 1968	FY 1969
Transportation of Things	$ 269,242	$ 413,000	$ 359,000
Communications Services	2,288,935	2,884,000	3,521,000
Rents and Utilities	814,685	1,074,000	1,418,000
Printing and Reproduction	472,638	529,000	550,000
Other Services	5,158,602	6,169,000	7,219,000
Supplies and Materials	887,547	877,000	971,000
Total	$9,891,649	$11,946,000	$14,038,000

The breakdown of requirements between field offices and Headquarters is:

Contractual Services and Supplies by Field Offices and Headquarters

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Field Offices	$4,035,924	$ 4,151,000	$ 4,476,000
Headquarters	5,855,725	7,795,000	9,562,000
Total	$9,891,649	$11,946,000	$14,038,000

Field Offices: This estimate includes costs incurred by the fifteen field offices and their subordinate area offices. The estimates are related rather directly to employment levels and have been developed on the basis of experience and current plans. Comments and costs for field offices by activity for the three years follow:

Contractual Services and Supplies for Field Offices

	FY 1967	FY 1968	FY 1969
Transportation of Things	$ 123,358	$ 153,000	$ 162,000

This estimate includes cost for transportation of government property and the shipment of household goods for government employees and technical employees reporting to first duty station. The increase in FY 1969 is related to requirements for additional staff.

Contractual Services and Supplies for Field Offices - continued

	FY 1967	FY 1968	FY 1969
Communications Services	$1,042,141	$ 1,120,000	$ 1,156,000

This item includes cost of telephone services, including equipment and circuit rental, and teletype services. The increase in FY 1969 results primarily from the increased cost for additional staff, the requirements for the 200-BEV area office and the annualization of costs related to transferring the telephone switchboard at Richland to industry.

Rents and Utilities	$ 620,293	$ 682,000	$ 704,000

This estimate covers the cost of rental of office and other administrative space and utilities and rental of specialized equipment. The increased cost in FY 1969 provides for space at San Francisco and the annualization of space acquired in FY 1968 for the 200-BEV area office.

Printing and Reproduction	$ 148,122	$ 153,000	$ 154,000

This item includes charges for printing, binding, photostating and reproduction services.

Other Services	$1,648,375	$ 1,604,000	$ 1,838,000

This item covers cost of maintenance and operation of administrative buildings and equipment, guard services, management information system services, and various services performed by other agencies and private contractors. The costs under the two activities are listed below.

a. Services Performed by Other Agencies	$ 222,278	$ 95,000	$ 98,000

Other agencies provide certain services for some of the AEC offices, such as guard services, maintenance and operation of buildings and grounds, employee training and maintenance of crypto equipment. The increase in FY 1969 provides primarily for employee training.

Contractual Services and Supplies for Field Offices - continued

	FY 1967	FY 1968	FY 1969
b. Services Performed by Contractors	$1,426,097	$ 1,509,000	$ 1,740,000

This item includes services performed by contractors, such as, maintenance and operation of buildings and grounds; maintenance of motor vehicle and office equipment, guard services, outside training of employees, management information, and film distribution services. The increased costs relate to the addition of personnel, increased costs related to Management Information Services as the field offices bring more activities into the System and increased cost at Richland for functions transferred from the Special Nuclear Materials program to this program effective July 1, 1968.

Supplies and Materials	$ 453,635	$ 439,000	$ 462,000

This estimate covers cost for general office supplies, technical and professional books, and gasoline, oil and parts for Commission-owned vehicles. The increase of $23,000 is for staff increases and supply items required primarily for the automatic data processing activities.

Headquarters: This estimate includes costs incurred by the Headquarters, including those at a small office on a permanent basis in the District of Columbia and space in Bethesda, Maryland. The estimates have been developed by detailed analysis of needs under the various activities to provide the level of services and materials required for economical and efficient operations.

Comments and costs for the Headquarters by activity for the three years follow:

Contractual Services and Supplies for Headquarters

Activity	FY 1967	FY 1968	FY 1969
Transportation of Things	$ 145,884	$ 260,000	$ 197,000

This estimate includes costs for transportation of government property, and shipments of household goods and personal effects of employees in connection with domestic and foreign transfers and certain personnel reporting to first duty station.

Contractual Services and Supplies for Headquarters - continued

Activity	FY 1967	FY 1968	FY 1969
Communications Services			
a. Telephone	$ 666,775	$ 919,000	$ 1,098,000
b. Teletype	155,573	234,000	295,000
c. AEC-wide Postal Services	347,518	375,000	410,000
d. AEC Secure Automatic Data Information Exchange (SADIE)	xx	151,000	448,000
e. Other Communications Services	76,928	85,000	114,000
Total Communications Services	$1,246,794	$ 1,764,000	$ 2,365,000

a. Telephone ..... $ 1,098,000

This item covers costs of telephone services, including equipment and circuit rental and installation costs, long distance toll calls, the Federal Telecommunications System and tie line services. The increase of $179,000 in FY 1969 provides for increased staff and the annualization of the cost of operation of the Automatic Voice Network (AUTOVON) and the AEC long distance secure voice facilities.

b. Teletype ..... $ 295,000

This estimate covers costs of teletype services, including equipment and circuit rentals, and commercial message costs. The increase of $61,000 results primarily from the increased cost for refile charges related to higher use of government facilities.

c. AEC-wide Postal Services ..... $ 410,000

The estimates reflect payments to the Post Office Department for AEC-wide postal services. These estimates are developed by periodic sampling and estimated mailings. The increased costs in FY 1969 result from the annualization of the increased postal rates which became effective on January 7, 1968.

Contractual Services and Supplies for Headquarters - continued

d. AEC Secure Automatic Data Information Exchange (SADIE) ..... $ 448,000

The SADIE system, which was initially installed in FY 1968, provides a combined data and teletype transmission capability and will interconnect all AEC Field Offices and major contractors as needed to meet data transmission requirements, including the requirements of the Management Information System. The increase in FY 1969 of $297,000 provides $255,000 for annualization of the SADIE system and $42,000 for an increase in costs of leased TELPAK circuits being obtained through the General Services Administration.

e. Other Communications Services ..... $ 114,000

Included under this activity are costs for such items as communications services for foreign offices, telegrams, cablegrams, maintenance of communications equipment, lease of facsimile equipment and radio frequency management costs. The increase of $29,000 is primarily related to the costs of radio frequency management and emergency systems maintenance.

	FY 1967	FY 1968	FY 1969
Rents and Utilities	$ 194,392	$ 392,000	$ 714,000

This item includes costs of electric power, water and sewerage charges at Germantown, and rental of specialized equipment and office space. The increase in FY 1969 of $322,000 provides primarily for the annualization of space costs and equipment rentals acquired in FY 1968 and the rental of specialized automatic data processing equipment.

Printing and Reproduction	$ 324,516	$ 376,000	$ 396,000

This activity includes costs of printing forms, letterheads, routine and special reports, photographic services and special printing and duplicating services performed by other agencies and contractors. The cost increase of $20,000 is related to increased staff and the printing of special reports.

Other Services	$3,510,227	$ 4,565,000	$ 5,381,000

This activity includes costs for all contractual services not otherwise classified. These services which are performed by other Government agencies and private contractors are itemized below.

Contractual Services and Supplies for Headquarters - continued

	FY 1967	FY 1968	FY 1969
a. Services Performed by Other Agencies			
(1) Building Operation and Maintenance - General Services Administration	$1,058,255	$ 1,181,000	$ 1,316,000
(2) Guard Service - GSA	587,166	680,000	801,000
(3) Administrative Support - foreign offices - Department of State	109,918	135,000	134,000
(4) Other Miscellaneous Services	435,225	633,000	609,000
Total Services Performed by Other Agencies	$2,190,564	$ 2,629,000	$ 2,860,000

The increase in building operation and maintenance costs in FY 1969 results from higher charges by the General Services Administration. The increase in the cost of guard service is related to costs attributable principally to the additional space acquired during FY 1968 and the annualization of the Pay Raise which became effective on October 8, 1967.

b. Services Performed by Private Contractors	$1,319,663	$ 1,936,000	$ 2,521,000

This item includes services contracted for with private contractors, such as repairs and maintenance of equipment; handling foreign and domestic patent matters; reporting services for conferences and hearings; outside training of employees; and official entertainment both at Headquarters and field offices. The increase is principally for the cost of financial assistance to states for installation and maintenance of employee-state-Federal record-keeping system in connection with Workmen's Compensation for radiation injuries and special contractual services for the Division of Classification and the Regulatory group.

An amount of $30,000 is included in this activity for official entertainment to accord proper honor and recognition to (a) foreign dignitaries visiting facilities of the AEC, its contractors, or other points designated by AEC; (b) foreign dignitaries by heads of foreign offices in carrying out their assigned duties; (c) foreign dignitaries by representatives of the AEC during their visits to foreign countries; (d) important representatives

of state and local governments in connection with their participation in special events, such as dedications; and (e) a small amount for receptions for high scientific officials at awards ceremonies, such as the E. O. Lawrence Awards.

	FY 1967	FY 1968	FY 1969
Supplies and Materials	$ 433,912	$ 438,000	$ 509,000

This item includes costs of supplies and materials, such as office supplies; technical and professional books, gasoline, oil and parts for Commission-owned vehicles; and subscriptions for newspapers and periodicals. The increase in FY 1969 is related primarily to the higher level of employment, the higher cost of technical books and journals, and additional automatic data processing supplies.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

ADMINISTRATIVE PROGRAM - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$2,129,000
A Construction Projects	
A-1 Obligations for new projects	($ 240,000)
A-2 Obligations for prior year projects	($ 0)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($1,812,000)
B-2 Obligations from prior year appropriations .	($ 77,000)
Estimated Obligations FY 1968	$1,254,000
Actual Obligations FY 1967	$1,992,864

Obligations for the Administrative Program for FY 1969 are estimated at $2,129,000 of which:

a. $240,000 is for the construction project justified in Section A-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

b. $1,812,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

c. $77,000 is for Capital Equipment Not Related to Construction listed under Section B-2 below, which was authorized and for which funds have been appropriated, but which is being deferred from FY 1968 under the "FY 1968 cutback."

SECTION A-1

The project comprising Section A-1, which is requested for authorization in FY 1969, is:

Project No.	Title	Total Estimated Cost	Funded Thru FY 1968	Estimated Obligations FY 1969	Funding Required After FY 1969 to Complete Project
69-8	General Plant Projects	$240,000	$ 0	$240,000	$ 0

EXPLANATION OF PROJECT IN SECTION A-1

69-8 General Plant Projects ..... $ 240,000

This project provides for minor new construction and other capital alterations, additions and retirements to the land, buildings, and utilities systems at the Headquarters in Germantown, Maryland. Numerous small capital items are needed each year for reasons of economy, safety, health protection and efficient operation.

SECTION B-1

Capital Equipment Not Related to Construction comprising Section B-1, which is to be authorized and funded in FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
a. Equipment for regular operating requirements	$ 737,000
b. Automatic data processing equipment	1,019,000
c. Special equipment for AEC-wide communication capability	56,000
Total	$1,812,000

JUSTIFICATION

a. Equipment for regular operating requirements ..... $ 737,000

The estimate provides for the procurement of administrative equipment to meet the requirements of the 15 field offices, their subordinate area offices and the Washington Headquarters. Included are such items of equipment as office machines (typewriters, calculators, adding machines, etc.), office furniture, motor vehicles, security and protection equipment, reproduction equipment, and communications equipment.

It is estimated that $339,000 of these funds will be required for the normal replacement of equipment items which have become unserviceable or on which further repairs would be uneconomical; $100,000 for purchase of additional equipment such as safeguards equipment, communications equipment, reproduction equipment, graphics and visual aid equipment, and security equipment; and $173,000 for procurement of additional office furniture and machines for the staff increases requested for FY 1969. In addition, $125,000 will be required for a solid state microwave system for the ERC at Richland to provide a reliable communications system for emergency situations.

b. Automatic data processing equipment $1,019,000

This estimate provides $950,000 for the purchase of a second central processing unit to be interconnected with the IBM 360/50, which is to be used as a communications switch on the Secure Automatic Data Information Exchange (SADIE) system and for control of remote printers and Cathode Ray Tube displays in the Headquarters, $26,000 for ancillary computer equipment at New York and $43,000 for miscellaneous small items, such as, key punch and verifier and storage equipment.

c. Special equipment for AEC-wide communications capability 56,000

This estimate provides $40,000 for the procurement of radio equipment to maintain the AEC-wide radio systems and $16,000 for procurement of communications security equipment for the AEC Secure Automatic Data Information Exchange (SADIE) facilities.

SECTION B-2

Capital Equipment Not Related to Construction comprising Section B-2, which was authorized and appropriated in FY 1968 and for which obligations have been deferred until FY 1969, is as follows:

Activity	Estimated Obligations FY 1969
Equipment for regular operating requirements	$ 77,000

94-075 O-68 pt. 3—42

ALLOCATION OF JOINT COMMITTEE REDUCTION

Mr. MORRIS. Of the budgeted increase of $7,572,000, the Joint Committee has disallowed $500,000 in the authorization bill. How will you allocate this half-million-dollar reduction?

Mr. VINCIGUERRA. Do you want to speak to that, John?

Mr. ABBADESSA. Mr. Chairman, in addition to that $500,000, they also reduced a half million dollars for foreign travel, and $80,000 of it applies to this program. So, $80,000 will be against our foreign travel funds.

For the half million dollars disallowed, we will reduce the workmen's compensation and radiation recordkeeping assistance to States by $76,000; we will reduce the location allowance at NTS and NRDS by $14,000; we will reduce our training of employees by $5,000; and we will reduce regulatory miscellaneous activities by $50,000. The biggest reduction will be against personnel, which will not involve a reduction of our yearend strength, but by bringing people on slowly we think we can absorb a reduction of 23 man-years. This will involve $355,000 when you include the personnel benefits and travel that go with the people.

MANDATORY INCREASE

Mr. MORRIS. Of the increased authorization of $7,572,000, how much is considered to be mandatory in fiscal year 1969?

Mr. ABBADESSA. To state clearly for the record, Mr. Chairman, we need every single cent of our request. Honestly, sir, this is a very important but very tight program. As the chairman indicated in his opening statement, I believe he used the words "this is the most important money we have."

It is the money that goes into the technical areas needed to administer our entire program, where hundreds of millions of dollars are being spent. In addition, we have very serious needs on the regulatory side, we are building up in the ABM area, and we need more help in the reactor and physical research area. All of our request, except nine people, go into these three areas.

Dr. TAPE. On the regulatory side, Mr. Chairman, the Government has established regulations and licensing of these particular facilities and endeavors. One just has to have the people to provide that kind of regulatory service as it is requested.

As the nuclear power industry grows, the Government has to have the regulatory authority to go with it. This is why you see this large increase which, as Mr. Abbadessa has said, is minimal. It is cut back just as far as we possibly can in view of all other things.

There is a problem that we cannot just arbitrarily say let's cut people, because at the same time we have an obligation to the industry as well, and to our citizens.

Mr. MORRIS. Also, Dr. Tape, you are required by law to perform certain regulatory functions.

Dr. TAPE. That is correct.

Mr. MORRIS. If you are unable to perform these functions because of lack of personnel and resources, then technically the Commission is in violation of the statute.

Dr. TAPE. We are at fault if we do not provide the implementation of the statute.

WORK PERFORMED BY REGULATORY EMPLOYEES

Mr. ROBISON. Mr. Chairman, could we have supplied for the record a description of the tasks performed in the job category of regulatory employees?

Dr. TAPE. Very good, sir.

(The information follows:)

DESCRIPTION OF TASKS PERFORMED BY REGULATORY EMPLOYEES

LICENSING ENGINEER

Analyzes specific features of the design and operation of proposed new reactors and modifications to reactors. Concentrates on engineering features from the standpoint of hazards which may develop from malfunctioning of mechanical devices, structural failures, and similar weak points of engineering design. Reactor safety is given prime consideration. Range of work includes licensing and regulation of power, test, and research reactors, and critical facilities.

REACTOR INSPECTOR

Inspects licensed reactors and reactor facilities from the standpoint of health and safety of employees in the general public. Reactor inspection work centers on making observations of the safety of reactor operations to determine compliance with provision of the license and regulations issued by the AEC. Reactor facilities under compliance inspection include power reactors, test reactors, research reactors, and critical facilities. Major emphasis is given to the adequacy of operational health and safety practices and conditions found in reactor facility operations. Inspections are conducted periodically from the start of construction through the operating lifetime of the facility.

REACTOR STANDARDS ENGINEER

Evaluates and develops safety standards, criteria, and guides for the location, design, construction, and operation of reactors and other nuclear facilities. Works in conjunction with AEC divisions, Advisory Committee on Reactor Safeguards, professonal standards organizations, and industry.

MATERIALS SAFEGUARDS INSPECTOR

Conducts inspections of licensee facilities for compliance with AEC regulations pertaining to the safeguarding of special nuclear materials; and conducts special investigations and surveys of licensee facilities where material is unaccounted for or where diversion is suspected.

INCREASE IN TRAVEL REQUEST

Mr. MORRIS. The Joint Committee in its report questioned the proposed travel increase from $3,750,000 for the curent year to $4,054,000 for fiscal year 1969. Could you comment on this large increase for travel?

Mr. ABBADESSA. Mr. Morris, if you remember, speaking just to the foreign travel portion where the Joint Committee took a half-million-dollar reduction, we have allocated that reduction to our various programs.

The President, as you know, has issued guidance to the executive departments to take a 25-percent reduction in planning 1969 travel. This is applicable only to Government employees. In our case, it would be an $80,000 reduction.

The Commission, in keeping with the spirit of the President's guidance, also applied the 25-percent reduction to contractor employees as well as to our own, which involves substantially more money.

We offered to the committee $435,000 in order to apply the 25-percent reduction both to Government employees and contractor employees. The committee, in their judgment, increased this reduction to a half million dollars, so the planned foreign travel for both Government employees and contractor employees will be reduced more than 25 percent under the Joint Committee's markup.

COMMUNICATIONS SERVICES

Mr. MORRIS. As outlined on page PDA–18, please highlight the need for the increase of $601,000 for communications services, which is an increase of about 30 percent.

Mr. ABBADESSA. Mr. Chairman, this is essentially, from our point of view, an uncontrollable expense in certain respects. This pays for the FTS and for annualization of other special communications including the secure automatic data information exchange (SADIE) system. We pay the amount that is billed to us by GSA for FTS, which is an allocation from the overall Government cost.

To date, we have taken a beating on this account because the billings have exceeded our estimates. This request is based on our best judgment of our expected usage and what the GSA billing will be. The largest increase is for the SADIE system, which has just been activated.

Mr. ROBISON. Why is SADIE costing so much more?

Mr. ABBADESSA. That is different. This is not the GSA system. SADIE is a communications system that is dedicated to the Government, to the AEC activity. What is involved here is a communication network for all of our field offices, and the funds are needed to put in the equipment necessary for each of the offices, and to lease the lines from A.T. & T. SADIE is needed in order that we can transmit classified data between computers which we cannot do over the FTS or our present teletype system and, it is essential for it ties in with the management information system that we are establishing for the entire Commission. This will lead to putting in computers and switching gear and things of that nature, so we can accumulate the information that we use for administrative purposes considerably more efficiently than we are now doing.

That is essentially what this amount is for.

Mr. MORRIS. It seems to me $300,000 is a considerable increase from 1968 to 1969. Then you have other communications service increased from $85,000 to $114,000. In all, you have about $1,263,000 for communications.

Mr. ABBADESSA. Mr. Chairman, SADIE is something that got started only in 1968. Just annualizing the existing cost accounts for almost $300,000 of the $448,000. It is something that has just started and it is not an increase in the sense that this will be a continuing increase each year. It is annualizing because you are looking at a full-year's cost for the first time of a new activity.

I do not want to mislead you. There could well be an increase again next year, but it will be for a different reason.

SERVICES PERFORMED BY PRIVATE CONTRACTORS

Mr. MORRIS. On page PDA–20, $2,521,000 is budgeted for "Services performed by private contractors," an increase of $585,000 or about 25 percent.

What is the basis for this large increase?

Mr. CORSO. I will give you the breakdown.

For assistance to States for the installation and maintenance of employees' State and Federal recordskeeping system for the workmen's compensation group——

Mr. MORRIS. I thought the legislative committee turned down that program.

Mr. CORSO. The Commission modified the scope of the program consistent with the action of the legislative committee. This is not the same program that was contemplated at the time the Commission testified last year on this.

Mr. MORRIS. The committee would like to have for the record a detailed breakdown of this item, particularly in reference to the recordkeeping system. We had a long hearing on this when it was considered by the Joint Committee.

Mr. ABBADESSA. Part of the increase is for that activity. We can give you the precise figures.

It also includes contractual services for the regulatory group. The regulatory group is getting more and more into the safeguards activity, which is a growing activity.

There is money in here for increased samples, and things like that, in the safeguards program. We can give you a specific breakdown of that.

(The information follows:)

The increase of $585,000 under "Services performed by private contractors" is comprised of the following:

	Costs
1. Workmen's compensation—Radiation recordkeeping assistance to States	$107,000
2. Special regulatory activities:	
(*a*) Technical support services to develop standard analytical models to facilitate in the review of nuclear power reactor applications	120,000
(*b*) Technical services required to collect and analyze data on reactor system characteristics and on operational, incident and emergency experience data for publication and dissemination to licensees and the nuclear power industry	50,000
(*c*) Collection and analysis of environmental and radiation safety data from licensed nuclear facilities to determine compliance with radiation standards and exposure limits	43,000
(*d*) Analysis of samples relating to the nuclear materials safeguards program	39,000
(*e*) Engineering consulting firms to aid in inspecting nuclear facilities for resistance to earthquakes and ground motions	15,000
(*f*) Analysis of isotopic content of materials being imported or exported	15,000
(*g*) Miscellaneous services, such as, film-badge study on radiation exposure statistics, reactor operators examinations, and consulting services related to safety features in the construction areas	36,000
Total regulatory	318,000

3. Classification film for educational purposes within the AEC	$75,000
4. Management information system	35,000
5. Miscellaneous services, such as, reporting services, equipment repairs and maintenance, patent filing fees, and employees training	50,000
Total increases, services performed by private contractors	585,000

AUTOMATIC DATA-PROCESSING EQUIPMENT

Mr. MORRIS. Under capital equipment, a total of $1,019,000 is budgeted for automatic data-processing equipment, including $950,000 for purchase of a second central processing unit at headquarters.

What is the big urgency for acquisition of this new equipment during this fiscal year?

Mr. ABBADESSA. We brought aboard in January of this year a 360/50 machine. The purpose of the equipment request is to buy a model 65 central processing unit and put it with our new system. It upgrades our computer capability consistent with our planned increase in this area.

We will take our present central processing unit and hook it up with the Sadie system to serve as a computer switching station and as a controller of remote terminal stations. The purpose of this is to allow us to communicate directly between headquarters and our various field offices, particularly from one computer directly to another computer; with this arrangement we do not have to process our data in the field, send it through the mail, and then hook it up and put it into the computer. It is a step forward, taking advantage of present-day technology, which will increase considerably our ability to process our information. That is the purpose of this second processing unit.

EFFECT OF DEFERRAL OF EQUIPMENT

Mr. MORRIS. What would be the effect on your ability to perform the functions and mission of your agency under the statute if it were deferred for a year?

Mr. ABBADESSA. If it were deferred or if this committee cuts a substantial amount of our total equipment money, it would force us to take a look at our computer needs. We would make every effort to defer the acquisition of computers if at all possible.

In the event our programmatic needs are such that it just does not make any sense to defer the acquisition of computers, we will probably lease instead of purchase. This is an unfortunate thing, because while we make a short-term savings in current appropriations expenditures, leasing computers will cost the Government more in the long run.

Congressional hearings were held on this subject. The GAO issued some 90 reports. The AEC, with considerable support from the Joint Committee and the Appropriations Committee, has always followed the policy of buying rather than leasing when it was economically advantageous.

From the congressional hearings, guidance was given to the rest of the Government suggesting our method of procurement and acquisition of computers.

I would hope that this committee could give very particular attention to our equipment needs, particularly in computers. Obviously, if we are cut, we will make every effort to stretch out acquisitions.

But if we just have to have the computers—these scientific and technical areas are more and more relying on computers, particularly in the weapons area—we will be forced to lease them, Mr. Chairman, and in the long run it will cost the Government money.

TYPEWRITERS AND CALCULATORS

Mr. MORRIS. It is noted that under the capital equipment program for the administrative program, during the current fiscal year and in fiscal year 1969, it is planned to purchase 338 electric typewriters and 156 calculators.

Is all this equipment absolutely essential during the next fiscal year?

Mr. CORSO. Our purchases are generally for replacement, sir. There will be some additions to take care of employees who are coming on, such as those under the regulatory and operational parts of the Commission's work. Essentially, it is for replacement of equipment as it wears out.

This is pretty carefully reviewed to make sure replacement of a particular piece of equipment would be more economical than continued maintenance.

Mr. MORRIS. Do you have a standard for replacement of calculators and typewriters?

Mr. BAUER It is my understanding that a record is kept on each of the major items of office equipment. There is a maintenance history. It is only when the costs for maintenance are excessive that the people in charge of such acquisition will authorize purchase of new equipment for replacement.

Mr. MORRIS. The committee would like you to provide some sampling of these records for the committee.

Mr. ABBADESSA. Mr. Chairman, we have a property and supply group under the Director of Contracts who, unfortunately, is not here today. This group works very closely with the GSA in this area.

We will provide for the record the procedures we follow on these types of equipment.

Mr. MORRIS. Will you tell him to take a particular look at the typewriters and calculators, please.

(The information follows:)

REPLACEMENT STANDARDS FOR AEC-OWNED TYPEWRITERS AND CALCULATORS

AEC policy provides that Government-owned personal property shall be (a) limited to the minimum requirements to meet program needs economically and efficiently, and (b) retained in use even though any specific standard permits replacement as long as it will serve its intended purpose and can be used or operated without excessive maintenance cost or substantial reduction in trade-in value.

Applicable procedures provide that prior to the purchase of new typewriters, AEC and its cost-type contractors shall fulfill their needs insofar as practicable through redistribution, repair, or rehabilitation of already owned typewriters. In furtherance of the use of rehabilitated typewriters, inventories shall be reviewed on a continuing basis to ascertain those items which can be economically rehabilitated and institute programs for their orderly repair and rehabilitation. All such items which are not required for immediate needs shall be reported as excess.

The folowing AEC standards, consistent with Government-wide replacement standards (Federal Property Management Regulations 101-25.403), are prescribed for replacement of typewriters:

Year:	*Percentage of replacement cost*
2d	80
3d	80
4th	80
5th	70
6th	70
7th	60
8th	50
9th	40
10th	30
11th	20
12th	10

Example.—An example of the application of the "Standard replacement cost percentage scale" to a typewriter costing $109 is as follows:

Year	Assumed trade-in sale value	Replacement cost	Estimated repair cost justifying replacement
2d	$50.00	$59.00	$47.20
3d	50.00	59.00	47.20
4th	50.00	59.00	47.20
5th	45.00	64.00	44.80
6th	45.00	64.00	44.80
7th	45.00	64.00	38.40
8th	45.00	64.00	32.00
9th	40.00	69.00	27.60
10th	37.50	71.50	21.45
11th	37.50	71.50	14.30
12th	30.00	79.00	7.90

Exception.—When unusual circumstances justify replacement of a typewriter at a date earlier than would be permitted by application of the standard replacement cost percentage scale, a written justification for such replacement shall be approved by the official designated, or his designated representative, and the replacement of the typewriter may be made. The justification shall be retained as a part of the requisitioning file of the office.

Specific replacement standards have not been promulgated by AEC for replacement of calculators. However, estimates for replacement of such equipment are based on reviews made of records which provide data on age, capability, maintenance costs, utilization, service life, and planned replacement data, and on which an evaluation of need for retention or replacement can be made.

DEFERRAL OF CAPITAL EQUIPMENT

Mr. MORRIS. Of the total of $269.6 million deferred during the current year under the stretchout program, $36,568,000 was made in the capital equipment category.

Please outline how these deferrals in the capital equipment program were determined.

(The information follows:)

Deferrals in fiscal year 1968 planned obligations for equipment were determined in the following manner:

(*a*) A detailed review was made of our operating programs in order to identify savings and reductions that could be effected in these areas;

(*b*) Our plans for construction were reviewed to identify those projects and subprojects which could most easily be deferred. By and large, these projects and subprojects were those on which construction had not yet started and those whose availability for beneficial occupancy was not of the highest priority in terms of military or health and safety requirements;

(c) The combination of operating programs reduced and construction projects deferred left a balance of $36,568,000 to be identified in order to meet the overall target reduction of $270 million set for the AEC. This amount was met by arbitrarily deferring our planned obligation for equipment. In order to minimize the impact of this reduction, we identified those items which could be leased with a purchase option, that is, computers; those items scheduled for late order and delivery, etc.; and, finally, we deferred additional funds on command decision basis to hit our quota.

DETERMINATION OF NEW EQUIPMENT REQUIREMENTS

Mr. MORRIS. For fiscal year 1969 a total of $176,040,000 is requested in new appropriations for capital equipment.

Please outline the review policy followed by the Commission in determining these new equipment requirements.

(The information follows:)

The equipment required to support the conduct of AEC programs can generally be characterized either as replacement items or new acquisitions. Replacement of capital items is carefully controlled by imposing various sets of use, age, and condition benchmarks. For example, for many kinds of equipment there are standard GSA criteria which govern the determination of whether specific items of equipment should be replaced or not. Replacement items, therefore, are generally required because the items which they replace are either worn out or cannot continue to be operated economically. With respect to the acquisition of new items of equipment, the decision to buy is dictated by the demands of the program. In essence, equipment is bought where planned programs cannot be accomplished without such acquisition. This includes production equipment, computers for laboratories, and a variety of equipment types, such as bubble chambers, and so forth, required for the conduct of experimental programs.

The review procedures followed in determining requirements for new equipment start at the level at which the work is to be done. It is at this level that the initial determinations are made in the light of existing and generally recognized replacement standards or program requirements. By the time an equipment budget is presented to the Congress, it has undergone several levels of review in our field offices, program divisions, by the AEC's budget review committee consisting of the Controller and the assistant general managers for research and development, reactors, operations, administration, military application, and plans and production. In addition, the equipment budget is also reviewed by the General Manager and the Commission. Finally, before contractors can proceed with the purchase of significant items of equipment, each proposed procurement action must be approved by the manager of the cognizant AEC operations office to assure that the item is still needed in accordance with the justification presented in the budget and that pertinent procurement regulations are being observed.

NEED FOR INCREASE IN CAPITAL EQUIPMENT CATEGORY

Mr. MORRIS. This new request, together with the deferred funds from 1968, provide a total of $212,608,000 for equipment in fiscal year 1969. This compares with only $120.9 million to be expended during the current fiscal year.

Why is it necessary to almost double these purchases in fiscal year 1969?

(The information follows:)

The $212.6 million available for obligation in fiscal year 1969 for equipment acquisition includes $36.6 million deferred from fiscal year 1968. We believe the need is still firm for these deferred items. For example, over $10 million of this amount represents computer acquisitions which we have entered into on a lease/purchase option basis. We would hope to exercise our purchase option thereby avoiding the economic penalty of continued rental. After deducting the deferral items included in the $212 million, there remains a requirement for $176 million

for new appropriations for capital equipment. This compares to $156.1 million approved by this committee last year. The increase of $19.5 million requested is more than accounted for by the $24.3 million increase requested for the weapons program to meet production and development schedules. As indicated in the answer to the previous question, the stated needs for equipment have been carefully reviewed at all levels within the AEC complex and, under the pressure of overall budgetary constraints, we are convinced that these funds are required to provide equipment essential to effective conduct of AEC programs.

EQUIPMENT INVENTORY CONTROL SYSTEM

Mr. MORRIS. What type of equipment inventory control system does AEC maintain to monitor equipment requirements?

(The information follows:)

AEC's accounting system provides for financial control of property. AEC maintains an item-by-item inventory of equipment used in its direct operations and responsibility is placed on the contractors to maintain equipment inventory control systems adequate to monitor equipment in their custody. In general, these systems provide for individual property records and an item-by-item inventory of all equipment meeting AEC's capitalization requirements. (Generally, all units costing $100 or more and having a useful life in excess of 1 year and for certain other items of a sensitive nature regardless of cost.) For the most part they are established in the contractor's automatic data processing systems which form the basis for (1) reviews of equipment maintenance and operation costs (2) equipment utilization reports (3) forecasts for needs of replacement and additional equipment and (4) determinations concerning upgrading of equipment and other utilization and disposal functions. The adequacy of these systems is reviewed periodically by both AEC and contractors to evaluate their effectiveness in providing management data for the necessary monitoring and control of equipment requirements.

AEC monitors major equipment requirements on a continuous basis and specifically during the budget process, again at the time of project approval, and finally at the time of actual purchase.

IDENTIFICATION AND USE OF SURPLUS EQUIPMENT

Mr. MORRIS. What assurance do you have that there is not surplus equipment in the current inventory?

(The information follows:)

AEC policy provides that a program for the management of Government-owned personal property shall be established and maintained to meet AEC program needs economically and efficiently.

The objective is to establish effective administrative procedures to the extent practicable and economical, which will insure proper utilization of Government property.

Various procedures are employed to accomplish this program including (1) special plant walkthroughs for the specific purpose of identifying equipment which is not being used and should be reported as excess and made available for utilization in AEC locations and at other Federal installations, (2) periodic physical inventories at which time the continuing need for the equipment is reviewed to determine that which could be made available for utilization elsewhere, (3) special reviews of certain inventories at the time changes in programs are made to adjust the inventory of related property consistent with the modified program requirements, and (4) other techniques designed to insure that only currently needed items are retained in inventory.

Mr. MORRIS. To what extent is surplus equipment transferred to avoid new purchases?

(The information follows:)

AEC policy provides for excess and surplus property to be used as the first source of supply.

Procedures are established for AEC and contractor procurement offices to screen lists of property available from other AEC installations and other Federal agency locations in order to avoid procurement from commercial sources whenever Government-owned property can be substituted on a practical basis.

During fiscal year 1967, $10.3 million worth of equipment was utilized within AEC which was acquired from AEC excess lists. Excess equipment amounting to $12.5 million was acquired from other Federal agencies.

REPLACEMENT OF WORNOUT EQUIPMENT

Mr. MORRIS. To what extent is the new equipment requested required to replace wornout equipment?

(The information follows:)

This will vary from year to year and from program to program, but based on our recent experience, dollar requirements for replacement items range fom one-third to one-half of the amounts requested.

ADDITIONAL REDUCTIONS IN EQUIPMENT REQUEST

Mr. MORRIS. The Joint Committee, in the authorization bill, made a reduction of only $1 million in the equipment request.

What additional reductions can be made in the equipment estimate based on the program reductions made in the authorization bill totaling $41 million?

(The information follows:)

Of the total request of $176,040,000, an amount of $99,230,000 is required to support programs that were either not reduced or increased by the Joint Committee. Included here are our programs for raw materials, special nuclear materials, weapons, isotopes development, and civilian applications of nuclear explosives (Plowshare). The remaining equipment request of $76,810,000 is identified by program as follows:

Reactor development	$38,550,000
Physical research	30,850,000
Biology and medicine	5,000,000
Training, education, and information	595,000
Community	3,000
Administrative	1,812,000
Total	76,810,000

Of these, the equipment request for the physical research program has been reduced by $1 million in consequence of the Joint Committee's action. The operating cost reductions in the biology and medicine, training, education, and information, community, and program direction and administration programs do not decrease the need for the equipment items requested for these programs. A review of the reductions in the operating activities of the reactor development program discloses that in only two areas, the space electric work on the liquid-metal-cooled reactor and research and development on the Argonne advanced research reactor, do the Joint Committee's actions clearly indicate an appropriate reduction in equipment funds. The amounts included in our request are $680,000 and $25,000 for these two activities, respectively.

Mr. MORRIS. The gentleman from New York.

Mr. ROBISON. All of us have concern over the rapid growth of the Federal payroll, not just in dollars but also in numbers of employees.

I would express the hope that the Commission would be as careful as it can be, in the forthcoming year, with respect to the additional employees you have asked for.

PROFESSIONAL AND MANAGEMENT TRAINEES

On page PDA–3, there is a reference to professional and management trainees. Are these not regular employees? If so, how many do you have? It says they are "on board" for a 6-month period.

Mr. VINCIGUERRA. We have a management intern program wherein we try to bring in qualified technical and professional employees to be trained for a 6-month period, and then they are put on the rolls on a permanent basis after the 6 months. This is the general rule.

They are within the ceiling authorized to us by the Congress. At the moment, how many do we have, Mr. Bostock?

Mr. BOSTOCK. We have 84.

Mr. ABBADESSA. The point here, Mr. Robison, is that at any point during the year we know we will have a certain amount of turnover. These people are brought in, primarily people with masters degrees, and go through a predetermined training program, with the understanding that they will be absorbed within our ceiling and within the amount of money that Congress has given us.

This is an attempt to do specific recruitment of highly qualified technical people.

PART-TIME EMPLOYMENT OF PROFESSIONAL WOMEN

Mr. ROBISON. Why do you apparently have a special program or effort for the part-time employment of professional women?

Mr. VINCIGUERRA. This is something that has been imposed on the AEC, as well as certain other types of programs, by the administration.

Mr. ROBISON. Is it an effort to get the Commission to hire more women than it has in the past?

Mr. BOSTOCK. The President's program for the employment of women has been going on for some time in an effort to bring more women into the labor market.

Mr. ROBISON. Ordinary women, or "disadvantaged" women?

Mr. BOSTOCK. Professional women. We have had this program for some time, because we are interested in attempting to bring into AEC those women who have professional backgrounds and, sometime in the past, have been employed in laboratories or other endeavors and are now ready to reenter the market, but not necessarily on a full-time basis.

We have a number of them at the present time, approximately 50 throughout the Atomic Energy Commission. These are primarily in the technical field. Some are in the legal field.

They work on a part-time basis with the Atomic Energy Commission.

Mr. ABBADESSA. You recognize that this is a Government-wide program, and not unique to the AEC.

PAY ABOVE STATED ANNUAL GRADE

Mr. ROBISON. Reference is made to the category of pay above stated annual grade.

What is that?

Mr. BOSTOCK. That is 1 extra day.

Mr. ROBISON. Because of this being leap year?

Mr. CORSO. This will vary from year to year. Some years the change represents a plus figure and some years a minus. The year does not always divide precisely into 26 pay periods.

These dollars are reflected on a cost basis. Some years you have to put 1 to 2 extra days' pay in, and in other years you have a 260-day year.

Mr. ROBISON. You did not have any last year. This year you ask $292,000 for this for some reason.

Mr. ABBADESSA. It was the one year in five that it came out even, if I remember correctly.

Mr. CORSO. That is right. Last year it worked out right for the first time in several years.

ADDITIONAL EMPLOYEES TO ELIMINATE PROGRAMS AND PROJECTS OF MARGINAL UTILITY

Mr. ROBISON. On page PDA–5, in partial justification for hiring an additional 20 people to work in the reactor development and technology program, one of the things some of them will do, you say, is to help "eliminate programs and projects of marginal utility and redirect and reorient their associated resources including facilities in support of priority progams."

I am all for that.

Mr. VINCIGUERRA. You heard Mr. Shaw testify yesterday and I am sure he gave you examples of the types of things done. This includes the EBR and Piqua. He has made a major effort to reduce the number of technologies to be supported in order to be better able to fund the essential work he wants to do.

Mr. ROBISON. It seems curious that you have to hire additional people just to eliminate programs of lesser priorities.

Mr. ABBADESSA. The purpose of this listing is not to indicate that we hire a person to do only one or two of these things, such as kill programs. This is an indication of the types of work these professional people can do.

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Mr. ROBISON. On page PDA–7 there is a reference for the first time to an organization called the Federal Council for Science and Technology which apparently prepares Government-wide informational reports. What is this organization?

Mr. ABBADESSA. This is coordinated by the Office of Science and Technology, Dr. Hornig's office, who is the Presidential Scientific Adviser.

This group is trying to establish standards to provide for a Government-wide information system on scientific efforts.

There is already quite a bit of work done regarding scientific results that are published and distributed. This effort is in two sections.

One section is to try to report research which is in progress, so people will know of the work in an effort to try to avoid duplication.

It is an effort to better communicate information of what is happening in the scientific area and to take full advantage of it.

Dr. TAPE. This morning we talked about the ability to know what the government as a whole is doing in certain areas, so the Federal Council on Science and Technology which covers all the agencies involved in science and technology, has agreed to move into the information area of trying to coordinate and collect information on projects, and grants by universities, by geographical location, by subject matter, and so on. This is done under the aegis of the Council.

UTILIZATION OF MANPOWER

Mr. ROBISON. On page PDA–8 there is a reference to your efforts to improve utilization of your manpower.

Don't take time now, but whoever wants to answer this for the record please tell me what you are doing along these lines, especially what you are doing now that you were not doing before.

Mr. VINCIGUERRA. All right.

(Information requested follows:)

MANPOWER UTILIZATION PROGRAM

AEC's continuing manpower utilization program consists of the following major efforts:

1. A long-range effort to minimize manpower requirements, including the critical examination of agency policies, procedural requirements, practices, and programs which affect workloads;
2. A program of studies of organization and manpower utilization in the organizational components of AEC;
3. Analysis and critical evaluation of current and estimated staffing requirements in the preparation and internal review of the AEC budget;
4. Continuous control of positions and employment within authorized complements and yearend employment ceilings; and
5. Appraisal and evaluation of field office manpower utilization activities.

In all the above, major emphasis is placed on identification of programs and activities where adjustments may be made in staffing requirements to redeploy positions from areas of declining activity or lower priority to areas where more critical needs exist. The principal elements of the manpower utilization program are described briefly as follows:

1. Review of each position becoming vacant or before reevaluation to determine whether duties can be eliminated, assigned to other positions, or modified to permit performance at a lower grade.

2. Proposed organizational changes are reviewed from the standpoint of work design, occupational and grade distribution, manpower requirements and costs. Proposed organization changes at certain levels require prior approval.

3. Functional analyses of staffing are conducted through a functional inventory of AEC staffing which reflects man-years in various functions of the AEC. Analyses within selected functions are conducted AEC-wide and in various offices or divisions. Analyses also include trends in the distribution of staff time in relation to changes in programs, changes in management concepts, and changes in comparison to workloads.

4. Long-range forecasts of staffing requirements are prepared annually by field offices and AEC divisions. The forecasts are in relation to known or expected changes in workload and are utilized in analysis of staffing requirements and preparation of budget estimates.

5. Employment projections are reported by field offices and headquarters divisions for the next 6 months of the fiscal year. Projections are reviewed in relation to authorized ceilings and employment levels to ascertain possibilities for effecting manpower economies, utilizing vacant positions, and to foster realistic planning of staffing requirements and recruitment.

6. Organization and management studies are conducted on a continuous basis for the staffing review committee by the organization and management staff of the Division of Personnel. Headquarters study teams are frequently supplemented by members from field offices. The objectives of the studies are to examine workloads, staffing, organization, and functions to identify areas of immediate

and potential position savings; to identify possibilities for redeployment of positions from programs and activities which are declining or which are of relatively lower priorities; and to otherwise obtain improvements in the utilization of manpower.

In the past 4 years, changes in management concepts for reactor programs, growth of regulatory workloads, expansion of test facilities, development of a management information system, growth in other research and development, a variety of special management requirements and other program changes resulted in the need for almost 600 additional positions over the 4-year period.

The needs were revealed at early stages through the process for internal review of staffing requirements. In planning to meet these needs, particular attention has been focused on the continuing program of manpower studies. During the period fiscal years 1963–67, studies were conducted of all major field offices and various headquarters organizations with intensified efforts to achieve manpower savings and redeploy positions to meet higher priority needs. As a result of the studies and other manpower utilization activities, almost half of the additional 600 positions were supplied from within thus avoiding the necessity for further increases in the agency employment level.

7. The Internal Review Process is a formalized system under the direction of staffing review committee for determination of staffing requirements, issuance of staffing authorizations, and control of positions. The staffing review committee is chaired by the Assistant General Manager for Administration and includes the Controller and the Assistant General Managers for Operations, Reactors, and Research and Development. The process is coordinated with the preparation and execution of the personal services budget and involves the following distinct operations:

(*a*) Evaluation of staffing requirements at the branch chief or equivalent level as operating plans are formalized;

(*b*) Evaluation by managers of field offices and heads of headquarters divisions;

(*c*) Submission by headquarters divisions and field offices of planned requirements for the 3 years encompassed by the budget cycle, providing detailed justification for proposed increases in staffing requirements.

(*d*) Headquarters Review:

(1) The Division of Personnel in a staff capacity to the staffing review committee analyzes submissions, obtains comments and coordinates review by headquarters divisions having line responsibility for a field office and those divisions having responsibility for functions carried out in field offices. This analysis considers comments supplied by the headquarters divisions, results of appraisal reports, results of organization and manpower surveys, and functional analysis. Results of this analysis and proposed staffing plans are presented to the staffing review committee.

(2) The Staffing review committee reviews the proposed plan and requirements together with supporting data, determines relative priorities, allocates the agency staffing authorization to organizations, and establishes estimated agency requirements for approval by the general manager and the Commission and inclusion in the AEC budget. The staffing review committee may call upon division directors or field office managers to personally explain or justify staffing requests and may consult with other divisions to obtain their views on proposed plans and requirements.

YOUTH OPPORTUNITY PROGRAM

Mr. ROBISON. On page PDA–10 you talk about the youth opportunity program, or summer employment of high school students.

Provide an answer for the record on this please, a summary of the number of high school students you have had in 1968 and the number you expect to have in 1969.

(The information requested follows:)

Students employed under the youth opportunity program for program direction and administration are as follows:

Actual employment, June 1967	164
Planned employment:	
June 1968	178
June 1969	178

OVERSEAS PAY DIFFERENTIAL

Mr. ROBISON. Also there is mention made on the same page that there are salary differentials with certain of your employees stationed overseas.

Please provide for the record some sort of summary as to the number of AEC employees overseas, pay differentials, and so on.

(The information follows:)

AEC EMPLOYEES RECEIVING PAY DIFFERENTIALS FOR DUTY AT FOREIGN AND OFF-CONTINENT U.S. POSTS

	Actual fiscal year 1967	Estimated fiscal year 1968	Estimated fiscal year 1969
Argentina	1	2	2
Brazil	0	2	2
Belgium	7	7	7
Canada	4	3	3
England	3	3	3
France	3	3	3
Japan	3	3	3
India	0	0	2
Subtotal	21	23	25
Hawaii	12	13	13
Johnston Atoll	2	2	2
Puerto Rico	6	6	6
Subtotal	20	21	21
Total	41	44	46
Cost of differential	$67,269	$75,000	$80,000

Pay differentials include post allowance, supplementary post allowance, transfer allowance, and education allowance. Differentials for foreign posts are determined and published by the Department of State and differ from post to post depending on cost-of-living differences. Differentials for off-continent U.S. Territories and States are established by the Civil Service Commission. Increased costs for fiscal year 1968 and fiscal year 1969 are due to general salary increase and increased employment.

OFFICIAL ENTERTAINMENT EXPENSES

Mr. ROBISON. Finally on page PDA–20, for the benefit of any Congressman who might be looking for it, I notice there is $30,000 asked for for official entertainment. The same amount has been asked every year.

Mr. MORRIS. I thank the gentleman from New York.

This concludes hearings on the AEC budget.

I have some questions covering the community program and other items that we shall insert in the record and ask that you respond in writing to them.

Community Program

GENERAL STATEMENT

The AEC community program provides for financial assistance payments to the city of Oak Ridge, Tenn., the city of Richland, Wash., the Richland School District, the county of Los Alamos, N. Mex., the Los Alamos County Board of Educational Trustees and the Lutheran Hospital and Homes of America, Inc. resulting from the transfer of the Los Alamos Medical Center. The payments are based on the provisions of the Atomic Energy Community Act of 1955, as amended—P.L. 84–221. In addition to the assistance payments, the community program provides for AEC's overall municipal and supervision costs in completing the termination of Federal Government's ownership and management of the Los Alamos community.

Of the community program total estimate of $6,942,000 for fiscal year 1969, $5,855,000 was allocated for assistance payments; $1,087,000 was for overall municipal administration and supervision of community activities at Los Alamos.

After the authorization hearings, the Joint Committee on Atomic Energy recommended a reduction of $150,000 in the fiscal year 1969 operating costs for the community program.

Mr. Morris. We will insert pages COM–1 through 10 covering the request for the Community Program.

(Pages follow:)

94-075 O-68-pt. 3—43

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

COMMUNITY PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$6,942,000
Estimate FY 1968	6,771,000
Increase	$ 171,000

The Community Program estimates in FY 1969 provide for:

1. Assistance payments to the former AEC cities of Oak Ridge, Tennessee, and Richland, Washington, and the Richland School District in accordance with the Atomic Energy Community Act of 1955 (Public Law 84-221), as amended.

2. Assistance payments at Los Alamos to the Lutheran Hospitals and Homes Society of America, Inc., resulting from the transfer of the Medical Center, effective January 1, 1964; to the Los Alamos County Board of Educational Trustees due to the transfer of the schools effective July 1, 1966; and to the County of Los Alamos resulting from the transfer of most of the municipal functions on July 1, 1967. These payments are authorized under the Atomic Energy Community Act of 1955 (Public Law 84-221), as amended.

3. Overall municipal administration and supervision of the continuing rental program of the housing and concession activities at Los Alamos. Commercial facilities are generally operated by private enterprise through lease or concession agreement.

The estimates for FY 1969 assistance payments are based on Public Law 84-221, as amended, which provides that for a period of ten years from the date of transfer of any municipal installation to a governmental or other entity, AEC shall make annual assistance payments of just and reasonable sums. In determining the amount and recipient of such payments, the statute states that AEC shall consider:

1. The approximate real property taxes and assessments for local improvements which would be paid to the governmental entity upon property within the community if such property were not exempt from taxation by reason of Federal ownership.

2. The maintaining of municipal services at a level which will not impede the recruitment or retention of personnel essential to the atomic energy program.

3. The fiscal problems peculiar to the governmental entity by reason of the construction at the community as a single purpose national defense installation under emergency conditions.

4. The municipal services and other burdens imposed on the governmental or other entities at the community by the United States in its operations in the project area.

The increase in gross operating costs of $171,000 in FY 1969 is due to an increase in assistance payments offset to some degree by the decline in direct AEC costs for operation of Los Alamos due to transfer of most of the municipal functions and the sale of additional houses and apartments. Decreases in revenues resulting from the disposal of the utilities and most of the real estate, both of which are revenue producing facilities are covered under the program "Revenues Applied."

A summary comparison of the community operating costs and revenues and justifications for Los Alamos, Oak Ridge, and Richland are shown on the following pages.

Summary of Community Costs and Revenues by Category

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
	Gross Operating Costs			
COM-4	Operation of Community:			
	Los Alamos:			
	Assistance in Organization and Establishment of Local Government	$ 550,002	0	0
	Other Operations	3,315,981	$1,398,000	$1,087,000
	Total Operations of Community	$3,865,983	$1,398,000	$1,087,000
	Assistance Payments:			
COM-4	Los Alamos	$3,116,084	$2,903,000	$3,241,000
COM-8	Oak Ridge	1,373,160	1,475,000	1,565,000
COM-8	Richland	992,728	995,000	1,049,000
	Total Assistance Payments	$5,481,972	$5,373,000	$5,855,000
	Total Gross Costs	$9,347,955	$6,771,000	$6,942,000
	Revenues (Budgeted under "Revenues Applied")			
COM-4	Los Alamos	$-3,284,693	$-1,167,000	$ -513,000
COM-8	Richland	-3,485	0	0
	Total Revenues	$-3,288,178	$-1,167,000	$ -513,000
	Net Operating Costs			
COM-5	Los Alamos	$3,697,374	$3,134,000	$3,815,000
COM-8	Oak Ridge	1,373,160	1,475,000	1,565,000
COM-8	Richland	989,243	995,000	1,049,000
	Total Net Operating Costs	$6,059,777	$5,604,000	$6,429,000

Summary of Los Alamos Community Estimates

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
1. Gross Costs			
a. Municipal	$1,263,366	$ 478,000	$ 437,000
b. Utilities	1,256,174	0	0
c. Real Estate Operation	796,441	920,000	650,000
d. Assistance in Organization and Establishment of Local Government	550,002	0	0
Subtotal Operating Costs	$3,865,983	$1,398,000	$1,087,000
e. Assistance Payments to Hospital	29,250	31,000	30,000
f. Assistance Payments to Municipalities	0	1,036,000	1,236,000
g. Assistance Payments to Schools	3,086,834	1,836,000	1,975,000
Subtotal Assistance Payments	3,116,084	2,903,000	3,241,000
Total Gross Costs	$6,982,067	$4,301,000	$4,328,000
2. Revenues (Budgeted Under "Revenues Applied")			
a. Other Municipal	$ -293,035	$ -1,000	$ -1,000
b. Utilities	-1,674,048	0	0
c. Real Estate Operation	-1,317,610	-1,166,000	-512,000
Total Revenues	$-3,284,693	$-1,167,000	$ -513,000

Summary of Los Alamos Community Estimates (Continued)

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
3. Net Costs			
a. Municipal	$ 970,331	$ 477,000	$ 436,000
b. Utilities	-417,874	0	0
c. Real Estate Operations	-521,169	-246,000	138,000
d. Assistance in Organization and Establishment of Local Government	550,002	0	0
Subtotal Net Operating Costs	$ 581,290	$ 231,000	$ 574,000
e. Assistance Payments to Hospital	29,250	31,000	30,000
f. Assistance Payments to Municipalities	0	1,036,000	1,236,000
g. Assistance Payments to Schools	3,086,834	1,836,000	1,975,000
Total Net Costs	$3,697,374	$3,134,000	$3,815,000

Justification of Los Alamos Community Operating Expenses

The Los Alamos Community budget estimates reflect the AEC's support of community affairs at Los Alamos, New Mexico.

Beginning in FY 1968, the estimates provide for Assistance Payments to Municipalities based upon transfer of all municipal functions except fire protection to the County on July 1, 1967. Operation of the school system is being funded under Assistance Payments to the Los Alamos County Board of Educational Trustees following the transfer of the school plant and equipment on July 1, 1966.

Detailed justifications for FY 1969 by category follow:

1. Municipal ..... $ 437,000
   The estimate for FY 1969 is to cover overall community administration, fire protection and supervision of miscellaneous caretaker duties for which AEC will continue to have responsibility. The remaining municipal functions will be funded under assistance payments.

2. Utilities 0
   At the beginning of FY 1968, the town distribution systems for water, gas, and electricity were transferred to the County. The Mountain States Telephone and Telegraph Company acquired the telephone system for the townsite, July 1, 1967.

3. Real Estate Operation $650,000
   The estimate for FY 1969 is to cover routine maintenance on housing units retained as rental property and on those units remaining which have not been sold. The Real Estate category shows a continuing reduction in both cost and revenue due to the impact of disposal. Estimates are based on the sale in FY 1968 of all single family units which were offered. The apartment sales, which were scheduled to begin in November 1966 were delayed due to reconsideration of the legislation concerning cooperatives. A revised system of priorities applicable to the sale of apartment houses became law on December 14, 1967. Of the 1,108 apartment units classified for sale it is now estimated that none will be sold in FY 1968; 75% will be sold in FY 1969 and the balance in FY 1970. Sale of commercial property is expected to be about 70% complete at the end of FY 1968 and about 95% complete by the end of FY 1969.

COMMUNITY PROGRAM - continued

4. Assistance Payments to Hospital $30,000
The Lutheran Hospitals and Homes Society of America, Inc., assumed ownership, operation and maintenance of the Los Alamos Medical Center on January 1, 1964. Small support levels continue to be budgeted for this activity, although it is expected that this facility will eventually become self-supporting.

5. Assistance Payments to Municipalities $1,236,000
All municipal functions have been transferred to the County with the exception of fire protection which through FY 1969 will continue as an AEC activity. Support payments for municipal services are estimated at a level of services consistent with the level which was established during government operation.

6. Assistance Payments to Schools $1,975,000
On July 1, 1966, school plant and equipment was transferred to the Los Alamos County Board of Educational Trustees. Effective with that date, supplemental support from the AEC is in the form of assistance payments. The FY 1967 amount for support payments includes funds for construction. Operating costs increase in FY 1969 for additional teachers, maintenance personnel, and miscellaneous items, due to increased enrollment and the additional facilities being put into operation.

Summary of Estimates

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Oak Ridge			
Assistance Payments to the City	$1,373,160	$1,475,000	$1,565,000
Richland			
Assistance Payments to the City	335,123	275,000	300,000
Assistance Payments to the Schools	657,605	720,000	749,000
Total Assistance Payments	992,728	995,000	1,049,000
Revenues from Operations (Budgeted under Revenues Applied)	-3,485	0	0
Total Net - Richland	$ 989,243	$ 995,000	$ 1,049,000

The estimated FY 1969 assistance payments to the cities of Oak Ridge and Richland provide for continuation of essentially the current level of services. Original authority for assistance payments under P.L.84-221 expires as follows:

Oak Ridge :	June 26, 1969
Richland Schools:	December 15, 1968
City of Richland:	June 1, 1969

P.L. 90-190 providing for the extension of assistance authority beyond the above dates was signed on December 14, 1967.

COMMUNITY PROGRAM - continued

Oak Ridge

Assistance payments will continue to be made in accordance with the financial assistance agreement executed February 18, 1964, which establishes a base payment of $1,252,000 plus or minus the per cent the tax rate varies from the 1964 rate of $1.24 per hundred dollars of assessed value. The FY 1968 payment is based on the approved tax rate of $1.46 per $100 of assessed property value. Estimates for FY 1969 assume this rate will have to be increased to $1.55 to allow for funding the projected cost level.

Richland

Assistance payments to the City are expected to remain relatively stable in FY's 1968 and 1969. Assistance payments to the schools will continue to be based on P.L. 81-874. Slight increases are expected as the base entitlement on which the formula is calculated continues to rise approximately $10 per pupil per year.

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

COMMUNITY - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$ 3,000
A Construction Projects	
A-1 Obligations for new projects	($ -0-)
A-2 Obligations for prior year projects	($ -0-)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 3,000)
B-2 Obligations from prior year appropriations	($ -0-)
Estimated Obligations FY 1968	$ 5,000
Actual Obligations FY 1967	$1,031,608

Obligations for the Community Program for FY 1969 are estimated at $3,000, of which:

a. $3,000 is for Capital Equipment Not Related to Construction justified in Section B-1 below, requested for authorization in the proposed FY 1969 Authorization Act.

SECTION B-1

Activity	Estimated Obligations FY 1969
Capital Equipment not Related to Construction	$ 3,000

JUSTIFICATION

The FY 1969 estimate of $3,000 will provide for necessary replacements of stoves and refrigerators due to the delay in sale of Government-owned apartment buildings at Los Alamos, New Mexico.

ALLOCATION OF JOINT COMMITTEE REDUCTION

Mr. MORRIS. The joint committee, in the authorization bill, has disallowed $150,000 of the budgeted increase of $171,000 in fiscal year 1969.

How will this reduction be allocated?

(Information requested follows:)

The $150,000 reduction in the authorization bill is planned tentatively to be taken as follows:

[In thousands of dollars]

Activity	Previous estimate	Change	Reduced estimate
Los Alamos:			
Municipal	437	−27	410
Real estate	650	−18	632
Assistance payment:			
Hospital	30	−5	25
Municipalities	1,236	0	1,236
Schools	1,975	−50	1,925
Subtotal, assistance payments	3,241	−55	3,186
Total, Los Alamos	4,328	−100	4,228
Oak Ridge	1,565	0	1,565
Richland:			
City	300	−50	250
Schools	749	0	749
Subtotal, Richland	1,049	−50	999
Total community	6,942	−150	6,792

The JCAE in the authorization bill stated its belief that a portion of the reduction could be absorbed in "Assistance payments to municipalities" category of the Los Alamos budget. However, a recent review of the Los Alamos municipal budget indicates an upward trend in municipal costs. Therefore, it was decided to hold the assistance payments at $1,236,000 and seek other sources for the $150,000 reduction.

ASSISTANCE TO SCHOOLS AT LOS ALAMOS

Mr. MORRIS. In reference to the Los Alamos community as indicated on pages 4 and 5, why is it that assistance payments to schools is required in the amount of $1,975,000, an increase of $139,000 over 1968?

(Information requested follows:)

The increase of $139,000 in the assistance payments for fiscal year 1969 was considered necessary because of—

A. Length of service salary increases for administrative personnel.

B. Upward adjustment of hiring salary schedule for new teachers and salary increases for returning teachers to retain personnel and remain in competitive hiring position with school systems having a similar educational program.

C. Filling of the positions of secondary curriculum director and remedial reading teacher which remained unfilled during previous year since personnel could not be recruited.

D. Increased costs of supplies and materials as well as maintenance cost increases due to increased age of physical plant.

E. Cost of operating library central processing center and nonbook materials required as a result of completion of learning materials center during the last quarter of the current school year.

However, a current review of the school budget indicates a slight reduction in school enrollment as compared to projections made when the budget was first drafted. Therefore, as I indicated previously we are likely to reduce the proposed increase of $139,000 in the fiscal year 1969 school assistance payments by $50,000.

LOCAL CONTRIBUTION TO SCHOOL SYSTEM

Mr. MORRIS. What is the locality now contributing to the support of the educational system?

(Information requested follows:)

The total local revenues of $2,347,000 include $290,900 from local county taxes and use of facilities, and $2,056,100 from the State.

ASSISTANCE PAYMENTS TO OAK RIDGE

Mr. MORRIS. What is the basis for the estimate of $1,565,000 for assistance payments to the city of Oak Ridge?

(Information requested follows:)

The financial assistance to this community is based on an agreement between the AEC and the city. The agreement establishes a base payment of $1,252,000 plus or minus the percent the current Oak Ridge tax rate varies from the 1964 tax rate of $1.24 per hundred dollars of assessed value. The current tax rate of the city of Oak Ridge is $1.46, and we have assumed an increase in the tax rate to $1.55 as being necessary to finance the fiscal year 1969 projected cost level for the community.

REMAINING ITEMS

Mr. MORRIS. We will insert the balance of the justifications covering remaining items.

(Pages referred to follow:)

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

SECURITY INVESTIGATIONS PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$6,588,000
Estimate FY 1968	$6,795,000
	$ 207,000

This program covers cost of security investigations of individuals requiring security clearance or access authorization under the provisions of the Atomic Energy Act of 1954, as amended. Cost of investigations of individuals for whom access authorizations are required under the Access Permit Program is not included. This is budgeted under "Cost of Work for Others."

The Atomic Energy Act of 1954, as amended, provides that no individual shall be permitted access to Restricted Data until the U. S. Civil Service Commission, another Federal agency which conducts personnel investigations, or, under certain conditions, the Federal Bureau of Investigation shall have made an investigation and report to the AEC on the character, associations and loyalty of the person concerned; and the AEC shall have determined that permitting such individual access to Restricted Data will not endanger the common defense and security. Published policies and procedures provide guidance in determining eligibility and need for AEC security clearance or access authorization.

Pursuant to the provisions of Section 145(f) of the Atomic Energy Act of 1954, as amended, distribution of total investigative caseload between CSC and FBI is based on Commission-approved criteria. Requests for investigation of persons who are to occupy positions of a "high degree of importance or sensitivity" are referred to the FBI, all others to the CSC.

The Commission-approved program for selective reinvestigation of previously cleared personnel continues in order to assure that the AEC program is protected from individuals whose clearance eligibility may have changed since the time of the last clearance action in their cases.

Clearance needs of AEC contractors account for about 79% of the 16,897 "Q"-type investigations budgeted for FY 1969. Clearances of AEC personnel represent 8% of the total requirement; reinvestigations of persons previously cleared, 5%; and clearance of others, including suppliers and employees of other Government agencies, 8%.

The following table shows the estimated number of cases to be referred to the investigating agencies. Costs are expressed in terms of the number of cases multiplied by the unit cost per investigation. Unit costs are those furnished by the investigating agencies. The unit cost of FBI investigations increased from $445 to $475 on October 8, 1967 and to $490 on December 17, 1967 due to the Federal Salary Act of 1967 (PL 90-206). The unit cost of CSC investigations was $415 during FY 1967. As a result of an analytical study, the scope of the CSC investigative coverage is being reduced for a trial period of six months during FY 1968, at the end of which an assessment will be made on its impact on costs and quality. CSC advised that it could not determine the actual savings without experience but estimated a reduction of $50 per case. On the assumption that unit costs will be reduced $50, a unit cost of $365 is being reflected in this budget for one half of the 13,882 cases for FY 1968 or 6,941 cases, and $415 for the other half or an average of $390 for the year. On the assumption that the reduced scope of investigative coverage will be continued, a unit cost of $365 has been used for FY 1969. The unit cost of National Agency Checks was $7.30 during FY 1967 and CSC projects a decrease to $6.15 for FY 1968 and FY 1969.

Item	Actual FY 1967	Estimated FY 1968	Estimated FY 1969
1. Cost of Investigations:			
"Q" Clearances:			
Number referred to Federal Bureau of Investigation	2,725	2,753	2,811
Cost per investigation	$444.87*	$476*	$490
Total cost, FBI	$1,212,280	$1,310,000	$1,377,390
Number referred to Civil Service Commission	11,961	13,882	14,086
Cost per investigation	$415	$390*	$365
Total cost, CSC	$4,963,815	$5,413,980	$5,141,390
Total cost of "Q" Clearances	$6,176,095	$6,723,980	$6,518,780
"L" Clearances			
Number referred to Civil Service Commission	10,136	11,548	11,255
Cost of National Agency Checks	$7.30	$6.15	$6.15
Total cost of "L" Clearances	$ 73,993	$ 71,020	$ 69,220
2. Total Security Investigations Program	$6,250,088	$6,795,000	$6,588,000

*Average cost

JUSTIFICATION OF ESTIMATES

The estimated number of cases to be referred for full field investigation (item 1 of the preceding table) is summarized below.

Category	Full Field Investigations ("Q" Clearances) Actual FY 1967	Estimated FY 1968	Estimated FY 1969
AEC.....	1,125	1,203	1,286
CONTRACTOR (Construction)...	354	1,282	806
(Operating).....	11,147	11,915	12,516
ALL OTHERS.....	1,218	1,385	1,439
REINVESTIGATIONS.....	842	850	850
TOTAL.....	14,686	16,635	16,897

OTHER COSTS

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

COST OF WORK FOR OTHERS PROGRAM - OPERATING COSTS

PROGRAM STATEMENT

Estimate FY 1969	$ 14,533,000
Estimate FY 1968	11,219,000
Increase	$ 3,314,000

Under the program "Cost of Work for Others" the Commission budgets for certain costs incurred in: (1) the manufacture of materials, which it sells to eligible purchasers; and (2) rendering laboratory, research, and other services to industrial and research organizations. Reimbursements received by the Commission for the costs incurred in manufacturing products and rendering services are applied to reduce the Commission's fund requirements. These reimbursements constitute an offset against "Cost of Work for Others" and are shown under the program "Revenues Applied." The increase of $3.3 million is principally related to increased sales of heavy water and the resultant increase in costs related to these sales.

94-075 O-68-pt. 3—44

COST OF WORK FOR OTHERS PROGRAM - continued

Summary of Estimates by Category

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
CWO-3	1. Cost of Products			
	a. Special Reactor Materials Sold	$ 12,898,629	$ 2,100,000	$ 6,700,000
	b. Isotopes			
	(1) Fission Products	2,831,365	1,713,000	1,400,000
	(2) Other Isotopes	2,188,348	2,526,000	2,383,000
	c. Other Products Sold	4,079,912	2,300,000	1,600,000
	Total Cost of Products Sold	21,998,254	8,639,000	12,083,000
CWO-4	2. Cost of Services			
	a. Use of AEC-Owned Facilities and Equipment, and Irradiation Services	524,378	900,000	800,000
	b. Withdrawals, Analyses and Fabrication	246,249	300,000	300,000
	c. Other Services	1,615,891	1,323,000	1,306,000
	Total Cost of Services	2,386,518	2,523,000	2,406,000
CWO-4	3. Cost of Security Investigations	63,618	57,000	44,000
	Total Cost of Work for Others	$ 24,448,390	$ 11,219,000	$ 14,533,000

Comparison of Cost of Work for Others with Related Revenues

Total Cost of Work for Others	$ 24,448,390	$ 11,219,000	$ 14,533,000
Related Revenue Included under "Revenues Applied",	31,408,779	13,140,000	19,365,000
Excess of Revenues over Related Costs	$ 6,960,389	$ 1,921,000	$ 4,832,000

JUSTIFICATION OF CATEGORIES

1. Cost of Products Sold $12,083,000

a. Special Reactor Materials Sold - FY 1967: $12,898,629 - FY 1968: $2,100,000 - FY 1969: $6,700,000

This estimate includes costs of sales of 220 tons of heavy water and a minor amount for sales of other products in FY 1969. Sales of heavy water in FY 1967 totaled 421 tons and FY 1968 sales are estimated at 65 tons. Related revenue of $10,930,000 in FY 1969 is included under the budget program "Revenues Applied."

b. Isotopes

(1) Fission Products - FY 1967: $2,831,365 - FY 1968: $1,713,000 - FY 1969: $1,400,000

This estimate includes the costs associated with the sale of strontium-90, cesium-137, and promethium-147. Sales are projected at Commission approved catalog prices which are estimated to produce revenues of $150,000 in FY 1969 and are included under the budget program "Revenues Applied."

(2) Other Isotopes - FY 1967: $2,188,348 - FY 1968: $2,526,000 - FY 1969: $2,383,000

This estimate includes the cost of isotopes sold, exclusive of the above fission products, to research laboratories, industry, educational institutions and foreign countries. The estimates are based on current sales projections. Related revenue in the amount of $3,030,000 in FY 1969 is included under the budget program "Revenues Applied."

c. Other Products Sold - FY 1967: $4,079,912 - FY 1968: $2,300,000 - FY 1969: $1,600,000

This estimate includes costs of miscellaneous products sold, principally to the United Kingdom under Mutual Defense, and reflects projected sales under present agreements. Related revenue of $2,350,000 in FY 1969 is included under the budget program "Revenues Applied."

COST OF WORK FOR OTHERS PROGRAM - continued

2. Cost of Services ..... FY 1967: $2,386,518 - FY 1968: $2,523,000 - FY 1969: $2,406,000

This estimate includes costs related to the use of AEC-owned facilities and equipment, irradiation services, withdrawals, analyses, fabrication, and other associated activities in the field of atomic energy. Revenue from Services Performed in the amount of $2,805,000 in FY 1969 is included under the budget program "Revenues Applied."

3. Cost of Security Investigations ... FY 1967: $63,618 - FY 1968: $57,000 - FY 1969: $44,000

This estimate includes costs of investigations relative to the granting of access authorization under the Access Permit Program. As a means of encouraging American industry to participate more fully in the atomic energy program, the Commission initiated a program for release of selected classified non-military information, after obtaining the necessary security clearance (access authorization), to applicants who can demonstrate the need for this information in their business or profession. It is estimated that 160 limited security clearances and 112 full field investigations will be undertaken in FY 1969 at a total cost of $44,000 from which the Commission will derive $100,000 in revenues. These revenues have been included under the budget program "Revenues Applied."

Comparison of Cost of Work for Others with Related Revenues

The estimated total revenue related to the sale of products and services included under the budget program "Revenues Applied" is $19.3 million as compared to costs of the related products and services of $14.5 million reflecting an excess of revenue over costs of $4.8 million on the products and services included in the program "Cost of Work for Others."

SELECTED RESOURCES

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

INCREASE OR DECREASE IN SELECTED RESOURCES

PROGRAM STATEMENT

Estimate FY 1969	$957,501,954
Estimate FY 1968	901,822,954
Increase	$ 55,679,000

This program "Increase or Decrease in Selected Resources" presents the net increase or decrease in levels of resources required to support the programs of the Commission. This program includes requirements for Inventories, Collateral Funds and Other Deposits, and Goods and Services on Order. The category Goods and Services on Order includes contracts for materials and services to be delivered after FY 1969 and financing of contractors in accordance with Commission policy beyond the end of the fiscal year to insure continuity of operations. The contractor requirements included in the estimate provide for three months of forward financing. The levels of selected resources are assets that may be applied to program costs of future years operations.

The increase of $55,679,000 for FY 1969 consists of an increase of $460,000 in inventory levels and an increase of $55,219,000 in the level of goods and services on order.

The net increase in inventories of $460,000 consists of:

1. A net increase of $1,500,000 in stores inventory is related to a net increase of $1,700,000 for process spares which is partially offset by a net decrease in other stores in the amount of $200,000.

2. A net decrease of $700,000 in special reactor materials inventory principally results from decreases in heavy water and zirconium being partially offset by an increase for boron-10.

3. A decrease in other special materials inventory of $480,000 principally related to usage from inventory of barrier materials and platinum.

4. An increase of $140,000 for isotopes inventory principally for carbon-13, helium-3, oxygen-17, and 18 related to projected future sales and program requirements.

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

The net increase in the level of goods and services on order is principally related to increases in program cost levels which are partially offset by decreases in uncosted balances for the Cooperative Power Reactor Demonstration Program.

SUMMARY OF ESTIMATES BY CATEGORY

Page No.	Balances at end of Year	Actual FY 1967	Estimate FY 1968	Estimate FY 1969	Increase or Decrease (-)
	1. Inventories:				
SelR-3	a. Stores	$ 89,795,959	$ 90,042,000	$ 91,542,000	$ 1,500,000
SelR-3	b. Special Reactor Materials	67,322,653	71,721,000	71,021,000	-700,000
SelR-3	c. Other Special Materials	14,298,605	13,690,000	13,210,000	-480,000
SelR-4	d. Isotopes	16,905,341	17,279,000	17,419,000	140,000
	Total Inventories	188,322,558	192,732,000	193,192,000	460,000
SelR-4	2. Collateral Funds and Other Deposits	12,978,743	12,979,000	12,979,000	0
SelR-6	3. Goods and Services on Order	692,960,421	696,111,954	751,330,954	55,219,000
	Total Unapplied Resources at End of Year	$894,261,722	$901,822,954	$957,501,954	$ 55,679,000
	Increase or Decrease in Selected Resources	$ 3,231,100	$ 7,561,232	$ 55,679,000	

JUSTIFICATION OF CATEGORIES

1. Inventories:

a. Stores Inventory ..... Increase $ 1,500,000

Stores inventories are supplies, materials, and parts normally used or consumed in the production of source and special nuclear materials; in the maintenance of production plants, buildings, and other facilities; or in the operation of laboratories and experimental projects, communities and administrative activities. Stores exclude source and special nuclear materials, weapons components, special reactor materials, and other special materials.

The net increase of $1.5 million is comprised of an increase of $1.7 million for process spares and a decrease of $0.2 million in other stores. The following changes are included in the net increase for process spares: increase for naval reactor developmental cores at Schenectady, $1.2 million; increase for the Zero Gradient Synchrotron at Argonne National Laboratory, $0.9 million; increase for the Alternating Gradient Synchrotron at Brookhaven National Laboratory, $0.2 million; and a decrease in process spares for the gaseous diffusion plants, $0.6 million. The decrease of $0.2 million in other stores is the result of increases and decreases at several offices.

b. Special Reactor Materials Inventory ..... Decrease $ -700,000

This inventory consists of selected materials used in the construction and operation of reactors for production and research purposes.

The decrease is principally related to an increase in boron-10 and reductions in heavy water and zirconium.

c. Other Special Materials Inventory ..... Decrease $ -480,000

Other Special Materials Inventory is made up of the following items, requiring special accounting controls: Radium, Gold, Silver, Platinum, Rhodium, Palladium, Iridium, Osmium, Gallium, Americium-241, and Barrier Items.

The decrease is primarily related to program usage of barrier materials and platinum.

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

d. Isotopes ..... Increase $ 140,000

The increase in the inventory levels of isotopes is indicated below:

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969	Increase
Stable Isotopes	$ 1,107,733	$ 1,233,000	$ 1,398,000	$ 165,000
Radioisotopes	15,797,608	16,046,000	16,021,000	-25,000
Total Inventory ...	$16,905,341	$17,279,000	$17,419,000	$ 140,000

The increase of $165,000 in stable isotopes is principally related to an increase for carbon-13, helium-3, oxygen-17 and 18 based on projected future sales. The decrease of $25,000 for radioisotopes is related principally to sales of strontium-90.

2. Collateral Funds and Other Deposits ..... Increase $ 0

No change is planned in FY 1969 for collateral funds and other deposits. The FY 1969 year-end balance includes $11,750,000 for collateral funds consisting of insurance collateral funds, employee benefit and annuity funds; and $1,229,000 in other deposits required by vendors on containers and other deposits of a miscellaneous nature. The collateral funds were established under contracts originally entered into by the War Department, and were designed to provide for various extraordinary contingencies in the activities of cost-type contractors. For the most part, collateral funds are held by trustees and invested in U. S. Government Securities.

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

	Year-End Balances		
	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Collateral Funds and Other Deposits:			
Collateral Funds by Office and Contract			
Schenectady, New York			
General Electric Insurance Fund-Travelers Insurance Company	$ 5,250,000	$ 5,250,000	$ 5,250,000
Chicago, Illinois			
University of Chicago Employees Benefit Fund	500,000	500,000	500,000
Washington, D. C.			
University of California, Los Alamos and University of Chicago Insurance Fund-Royal and Globe Company	6,000,000	6,000,000	6,000,000
Total Collateral Funds	11,750,000	11,750,000	11,750,000
Other Deposits	1,228,743	1,229,000	1,229,000
Total Collateral Funds and Other Deposits	$12,978,743	$12,979,000	$12,979,000

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

3. Goods and Services on Order ..... Increase $55,219,000

Estimates for Fiscal Year 1969 are based on Commission policy of three months' forward-financing for cost reimbursement type contractors and funding of commitment levels at the end of the contract period to insure continuity of operations. The funding requirements are related to the cost levels presented under program costs. A summary table of requirements by category is included on the following page.

Summary of Requirements for Goods and Services on Order by Category

Category	Year-End Balance (In Thousands) Actual FY 1967	Estimate FY 1968	Estimate FY 1969	Increase or Decrease (-) in FY 1969
A. Major Long-Term Reimbursement Contracts - Over $1.0 million annual operating level:				
(1) Contractors with principal effort in production of source and special nuclear materials	$ 74,796	$ 77,478	$ 80,674	$ 3,196
(2) Contractors with principal effort in production of weapons and weapon components	66,708	56,834	61,198	4,364
(3) Contractors with principal effort in research and development	382,811	382,551	410,044	27,493
(4) Contractors with principal effort in supporting services	41,268	52,441	73,763	21,322
Total	$ 565,583	$ 569,304	$ 625,679	$ 56,375
B. Major Material Procurement Contracts	5,714	3,442	22,825	19,383
C. Research and Development - Other than those contractors included under Item A. (3)	54,304	55,631	56,358	727
D. Cooperative Power Reactor Demonstration Program ...	45,354	41,253	22,007	-19,246
E. Utilities	723	459	197	-262
F. All Other	21,282	26,023	24,265	-1,758
Grand Total, Goods and Services on Order	$ 692,960	$ 696,112	$ 751,331	$ 55,219

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

Explanation of the increases and decreases in the balances of goods and services on order follows:

A. Major Long-Term Reimbursement Contracts - Over $1.0 million annual operating level:

The estimates provide forward-financing of three months in addition to financing the level of outstanding commitments at the end of this period. Increases or decreases by category of contracts are listed below.

		(In Thousands)
(1) Contractors with principal effort in production of source and special nuclear materials	Increase	$ 3,196
This increase results from a net increase in the funding levels for the several contractors involved for the processing and production of materials to meet AEC requirements and an increase in the level of effort for the weapons program.		
(2) Contractors with principal effort in production of weapons and weapon components	Increase	4,364
This increase is related to production of weapons to meet military requirements		
(3) Contractors with principal effort in research and development	Increase	27,493
This increase is principally related to increases in funding levels for several contractors involved in research and development activities and includes an increase of $10.9 million for commitments for the LWBR Core.		
(4) Contractors with principal effort in supporting services	Increase	21,322
This increase is primarily related to an increased level of effort for the weapons test program.		
Total Major-Long Term Reimbursement Contracts	Increase	$ 56,375

		(In Thousands)
B. Major Material Procurement Contracts	Increase	$ 19,383

This increase is principally for the procurement of developmental naval reactor cores.

C. Research and Development - Other than those contractors included under Item A(3)	Increase	727

The net increase of $0.7 million under this category is principally related to the funding of the following research and development contracts:

		In Millions
Contracts for development of space electric power sources:		
Thermionic Space Generator	Increase	$ 1.5
250-watt generator	Increase	1.5
Thermionic reactor	Increase	0.8
Compact converter	Increase	3.3
Net of other contracts	Increase	0.7
Total space electric power sources	Increase	$ 7.8
Contracts for development of terrestrial electric power sources:		
SNAP-23 SR-90 25/100 and 60 watt systems	Decrease	$ -0.6
Pu-238 Milliwatt generators	Decrease	-1.0
SNAP-21 SR-90 Deep Sea Generator	Decrease	-0.9
Net of other contracts	Decrease	-0.2
Total terrestrial power sources	Decrease	$ -2.7
Contracts for Euratom and other programs:		
Euratom program	Decrease	$ -2.5
Net of other research and development contracts	Decrease	-1.9
Total Euratom and Other contracts	Decrease	$ -4.4
Total Research and Development Category	Increase	$ 0.7

		(In Thousands)
D. Cooperative Power Reactor Demonstration Program	Decrease	$ -19,246

The following table reflects the level of uncosted balances at the end of the fiscal year under various contracts in the cooperative power reactor demonstration program for the advancement of civilian nuclear power:

CIVILIAN POWER REACTORS	Year-End Balances (In Thousands) Actual FY 1967	Estimate FY 1968	Estimate FY 1969	Increase or Decrease (-) in FY 1969
Consumers Public Power District	$ 1,840	$ 2,268	$ 1,000	$ -1,268
Elk River - Rural Coop. Power Assoc.	1,674	2,304	1,061	-1,243
City of Piqua, Ohio	476	620	4,970	4,350
Northern States Power Company	229	0	0	0
Carolinas-Virginia Nuclear Power Associates, Inc..	647	0	0	0
East Central and Florida West-coast Nuclear Group	20	0	0	0
Consumers of Michigan	264	0	0	0
LaCrosse Boiling Water (Dairyland)	2,405	824	989	165
Advanced High Temperature Reactor (Philadelphia Electric Co.)	706	456	206	-250
City of Los Angeles	6,007	5,807	3,807	-2,000
Southern California Edison	223	175	175	0
Public Service Co. of Colorado	30,863	16,055	3,055	-13,000
Metropolitan Water District	0	12,744	6,744	-6,000
Total Cooperative Power Reactor Demonstration Program	$45,354	$41,253	$22,007	$-19,246

INCREASE OR DECREASE IN SELECTED RESOURCES - continued

		(In Thousands)
E. Utilities	Decrease	$ -262
This decrease represents a reduction in the cancellation liability under the contract with the East Tennessee Natural Gas Company for the supply of gas at Oak Ridge, Tennessee.		
F. All Other	Decrease	-1,758
This decrease represents the net change resulting from adjustments in the levels of AEC obligations for miscellaneous contracts at several offices.		
Grand Total, Goods and Services on Order	Increase	$ 55,219

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Operating Expenses

REVENUES APPLIED PROGRAM

PROGRAM STATEMENT

Estimate FY 1969	$99,116,000
Estimate FY 1968	66,464,000
Increase	$32,652,000

The program "Revenues Applied" includes income from: (1) the sale and lease of products, materials, and services to eligible purchasers; and (2) revenue from community operations, hospitals, schools, and courses, collateral funds, and other miscellaneous sources. The program estimates are presented in four categories on the following pages. The first three categories consist of items for which the related costs are included under the program "Cost of Work for Others," while the fourth category consists of items for which the costs are reflected under the related program costs, and other income of a miscellaneous nature.

"Revenue from Sale of Products and Services" includes income from the sale of special reactor materials, isotopes, and other products as well as income from the use of AEC-owned facilities and equipment, irradiation services, services for withdrawals, analyses and fabrication of materials, other miscellaneous services and income from security investigations. Commission policy provides for full cost recovery for products, materials, and services, with the exception of use charge waivers under the Cooperative Power Reactor Demonstration Program as authorized by law, and other exceptions approved by the Commission.

The revenues received are applied in the budget to reduce the appropriation requirement of the Commission. The FY 1969 estimate includes an amount of $27.0 million associated with the providing of uranium enrichment services to foreign and domestic customers starting January 1, 1969. The net increase of $32,652,000 from the FY 1968 estimates is principally related to the following:

	(In Thousands)
Net increase in Sales, Enrichment Services, Recovery and Consumption of SS Materials.....	$29,410
Reduction related to one time ad hoc barter sales in FY 1968	-8,300
Increased sales of Special Reactor Materials	7,530
Increased income from lease of materials and interest from Deferred Sales of Materials ..	4,800
Net of Other Changes	-788
Total	$32,652

REVENUES APPLIED PROGRAM - continued

Summary of Estimates by Category

PAGE NO.	Category	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
REV-4	1. Revenue from Sale of Products			
	a. Special Reactor Materials	$20,123,896	$ 3,400,000	$10,930,000
	b. Isotopes			
	(1) Fission Products	175,011	200,000	150,000
	(2) Other Isotopes	2,890,010	3,180,000	3,030,000
	c. Other Products	5,288,880	3,200,000	2,350,000
	Total Revenue from Sale of Products	28,477,797	9,980,000	16,460,000
REV-5	2. Income from Services			
	a. Use of AEC-Owned Facilities and Equipment, and Irradiation Services	829,690	1,050,000	950,000
	b. Withdrawals, Analyses and Fabrication ..	284,886	350,000	350,000
	c. Other Services	1,707,876	1,653,000	1,505,000
	Total Income from Services	2,822,452	3,053,000	2,805,000
REV-5	3. Income from Security Investigations	108,530	107,000	100,000
	Total Revenues Related to Cost of Work for Others	$31,408,779	$13,140,000	$19,365,000

Summary of Estimates by Category - continued

Page No.	Category	Actual FY 1967	Estimate FY 1968	Estimated FY 1969
	4. Other Revenue (Related costs are included when applicable under program costs of current or prior years.)			
REV-6	a. Sale of Source and Special Nuclear Materials	$21,182,286	$12,840,000	$ 8,100,000
REV-6	b. Uranium Enrichment Services	0	0	27,000,000
REV-6	c. Income from Charges for SS Materials Consumed	13,413,948	16,500,000	24,000,000
REV-7	d. Income from Ad hoc Barter of SS Materials	3,028,505	3,300,000	0
REV-7	e. Income from Lease of Materials and Interest from Deferred Sales of Material	7,492,393	8,315,000	13,115,000
REV-8	f. Income from Community Operations	3,288,178	1,167,000	513,000
REV-8	g. Sale of Steam	2,013,665	2,492,000	3,370,000
REV-9	h. Income from Charges for Recovery of SS Material	5,465,357	1,250,000	900,000
REV-10	i. Income from Research Hospitals	558,947	500,000	500,000
REV-10	j. Income from Operation of Schools and Courses	32,345	40,000	52,000
REV-10	k. Sale of Publications and Other Fees	38,465	50,000	23,000
REV-10	l. Income from Collateral Funds	568,667	555,000	565,000
REV-11	m. Net Income from Services - Washington Public Power Supply System	90,155	55,000	40,000
REV-11	n. Income from License Fees	0	300,000	900,000
REV-11	o. Other Miscellaneous Income	8,507,055	960,000	673,000
	Total Other Revenue	65,679,966	53,324,000	79,751,000
	Total Revenues Applied	$97,088,745	$66,464,000	$99,116,000

COMPARISON OF REVENUE FROM SALE OF PRODUCTS AND SERVICES WITH RELATED COSTS UNDER THE PROGRAM "COST OF WORK FOR OTHERS"

Revenue	$31,408,779	$13,140,000	$19,365,000
Related Costs	24,448,390	11,219,000	14,533,000
Excess of Revenues over Related Costs	$ 6,960,389	$ 1,921,000	$ 4,832,000

94-075 O-68-pt. 3—45

JUSTIFICATION OF CATEGORIES

1. Revenue from Sale of Products $16,460,000

a. Sale of Special Reactor Materials - FY 1967: $20,123,896 - FY 1968: $3,400,000 - FY 1969: $10,930,000

This estimate reflects the anticipated sale of 220 tons of heavy water in FY 1969 and minor amounts for sales of other products. FY 1968 sales projections of heavy water are 65 tons and actual sales in FY 1967 totaled 421 tons. The related cost of these materials in FY 1969 is $6,700,000 and is included under the budget program "Cost of Work for Others."

b. Isotopes

(1) Sale of Fission Products - FY 1967: $175,011 - FY 1968: $200,000 - FY 1969: $150,000

This estimate consists of revenue derived from the sale of strontium-90, cesium-137, and promethium-147. The catalog prices for these isotopes have been established by the Commission at levels comparable to anticipated full commercial production prices. The related cost of these isotopes in FY 1969 is $1,400,000 and is included under the budget program "Cost of Work for Others."

(2) Sale of Other Isotopes - FY 1967: $2,890,010 - FY 1968: $3,180,000 - FY 1969: $3,030,000

This estimate consists of revenue from the sale of radio and stable isotopes exclusive of the above fission products, to research laboratories, industry, educational institutions and foreign countries. It is based on current sales projections. The related cost of these isotopes in FY 1969 is $2,383,000 and is included under the budget program "Cost of Work for Others."

c. Sale of Other Products - FY 1967: $5,288,880 - FY 1968: $3,200,000 - FY 1969: $2,350,000

This estimate consists of revenue derived from the sale of miscellaneous products, principally to the United Kingdom under Mutual Defense and reflects projected sales under present agreements. The related cost of these products in FY 1969 is $1,600,000 and is included under the budget program "Cost of Work for Others."

2. Income from Services ..... $ 2,805,000

a. Use of AEC-owned Facilities and Equipment, and Irradiation Services - FY 1967: $829,690 - FY 1968: $1,050,000 - FY 1969: $950,000

This estimate reflects income derived from non-AEC users in connection with industrial applications and research activities. This includes the use of Commission facilities and equipment and the performance of irradiation services in Commission facilities. Related costs of $800,000 are included in FY 1969 under the budget program "Cost of Work for Others."

b. Withdrawals, Analyses, and Fabrication - FY 1967: $284,886 - FY 1968: $350,000 - FY 1969: $350,000

This estimate reflects income derived from services performed for non-AEC users in connection with the withdrawal, analyses and fabrication of materials. Related costs of $300,000 are included in FY 1969 under the budget program "Cost of Work for Others."

c. Other Services - FY 1967: $1,707,876 - FY 1968: $1,653,000 - FY 1969: $1,505,000

This estimate reflects income derived from miscellaneous services performed by AEC for non-AEC users in the field of atomic energy. Related costs of $1,306,000 are included in FY 1969 under the budget program "Cost of Work for Others."

3. Income from Security Investigations - FY 1967: $108,530 - FY 1968: $107,000 - FY 1969: $100,000

This estimate consists of income derived from charges for access authorizations under the Access Permit Program. As a means of encouraging American industry to participate more fully in the atomic energy program, the Commission instituted a program for release of selected classified non-military information, after obtaining the necessary security clearance (access authorization), to applicants who can demonstrate that the information is needed in their business or profession. The related costs of investigations for access authorizations in FY 1969 are $44,000 and are included under the budget program "Cost of Work for Others."

4. Other Revenue $79,751,000

The amount of $79,751,000 under this category is detailed as follows:

a. Sale of Source and Special Nuclear Materials - FY 1967: $21,182,286 - FY 1968: $12,840,000 - FY 1969: $8,100,000

This estimate consists of income derived from the sale of uranium, plutonium, and other special nuclear materials to foreign countries, domestic licensees and other federal agencies. The FY 1969 estimate includes anticipated foreign sales of $7.2 million for enriched uranium and $0.8 million for plutonium and domestic sales of $0.1 for enriched uranium. Related costs of this material are included under the budget program "Special Nuclear Materials" either currently or in prior years.

b. Uranium Enrichment Services - FY 1967: $ 0 - FY 1968: $ 0 - FY 1969: $27,000,000

This estimate includes income derived from the service of toll enriching natural uranium for foreign and domestic users. The enrichment service starts January 1, 1969, and this estimate is based on a charge of $26 per unit for separative work with a tails assay of 0.20 percent. The majority of the estimate is related to services for foreign customers ($20.0 million); however, the estimates also anticipate that some domestic operators, who still have the option to lease until December 31, 1970, will request toll enriching services ($7.0 million). The estimate for FY 1969 is subject to adjustment dependent upon the accomplishment of program scheduling by users of material.

c. Income from Charges for Source and Special Nuclear Material Consumed - FY 1967: $13,413,948 - FY 1968: $16,500,000 - FY 1969: $24,000,000

This estimate reflects income derived from charges made for material consumed, either lost or "burned up," in the operation of private domestic power and test reactors, military reactors and some foreign reactors using fuel leased by the Commission. Current Commission policy requires that for such reactors, other than military or those for which the charges have been waived, material consumed be paid for periodically on a provisional basis subject to adjustment when the spent core is reprocessed and actual "burn up" is determined. These charges are billed currently from data submitted by the reactor operators. The FY 1969 estimate is based on past experience and projected operational schedules of these reactors, including for the first time the Jersey Central reactor, together with scheduled returns anticipated for military reactors.

4. Other Revenue - continued

d. Income from Ad hoc Barter of SS Materials - FY 1967: $3,028,505 - FY 1968: $8,300,000 - FY 1969: $ 0

This activity reflects income derived from barter arrangements, approved on an ad hoc basis by the Commission, for the furnishing of enriched uranium to foreign countries for the fueling of reactors.

Under these arrangements the approved foreign user will furnish to AEC natural uranium of a fixed quantity and price. The dollar value of this material will then be applied against the value of the enriched uranium to be supplied and the remaining balance paid in cash. This activity reflects this cash payment. All approved sales under barter arrangements are scheduled for completion in FY 1968.

e. Income from the Lease of Materials and Interest from Deferred Sales of Material - FY 1967: $7,492,393 FY 1968: $8,315,000 - FY 1969: $13,115,000

This estimate includes revenue derived from the following sources:

	FY 1967	FY 1968	FY 1969
		(In Thousands)	
Lease of Source and Special Nuclear Materials	$ 4,888	$ 5,600	$ 9,700
Lease of Special Reactor Materials	964	400	500
Lease of Stable Isotopes	8	15	15
Subtotal	5,860	6,015	10,215
Interest from Deferred Sales of Source and Special Nuclear Materials	1,632	2,300	2,900
Total	$ 7,492	$ 8,315	$13,115

Current Commission policy provides for a lease or use charge of 5.50% per annum on the sales value of material leased to qualified domestic and foreign users. The Commission has also established deferred payment plans for the purchase, by qualified foreign users, of enriched power reactor fuels, which provide for a ten-year deferral of the payment for the material purchased and equal annual installments over the next ten years with interest to be charged on the unpaid balance of

4. Other Revenue - continued

e. Income from the Lease of Materials and Interest from Deferred Sales of Material - continued

the purchase at rates set forth below. Purchases under the U.S. - Euratom joint program are subject to a fixed interest charge of 4% per annum while purchases under the Commission's "Limited Deferred Payment Plan" are subject to an interest charge of 5.50% per annum. A major portion of the revenue from lease of source and special nuclear materials is derived from the lease of enriched materials for domestic power reactors.

Revenue from lease of special reactor materials is derived primarily from lease of heavy water by foreign users. Interest on deferred sales is derived from material made available for the SENN and SENA reactors which have been built under the U.S. - Euratom joint program and from the SELNI and TARAPUR reactors which are obtaining their fuel under the Commission's "Limited Deferred Payment Plan." The increase in FY 1969 estimates over the FY 1968 is principally related to the increased estimates from the lease of enriched materials for domestic power reactors. The above estimates are subject to adjustment dependent upon accomplishment of program scheduling by users of material.

f. Income from Community Operations - FY 1967: $3,288,178 - FY 1968: $1,167,000 - FY 1969: $513,000

This estimate reflects income related to the operation of the AEC community at Los Alamos, New Mexico, and primarily includes revenue from housing and commercial properties. Operating costs which relate to this revenue are included under the budget program "Community Operations," together with schedules reflecting revenues by category. In FY 1969 these costs at Los Alamos are estimated to be $1,087,000. The decrease in revenues from this source reflect the planned disposal of the Los Alamos community which is presently in progress.

g. Sale of Steam - FY 1967: $2,013,665 - FY 1968: $2,492,000 - FY 1969: $3,370,000

This estimate reflects income from the sale of steam at the Shippingport Pressurized Water Reactor (Pittsburgh), the Bonus Reactor at Punta Hiquera, Puerto Rico, and the Cooperative Power Reactor Demonstration Projects at Elk River, Minnesota, and La Crosse, Wisconsin. Additionally, an estimate is included for the Sale of Steam from the New Production Reactor at Richland, Washington, to the Washington Public Power Supply System. Under the cooperative arrangements

4. Other Revenue - continued

g. Sale of Steam - continued

for the Elk River and La Crosse projects, the Commission owns and operates the reactor, the operating costs for which are included under the budget program "Reactor Development," and sells the reactor generated steam to the operating utility. The increase of $878,000 from the FY 1968 estimate is principally related to the attainment of initial power operation of the La Crosse reactor in FY 1968. Detail of the estimate by reactor follows:

ESTIMATES OF STEAM REVENUE BY REACTOR

REACTORS	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
		(In Thousands)	
Shippingport	$ 1,476	$ 1,326	$ 1,370
La Crosse	0	367	912
Elk River	425	490	500
BONUS	55	209	430
NPR, Richland, WPPSS	58	100	158
Total	$ 2,014	$ 2,492	$ 3,370

h. Income from Charges for Recovery of SS Material - FY 1967: $5,465,357 - FY 1968: $1,250,000 - FY 1969: $900,000

This estimate reflects income from charges, either estimated or actual, made for the separation of returned irradiated reactor fuels and for the recovery as UF_6 of unirradiated uranium by domestic, foreign and other federal agency users. The estimate is based on scheduled returns and therefore is subject to adjustment dependent upon their receipt. Related costs will be included under the budget program "Special Nuclear Materials" at the time the reprocessing or recovery is accomplished.

REVENUES APPLIED PROGRAM - continued

4. Other Revenue - continued

i. Income from Research Hospitals - FY 1967: $558,947 - FY 1968: $500,000 - FY 1969: $500,000

This estimate consists of revenue derived from payments for patient care at the Commission's research hsopitals. Related costs for the operation of the hospitals as well as for the operation of the Cancer Research Laboratories and other related facilities are included under the budget program "Biology and Medicine."

j. Income from Operation of Schools and Courses - FY 1967: $32,345 - FY 1968: $40,000 - FY 1969: $52,000

This estimate includes income from tuition charges for the following schools and courses:

	FY 1967	FY 1968	FY 1969
		(In Thousands)	
Puerto Rico Nuclear Center	$ 4	$ 2	$ 2
Radioisotope Technique Courses	20	28	32
Medical Qualification Courses	8	10	18
Total	$ 32	$ 40	$ 52

Related costs for these schools and courses are included under the budget program "Training, Education, and Information."

k. Sale of Publications and Other Fees - FY 1967: $38,465 - FY 1968: $50,000 - FY 1969: $23,000

This estimate consists of revenue derived principally from the sale of pamphlets to museum visitors, sale of classified technical publications to access permit holders and sale of unclassified technical publications to the Department of Commerce for resale to the public. Related costs are included under other budget programs either currently or in prior years.

l. Income from Collateral Funds - FY 1967: $568,667 - FY 1968: $555,000 - FY 1969: $565,000

This estimate reflects income from special funds held by AEC or its contractors for insurance collateral, employee benefits and annuity purposes.

4. Other Revenue - continued

m. Net Income from Services - Washington Public Power Supply System - FY 1967: $90,155 - FY 1968: $55,000 - FY 1969: $40,000

This estimate reflects net income from the Washington Public Power Supply System trust fund for services furnished them by AEC in connection with the construction and operation of power generation facilities at the New Production Reactor, Richland, Washington.

n. Income from License Fees - FY 1967: $ 0 - FY 1968: $300,000 - FY 1969: $900,000

This estimate includes income derived from fees charged for licenses to construct and operate nuclear reactors and other production or utilization facilities, for specific licenses for the source materials uranium and thorium and for the special nuclear materials uranium-233, uranium-235, and plutonium.

o. Other Miscellaneous Income - FY 1967: $8,507,055 - FY 1968: $960,000 - FY 1969: $673,000

This estimate includes income derived from insurance indemnity fees, timber sales, and other miscellaneous sources of a general nature. Additionally, the FY 1967 actual includes $6.2 million in interest income from Export-Import Bank loans made to South African Uranium producers and guaranteed by AEC. The interest, representing approximately one-fourth of the 4% rate which the loans carried, was held by the Export-Import Bank for the credit of AEC pending liquidation of the loans and discharge of the AEC guarantee. The liquidation of these loans was completed in FY 1967.

CONSTRUCTION PLANNING AND DESIGN

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates
Appropriation - Plant and Capital Equipment

CONSTRUCTION PLANNING AND DESIGN - PLANT AND CAPITAL EQUIPMENT OBLIGATIONS

PROGRAM STATEMENT

Estimated Obligations FY 1969	$ 2,448,000
A Construction Projects	
A-1 Obligations for new projects	($ 0)
A-2 Obligations for prior year projects	($ 2,448,000)
B Capital Equipment Not Related to Construction	
B-1 Obligations from new appropriations	($ 0)
B-2 Obligations from prior year appropriations	($ 0)
Estimated Obligations FY 1968	$ 1,561,000
Actual Obligations FY 1967	$ 745,419

Obligations for Construction Planning and Design funds for FY 1969 are estimated at $2,448,000, of which: $2,448,000 is for construction projects listed under Section A-2 below, which were authorized prior to FY 1969 and for which funds have previously been appropriated but are now carried over into FY 1969.

SECTION A-2

The projects comprising Section A-2 which have been previously authorized and for which funds have previously been appropriated but are now carried over into FY 1969 are:

Project No.	Title	Total Estimated Cost	Obligated Thru FY 1968	Obligations to be Incurred in FY 1969	Funding Required After FY 1969 to Complete Project
67-8	Construction planning and design	$2,000,000	$ 275	$1,725,000	$ -
66-10	Construction planning and design	2,145,000	1,475,000	670,000	-
64-AE	Construction planning and design	2,128,000	2,075,000	53,000	-
				$2,448,000	$ -

SUPPORTING TABLES

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates

ALL PROGRAMS - AEC DIRECT EMPLOYMENT

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Number of regular full-time civilian employees at the end of fiscal year:			
1. AEC Operating Expenses	7,005	7,168	7,308
2. AEC Trust Fund (Washington Public Power Supply System)	2	2	2
3. Advances and Reimbursements:			
Interoceanic Canal Commission	6	5	5
Total	7,013	7,175	7,315
Number of temporary, part-time and intermittent employees at the end of fiscal year (operating expenses)	493	490	490
Total all employees at the end of fiscal year	7,506	7,665	7,805
Average number of regular full-time civilian employees:			
1. AEC Operating Expenses	6,977	7,052	7,214
2. AEC Trust Fund (WPPSS)	2	2	2
3. Advances and Reimbursements:			
Interoceanic Canal Commission	7	6	5
All Other	4	xx	xx
Total	6,990	7,060	7,221
Total personal services costs:			
1. AEC Operating Expenses	$82,544,619	$87,143,000	$92,110,000
2. AEC Trust Fund (WPPSS)	25,855	27,000	27,000
3. Advances and Reimbursements:			
Interoceanic Canal Commission	125,064	127,000	96,000
All Other	61,924	xx	xx
Total Advances and Reimbursements	186,988	127,000	96,000
Total	$82,757,462	$87,297,000	$92,233,000

It is the basic policy of the Commission to conduct the atomic energy program through contractors to the greatest practical extent. The following functions are performed by AEC employees under the AEC Operating Expenses category within the basic policy: (1) program planning and direction, contract negotiation, liaison with contractors and inspection of contractor products; (2) the discharge of regulatory functions; (3) administration of industrial development and international cooperation activities; (4) the discharge of safeguards activities; (5) security measures including screening of personnel, protection of documents and property, guarding of security shipments and patrolling of sites where contractor guard service is not provided; (6) operation of the New Brunswick Laboratory and New York Health and Safety Laboratory; (7) operation of the fire department for the Weapons facilities at Los Alamos; (8) operation of health and safety activities at the National Reactor Testing Station in Idaho; (9) accounting, auditing, property management, and personnel services, assuring adequate controls by AEC offices and contractors; (10) control and dissemination of scientific and technical information; (11) provision of supporting services at the AEC Headquarters and field offices; (12) on-site inspection of unirradiated scrap reprocessors.

In addition, AEC employees perform personal services in connection with the AEC - Washington Public Power Supply System (WPPSS) contract which provides for sale of by-product energy from the Richland New Production Reactor. The cost of employees performing this work is fully compensated by WPPSS.

The estimates provide for AEC employees, who are performing nuclear operations studies in connection with the Atlantic-Pacific Interoceanic Canal Study, in accordance with Public Law 88-609 dated September 22, 1964. The costs of this work will be reimbursed by the Interoceanic Canal Commission.

The FY 1969 estimate reflects an increase of 140 permanent full-time employees over the June 30, 1968, end strength of 7,175. All of the staffing increases are in the Program Direction and Administration areas and are discussed in the narrative justification for this program.

Year-end strengths and average employment for permanent full-time employees and total personal services costs of the various programs under AEC Operating Expenses are shown in the table on the next page.

Comparison of Employment and Personal Services Costs

Program	Actual FY 1967 Employment End Strength	Actual FY 1967 Employment Av. Full Time	Actual FY 1967 Costs (In Thous)	Estimate FY 1968 Employment End Strength	Estimate FY 1968 Employment Av. Full Time	Estimate FY 1968 Costs (In Thous)	Estimate FY 1969 Employment End Strength	Estimate FY 1969 Employment Av. Full Time	Estimate FY 1969 Costs (In Thous)
Special Nuclear Materials	119	121	$ 1,266	118	117	$ 1,264	118	116	$ 1,292
Weapons	672	710	6,732	644	658	6,350	644	646	6,488
Reactor Dev. ..	228	233	2,081	228	227	2,145	228	228	2,221
Biology & Med.	98	94	1,165	106	102	1,271	106	105	1,360
Training, Ed. & Information	234	232	1,972	235	234	2,126	235	235	2,237
Community	27	47	453	25	25	246	25	25	255
Subtotal ...	1,378	1,437	13,669	1,356	1,363	13,402	1,356	1,355	13,853
Program Dir. & Administration	5,629	5,546	68,964	5,814	5,691	73,768	5,954	5,861	78,284
Less:									
Personnel assigned to Trust Fund (WPPSS)	-2	-2	-26	-2	-2	-27	-2	-2	-27
Advances and Reimbursements - All Other ..	xx	-4	-62	xx	xx	xx	xx	xx	xx
Net Prog. Dir. & Administration	5,627	5,540	68,876	5,812	5,689	73,741	5,952	5,859	78,257
Grand Total AEC Operating Expenses	7,005	6,977	$82,545	7,168	7,052	$87,143	7,308	7,214	$92,110

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates

ALL PROGRAMS - AEC DIRECT TRAVEL

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Estimated number of travel days:			
1. AEC Operating Expenses	87,077	97,632	103,411
2. AEC Trust Fund (Washington Public Power Supply System)	-	20	20
3. Advances and Reimbursements:			
Interoceanic Canal Commission	309	320	200
All Other	30	-	-
Total Advances and Reimbursements	339	320	200
Total	87,416	97,972	103,631
Total estimated cost of travel subject to travel regulations:			
1. AEC Operating Expenses	$3,612,405	$4,150,000	$4,453,000
2. AEC Trust Fund (WPPSS)	-	1,000	1,000
3. Advances and Reimbursements:			
Interoceanic Canal Commission	20,111	24,000	21,000
All Other	988	-	-
Total Advances and Reimbursements	21,099	24,000	21,000
Total	$3,633,504	$4,175,000	$4,475,000

This estimate covers the cost of official travel of government employees while discharging assigned AEC duties away from official duty stations. The number of travel days and the travel costs reflect the travel of four principal classes of personnel: (1) AEC permanent full-time employees, (2) AEC intermittent employees such as members of advisory groups and individual consultants, (3) AEC trainees and (4) about 250 military personnel on duty with the AEC, whose salaries are paid by the Department of Defense, but whose duties require considerable travel on AEC business.

Substantial travel is required to maintain a satisfactory degree of technical and administrative supervision over Commission offices and projects and liaison with contractors, to provide for attendance of technical and

scientific personnel at important domestic and foreign conferences and symposia, and to provide for coordination of and participation in overseas nuclear science demonstrations and exhibits.

Extensive travel is also required in connection with weapons production and quality assurance inspections under the Weapons Program; inspection of licensed facilities; and international cooperation activities.

In addition travel is required in connection with the Washington Public Power Supply System (WPPSS) and the Interoceanic Canal Study. Travel performed by AEC employees in connection with the AEC - Washington Public Power Supply System (WPPSS) contract which provides for sale of by-product energy from the Richland New Production Reactor is fully compensated by WPPSS. The travel estimated for the Interoceanic Canal Commission will be performed by AEC personnel engaged in nuclear operations studies in connection with the Canal Studies. The costs incurred for this project will be reimbursed by the Interoceanic Canal Commission.

The FY 1969 request represents the estimated requirements for travel essential to the proper discharge of Commission responsibilities in all areas. The estimate for the Special Nuclear Materials is related primarily to the volume of security shipments requiring escort personnel and for on-site inspection of unirradiated scrap reprocessors. The estimate for the Weapons Program is related to the projected level of operations which will necessitate a high volume of travel. The travel requested for the Reactor Development Program is required for travel in connection with health and safety activities at the National Reactor Testing Station in Idaho and for security shipments requiring escort personnel. The estimate included under the Biology and Medicine Program is for required travel of personnel assigned to the New York Health and Safety Laboratory. Travel funds are required under the Training, Education and Information Program by the Technical Information Extension at Oak Ridge. Under the Community Program limited travel will be performed by personnel engaged in community operations under the Albuquerque Operations Office. The estimate for Program Direction and Administration was discussed in the justification for operating costs of that program.

The table on the following page reflects a comparison of the estimated days of travel and estimated costs of the various programs under AEC Operating Expenses.

ALL PROGRAMS - AEC DIRECT TRAVEL - continued

Comparison of Estimated Days and Costs of Travel

Program	Actual FY 1967 Days	Actual FY 1967 Costs (Costs in Thousands)	Estimate FY 1968 Days	Estimate FY 1968 Costs (Costs in Thousands)	Estimate FY 1969 Days	Estimate FY 1969 Costs (Costs in Thousands)
Special Nuclear Materials	3,603	$ 87	4,261	$ 102	4,384	$ 104
Weapons	17,095	313	17,411	332	17,356	331
Reactor Development	447	19	874	38	874	38
Biology and Medicine	820	47	950	60	950	60
Training, Education and Information	319	13	381	16	428	18
Community	28	1	57	2	57	2
Subtotal	22,312	480	23,934	550	24,049	553
Program Direction and Administration	64,795	3,133	73,718	3,601	79,382	3,901
Less:						
Travel for personnel assigned to Trust Fund (WPPSS)	-	-	-20	-1	-20	-1
Advances and Reimbursements - All Other	-30	-1	xx	xx	xx	xx
Net Program Direction and Administration	64,765	3,132	73,698	3,600	79,362	3,900
Total AEC Operating Expenses Travel Subject to Travel Regulations	87,077	3,612	97,632	4,150	103,411	4,453
Additional costs to account for grand total of "Travel and Transportation of Persons":						
Rental of Passenger Vehicles from Inter-agency Motor Pools	xx	72	xx	96	xx	96
Contractual Local Transportation (Headquarters only)	xx	41	xx	54	xx	58
Grand Total AEC Operating Expenses		$ 3,725		$ 4,300		$ 4,607

U. S. ATOMIC ENERGY COMMISSION
FY 1969 Budget Estimates

STATEMENT OF PASSENGER MOTOR VEHICLES

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Net Active Fleet End of Fiscal Year	2,481	2,481	2,517
Number of Replacement Vehicles	71	400	553
Number of Additional Vehicles	0	0	36
Gross Cost of Replacement Vehicles	$625,892	$1,259,650	$1,409,950
Gross Cost of Additional Vehicles	0	0	146,600
Total Gross Cost of Vehicles	$625,892	$1,259,650	$1,556,550

Passenger motor vehicles are required by the AEC for security patrols of extensive plant and laboratory areas, inspection and audit of Commission and contractor operated facilities, and for other necessary official transportation of AEC and contractor personnel within and between project sites and areas in the management and operation of the programs conducted by the agency. The estimate includes requirements for both contractor operations and the AEC. Contractors are assigned passenger motor vehicles as Government-furnished equipment and operate them in carrying out the Commission's programs. The FY 1969 estimate provides for authorization of the procurement in FY 1969 of 589 passenger motor vehicles of which 553 are required for replacement of older vehicles and 36 are for additions to the fleet. All vehicles to be replaced will meet or exceed the GSA replacement standards. Of the 500 sedans required in FY 1969 (see Table A) 475 are for replacement purposes. This number represents 25% of our projected sedan fleet level at the beginning of FY 1969. It is estimated that rehabilitation costs ranging from $160 to $500 per vehicle will be saved through replacement of these old vehicles which have served their most economical lives, have been permitted to wear down through closely controlled preventive maintenance and replacement scheduling, and which can no longer provide reliable and economical transportation service dictated by good motor fleet management.

The additional vehicles requested include 25 sedans, 8 station wagons, 1 ambulance and 2 buses. Of this increase, 25 sedans and seven station wagons are required to provide transportation for AEC and contractor personnel engaged in the design and construction of the 200 BEV Accelerator near Chicago, Illinois. Interagency Motor Pool Service is not available in the area and GSA has indicated its inability to furnish these vehicles on a loan or rental basis. Also required are: one additional station wagon for transporting personnel and cargo in the overseas exhibit program, one additional ambulance at Ames Laboratory to transport injured and sick from the remote locations of the Reactor and Synchrotron sites since commercial ambulance service for this purpose has proven inadequate, and two additional buses at the National Reactor Testing Station for transporting employees from Idaho Falls to the various NRTS work locations.

94-075 O-68-pt. 3—46

STATEMENT OF PASSENGER MOTOR VEHICLES - continued

Eleven of the sedans included in the estimates will require additional equipment necessary for police purposes and their cost is estimated at $1,800 each. They are for use by deputized patrolmen in patrolling plant roads and state highways passing through plant areas in the enforcement of state motor vehicle laws and in the execution of security duties including apprehension of trespassers, erection of barricades, accident investigations, and transportation of arrested persons to county jails.

Table A, below, shows the passenger motor vehicle requirements, by type and fiscal year. A breakdown of the AEC fleet by type of vehicle is shown in Table B.

TABLE A

PASSENGER MOTOR VEHICLE REQUIREMENT

	Actual FY 1967		Estimate FY 1968		Estimate FY 1969	
	No.	Cost	No.	Cost	No.	Cost
Automobiles	40	$ 58,294	321	$ 483,600	500	$ 753,300
Station Wagons	3	5,838	59	115,050	55	107,250
Ambulances	0	0	1	11,000	7	62,500
Buses	28	561,760	19	650,000	27	633,500
TOTAL	71	$625,892	400	$1,259,650	589	$1,556,550

TABLE B

NET ACTIVE FLEET OF PASSENGER MOTOR VEHICLES AT END OF YEAR

	Actual FY 1967	Estimate FY 1968	Estimate FY 1969
Automobiles	1,902	1,902	1,927
Station Wagons	198	198	206
Ambulances	51	51	52
Buses	330	330	332
TOTAL	2,481	2,481	2,517

Highlight Statement

ADVANCES FOR NON-FEDERAL PROJECTS

Section 112 of Public Law 87-701 (AEC authorization act for fiscal year 1963) approved September 26, 1962, provides, under certain conditions, for the sale of steam from the Hanford New Production Reactor. Section 112 (c) provides as follows:

> "All expenses of modifications of the Hanford New Production Reactor made at the request of a non-Federal entity, and all expenses of constructing and operating the electric energy generating and transmission facilities at the New Production Reactor, shall be borne by such non-Federal entity."

Under these provisions the non-Federal entity, Washington Public Power Supply System, advances funds to the Federal government for all expenses for construction and operation incurred in connection with the sale of steam and generation of power. There has been established by the Treasury Department a trust fund to which all such advances made by the power supply system are credited and are then made available to the AEC for carrying out the work involved. The power supply system advances monies to the trust fund on the basis of a forecast of requirements made by the AEC. Under the proposed plan Washington Public Power Supply System is contracting directly for the necessary generating facilities and the amounts advanced to the trust fund are to cover all AEC expenses related to inter-connecting facilities between the reactor and generating facilities and for the reimbursement of any other expenses which AEC may incur in carrying out the arrangement

Estimates of advances to be used for this purpose are $391,000 for fiscal year 1968 and $338,000 for fiscal year 1969.

CHANGES IN AUTHORIZATION BILL REGARDING SALE OF HEAVY WATER TO CANADA

Mr. MORRIS. Please highlight for the committee the changes made in the authorization bill in the estimates for cost of work for others and revenues applied, in connection with the sale of heavy water to Canada.

(Information requested follows:)

The effect of the heavy water sale to Canada (AECL) on AEC's fiscal year 1969 budget estimates follow:

[In thousands of dollars]

	Fiscal year 1969		
	Budget estimate	Revised estimate	Change
Cost of work for others	$14,533	$29,038	$14,505
Revenues applied	−99,116	−122,808	−23,692
Difference	−84,583	−93,770	−9,187
Change in selected resources—Reduction in heavy water inventory	55,679	41,174	−14,505
Net decrease in fund requirements			23,692

FIVE-YEAR SUMMARY OF APPROPRIATIONS

Mr. MORRIS. Please provide for the record a statement similar to last year's, providing the 5-year history of appropriations for each of the programs.

(The information requested follows:)

BUDGET ESTIMATES AND ACTUAL COSTS OF AEC PROGRAMS, FISCAL YEAR 1964–69

[In millions]

Programs	Budget approved by Congress compared with actual costs					Change fiscal year 1968 current estimate from fiscal year 1964 actual	Budget to Congress, fiscal year 1969	Change fiscal year 1969 budget from fiscal year 1968 estimate
	Fiscal year 1964	Fiscal year 1965	Fiscal year 1966	Fiscal year 1967	Fiscal year 1968 [1]			
Raw materials:								
Budget	$320.0	$267.5	$210.0	$163.0	$129.1		$112.5	−$16.6
Actual costs	326.2	261.0	206.2	161.9	127.7	−$198.5		
Difference	6.2	−6.5	−3.8	−1.1	−1.4			
Special nuclear materials:								
Budget	475.0	398.5	376.0	[2] 354.3	[2] 346.4		334.3	−12.1
Actual costs	463.7	393.0	373.2	349.3	340.7	−123.0		
Difference	−11.3	−5.5	−2.8	−5.0	−5.7			
Weapons:								
Budget [3]	783.0	765.3	702.4	[2] 668.9	[2] 715.0		840.8	125.8
Actual costs	754.9	707.0	670.2	661.1	722.4	−32.5		
Difference	−28.1	−58.3	−32.2	−7.8	7.4			
Reactor development:								
Budget [4]	508.5	494.1	[5] 478.9	[5] 467.7	507.5		509.5	2.0
Actual costs	503.2	477.2	428.6	455.0	482.1	−21.1		
Difference	−5.3	−16.9	−50.3	−12.7	−25.4			

See footnotes at end of table.

Programs	Budget approved by Congress compared with actual costs					Change fiscal year 1968 current estimate from fiscal year 1964 actual	Budget to Congress, fiscal year 1969	Change fiscal year 1969 budget from fiscal year 1968 estimate
	Fiscal year 1964	Fiscal year 1965	Fiscal year 1966	Fiscal year 1967	Fiscal year 1968 [1]			
Physical research:								
Budget	$197.1	$214.0	$236.0	$255.3	$273.5		$280.0	$6.5
Actual costs	195.5	212.6	234.5	253.4	265.0	$69.5		
Difference	−1.6	−1.4	−1.5	−1.9	−8.5			
Biology and medicine:								
Budget	71.6	78.0	83.0	86.0	90.5		92.1	1.6
Actual costs	71.4	77.1	82.4	85.7	88.5	17.1		
Difference	−.2	−.9	−.6	−.3	−2.0			
Training, education, and information: [6]								
Budget	15.9	15.8	15.8	16.2	16.4		17.0	.6
Actual cost	14.7	15.4	15.6	15.9	16.4	1.7		
Difference	−1.2	−.4	−.2	−.3				
Isotopes development:								
Budget	8.4	9.3	[7] 7.5	[7] 7.8	7.8		7.2	−.6
Actual costs	7.9	9.1	7.0	6.9	7.4	−.5		
Difference	−.5	−.2	−.5	−.9	−.4			
Civilian applications of Nuclear explosives:								
Budget	13.5	11.0	15.4	16.2	20.7		14.5	−6.2
Actual costs	12.5	10.7	14.6	12.9	18.0	5.5		
Difference	−1.0	−.3	−.8	−3.3	−2.7			
Communities:								
Budget [8]	10.1	9.1	8.9	10.1	6.9		6.9	
Actual costs	9.3	8.2	7.9	9.3	6.8	−2.5		
Difference	−.8	−.9	−1.0	−.8	−.1			
Program direction and administration:								
Budget [9]	72.6	80.1	83.4	88.7	95.8		102.9	7.1
Actual costs	70.8	77.9	81.9	87.5	95.3	24.5		
Difference	−1.8	−2.2	−1.5	−1.2	−.5			
Security investigations:								
Budget [10]	6.9	7.3	5.7	5.6	6.8		6.6	−.2
Actual costs	6.3	5.3	6.3	6.3	6.8	.5		
Difference	−.6	−2.0	.6	.7				

[1] Budget approved by Congress compared with current estimate of costs rather than actual cost.
[2] Includes a reclassification of safeguards and materials management from weapons: 1967, $0.1; 1968, $0.5.
[3] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $0.3.
[4] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $0.1.
[5] Includes a reclassification from the isotopes development program for isotopic fuels and systems development: fiscal year, 1966, $4.4; fiscal year 1967, $8.6. There was offsetting reclassification in fiscal year 1967 of $6.2 (net) to "Goods and services on order."
[6] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $0.1; 1966, $0.1; 1967, $0.1; 1968, $0.1.
[7] Includes a reclassification from other AEC programs in fiscal year 1967 of $2; offset by a reclassification to the reactor development for isotopic fuels and systems development: fiscal year 1967, $8.6; fiscal year 1966, $4.4.
[8] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $0.1.
[9] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $4.1; 1966, $1.9; 1967, $2.1; 1968, $2.6.
[10] Adjusted for comparability purposes to include amounts added for pay-raise legislation: 1965, $0.3; 1966, $0.1; 1967 $0.2; 1968, $0.1.

Mr. MORRIS. The committee wants to commend the Commission and all the witnesses and staff who appeared before us during this rather long series of sessions. You did a fine job, were candid and forthright with your answers, and I want to commend you.

LIST OF WITNESSES

	Page
Abbadessa, J. P	1
Bauer, R. H	2
Baranowski, F. P	1
Bostock, D. E	2
Brunenkant, E. J	1
Corso, Victor	2
Crowson, D. L	2
Derry, J. A	2
English, S. G	1
Erlewine, J. A	1
Faulkner, R. L	1
Fowler, E. E	1
Giller, Brig. Gen. E. B	1
Hennessey, J. F	1
Hollingsworth, R. E	1
Johnson, W. E	1
Kavanagh, G. M	1
Kelly, J. S	2
Klein, Milton	1
Kratzer, M. B	1
McDaniel, P. W	1
Poor, R. S	1
Price, H. L	1
Quinn, G. F	1
Ramey, J. T	1
Rickover, Vice Adm. H. G	1
Seaborg, G. T	1
Shaw, Milton	1
Tape, G. F	1
Totter, J. R	1
Vinciguerra, J. V	1

INDEX

B

	Page
Biology and medicine	471
Biology laboratory, Pacific Northwest Laboratory	516
Budget increases, mandatory	506
Capital equipment	517
Ecological studies	521
Food preservation	518
Justification of the estimates	476
Marine research vessel	518
Oak Ridge Laboratory	519
Uranium mine radiation exposure study	506

C

Civilian applications of nuclear explosives (Plowshare)	555
Justification of the estimates	565
Community program	671
Construction planning and design	712

I

Isotopes development	525
Capital equipment deferral	553
Food preservation	552, 554
Heart pump, heat engine for	543, 553
Justification of the estimates	529
National Heart Institute participation	546, 553

O

Operating expenses	72
Other costs	687

P

Physical research	370
Accelerator, 200 Bev	460, 462, 466
Accelerator design and development	445
Accelerator improvements at Lawrence Radiation Laboratory	459
Budget increases, mandatory	448
Budget request, fiscal year 1968, analysis of	464
Budget request, fiscal year 1969, analysis of	463
Contract terminations	452
Controlled thermonuclear research	450
High-energy physics	445
Justification of the estimates	374
Low-energy physics program	449
Program summary statement	270
Projects completions in fiscal year 1969	451
Research activities of other agencies	446
Research and development costs	466
University research program	447, 460, 464
Program direction and administration	622
Automatic data processing equipment	660
Budget increase, mandatory	656
Capital equipment increase	663
Communications services	658

Page

Program direction and administration—Continued
Contractor services 659
Equipment deferrals 660, 662
Equipment inventory control 664
Federal council for science and technology 667
Manpower utilization 668
Official entertainment expenses 670
Overseas pay differential 670
Part-time employment of professional women 666
Pay above stated annual grade 666
Positions 628
Additional 629
Breakdown 628
Vacant 628
Reduction, allocation of 656
Regulatory employees, work performed by 657
Trainees, professional and management 666
Travel, budget increase for 657
Typewriters and calculators 661
Youth opportunity program 669

R

Raw materials 76
Automatic data processing 87
Geological Survey, responsibility of 85
Justification of the estimates 78
Private industry investment 87
Research and development 85, 88
Special nuclear materials 105
Capital equipment 135
Deferrals 144
Curtailments on diffusion plants, effect of 133
Electric power for diffusion plants 142
Feed materials costs 138
Justification of the estimates 105
Miscellaneous items 148
Plutonium purchase 139
Powder metallurgy facility at Savannah River 134
Process development 141
Radioactive waste management 134
Safeguards program 135
Safeguards training school 140
Savannah River waste storage tanks 143, 147
Reactor development 173
Advanced systems research and development 325
Desalting plants 299
Euratom program 306
General reactor technology 314
Merchant ships program 287
Naval propulsion reactors 173
Funding responsibility 184
Funds authorized, proposed use of 181
Light water breeder reactor 192
Nuclear guided missile escort issue 189
Nuclear ship program summary 176
Procurement of long leadtime propulsion plant items 180
Reprograming 185
Review of naval nuclear propulsion program 175
Soviet and United States submarine fleets 177
Supplemental questions 187
Nuclear safety 331
Operating costs 245
Operational services 344
Plant and capital equipment 347
Space electric power development 204

Reactor development—Continued
Page
Space nuclear systems 193
Justification of the estimate 198
Nerva I 194
Nuclear rocket program 193
Rover program, authorization reduction 196
Technology program, final phases 196
Terrestrial electric power development 308
Revenues applied 701

S

Security investigations 684
Selected resources 691
Statement of the Chairman of the Commission 2
Accelerator, 200 Bev, fiscal year 1969 funding 51
Atomic bomb casualty commission 40
Authorization bill, unbudgeted items in 17
Budget summary 19
Controlled thermonuclear research program 47
General reactor technology 39
Heart pump 40
Metropolitan water district reactor 47
Molten salt breeder reactor 53
Naval propulsion reactors 35
Nonweapons activities 33
Nuclear production of electric power 36
Operating expenses related to other requirements 34
Plowshare program 41
Program direction and administration 46
Project Buggy I 43
Project Gasbuggy results 44
Project Sloop 45
Raw materials program 49
Reactor development program 35
Reactors, use by private concerns 36, 38
Sentinal and Poseidon programs 33
Stretchout program, effect of 17, 35, 49
Unbudgeted items 2
Water conservation 45
Weapons testing 18
Summary justifications 53
Supporting tables 713

T

Training, education, and information program 577

W

Weapons program 148
ABM workload 169
Atmospheric test readiness 166
Capital equipment 165
Construction, new weapons production capabilities 168
Cost review 172
Environmental test facility, Lawrence Radiation Laboratory 168
Equipment deferrals 169
Justification of the estimates 149
Obligation program, current year 167
Off-continent test readiness program 168
Operating costs 161
Production and surveillance 161
Research and development 163
Supplemental test sites 167, 171
Testing 164
Weapons plant and capital equipment 165
Workload 162

O