TOP SECRET

RD/Rpl.

UNITED STATES ATOMIC ENERGY COMMISSION

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PROGRAM STATUS REPORT

June 30, 1954

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PROGRAM STATUS REPORT

June 30, 1954

This document consists of 59 pages
Copy No. 3 of 25 Series A.

By authority of the Atomic Energy Commission, per Dan S. Burrows
by Francis J. McCarthy Jr
Date July 30, 1954
Document No. LXXXI - 267 - 3A

Downgraded to Secret-RD
Group-1, per AEC Memo
dated 7/24/64
Capt

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Copy 5A through 23A are to be destroyed prior to March 1, 1955

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* Transmitted as separate document.

PART I

Raw Materials

Procurement (SECRET)

Uranium concentrates received from new production in fiscal year 1954 by the United States and the United Kingdom totaled 4,719 tons, as shown in Chart I-A and the accompanying table. This amount was somewhat higher than the projected 4,600 tons.

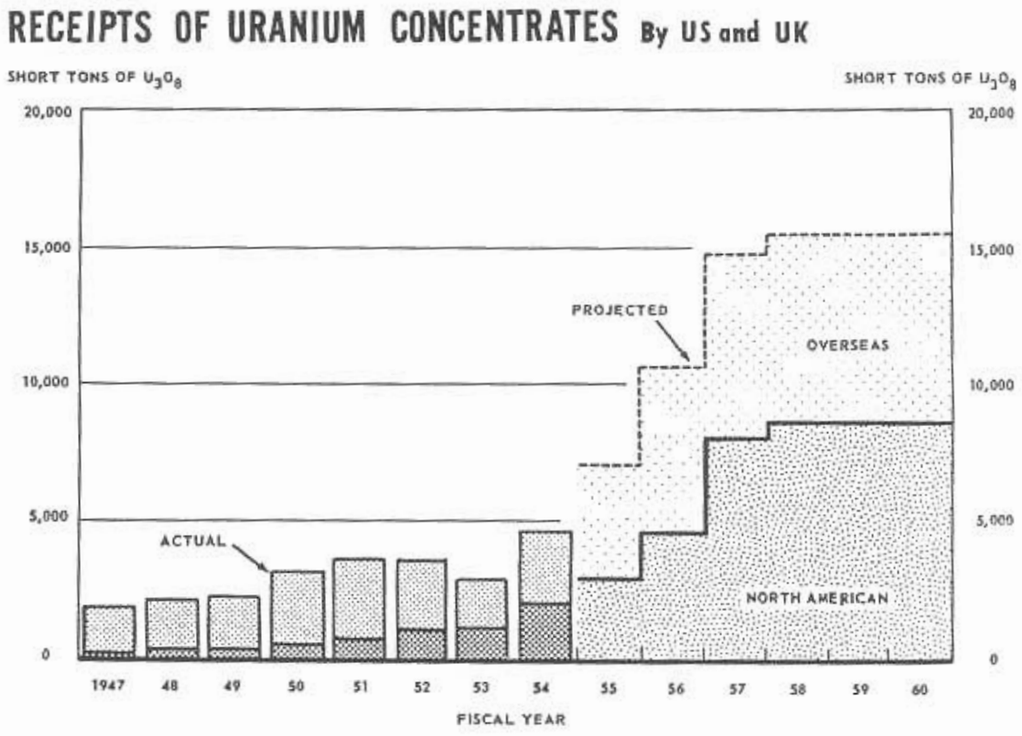

CHART I-A

Sharply increased production enabled the United States by a narrow margin to become for the first time the free world's leading producer of uranium, as Belgian Congo receipts declined slightly from the preceding year. It seems likely, however, that the rapid increase now occurring in production by South Africa will make that country the largest single source during the next two years. New discoveries on the Colorado Plateau indicate that earlier projections of United States production can be raised sharply, and production of 5,500 tons is now projected for fiscal year 1957. This rate is higher than that now forecast for South Africa.

United Kingdom Allocations

Under the allocations agreed upon for calendar year 1954, the United Kingdom will again receive 500 tons of U_3O_8 from the uranium concentrates obtained through the Combined Development Agency (CDA), representing the United States and the United Kingdom in procurement from major overseas sources. In 1953 the United Kingdom allocation was met in part from unallocated stocks of Congo material held by the CDA and in part by deliveries from South Africa, while unallocated stocks of Portuguese material and all other current production were delivered to the United States. The 1954 allocations must be met entirely from current production, with all quantities in excess of 500 tons to be delivered to the United States.

New Procurement Goal

On April 1, 1954, the Commission increased the approved annual procurement goal from 12,500 tons to 15,000 tons. New domestic discoveries and favorable developments in Canada and South Africa provide reasonable assurance that the new goal can be met. In fact further increases in procurement may be possible. Projected U_3O_8 procurement through 1960 is shown in Table 1.

Table 1 — U_3O_8 Procurement by United States and United Kingdom (Short Tons)

	Fiscal Year						
	Actual	Projected					
Source	1954	1955	1956	1957	1958	1959	1960
North America							
United States	1,453	2,000	3,500	5,500	5,500	5,500	5,500
Canada	693	800	1,100	2,400	3,000	3,000	3,000
Subtotal North America	2,146	2,800	4,600	7,900	8,500	8,500	8,500
Overseas							
Belgian Congo	1,410	1,500	1,500	1,500	1,500	1,500	1,500
South Africa	1,009	2,400	4,000	5,000	5,000	5,000	5,000
Portugal	154	100	100	100	100	100	100
Australia		200	400	400	400	400	400
Subtotal Overseas	2,573	4,200	6,000	7,000	7,000	7,000	7,000
TOTAL	4,719	7,000	10,600	14,900	15,500	15,500	15,500

FOREIGN OPERATIONS

South Africa

Uranium production in South Africa has been increasing rapidly, with mine development and plant construction virtually on schedule. Deliveries of U_3O_8 in fiscal year 1954 totaled 1,009 tons, as shown in Chart I-B. The present delivery rate is about 1,800 tons per year, compared with a rate of 900 tons in December 1953 and a projected rate of 2,400 tons per year by December 1954. As new plants come into operation, South African production will approach the annual rate of 5,000 tons of U_3O_8 by the end of calendar year 1956, the production goal

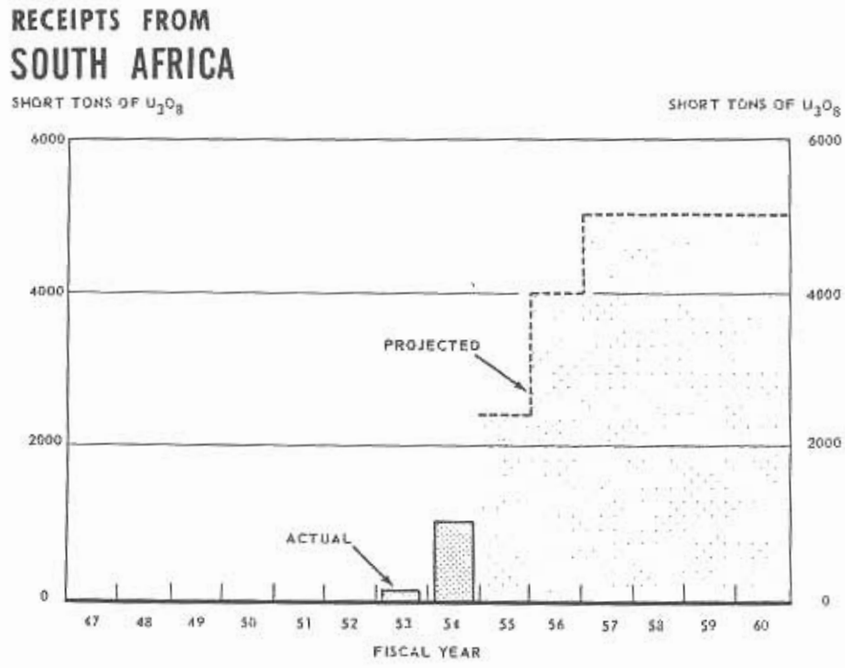

CHART I-B

accepted in January 1954 by the South African Atomic Energy Board and by the Combined Development Agency. Continued success in mine development might permit the goal to be raised by an additional 1,000 tons per year, but such production probably could not be realized before 1957 or 1958.

To reach the 5,000-ton goal the South Africans will have in operation by the end of calendar year 1956 a total of 16 leaching plants, including several completed plants which are being expanded. In February 1954 the sixth of these plants was placed in operation by Randfontein Estates and Gold Mining Co., Ltd. Four more plants are scheduled for completion in both calendar years 1954 and 1955, and two will be completed in 1956. It will also be necessary to construct additional acid production facilities, flotation plants, and pipelines. Total plant

investment will be about $190 million, two-thirds of which will be furnished by United States loans through the Export-Import Bank.

These plants will process feed from 28 mines, and uranium production from other new mines could be developed. The South Africans are now collecting information on new sources and on probable cost and production schedules for new plants. All evidence indicates that South Africa will continue to be a major world producer of uranium for many years. Most of the production plants have sufficient ore reserves for 20 to 40 years, and tremendous tonnages of gold-uranium ores in the Transvaal and Orange Free State remain to be developed.

Canada

Receipts of uranium concentrates from Canada in fiscal year 1954 totaled 693 tons. As shown in Chart I-C, production is expected to reach an annual rate of 3,000 tons of U_3O_8 by fiscal year 1958.

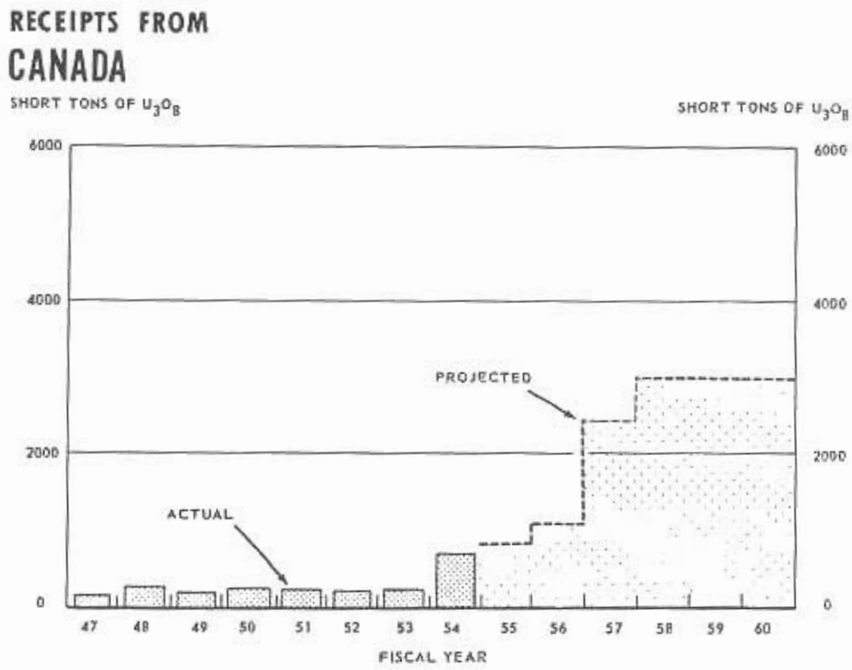

CHART I-C

Great Bear Lake. Production from the Port Radium mine and mill on Great Bear Lake by Eldorado Mining and Refining, Ltd., has been close to the capacity rate. Of the total of 362 tons of U_3O_8 produced in fiscal year 1954, 243 tons were produced in the six months just ended. Both the rebuilt gravity mill and the new leaching plant operated continuously during this period. The life of the Port Radium mine is limited, but the eventual loss of production from this source will be minor compared with future production from the Gunnar mine deposit south of Beaverlodge in the Lake Athabaska area and expected production from the Blind River area in Ontario.

Beaverlodge. Ore reserves at Eldorado's Beaverlodge mine near Lake Athabaska in northern Saskatchewan are being increased through underground development and by diamond drilling, which has revealed deposits below the present bottom level. The Fay shaft, through which ore is currently being hoisted, is being deepened to permit development of these ore zones. The 500-ton-per-day plant at Beaverlodge has been in continuous operation since April 1953, but corrosion difficulties have been encountered in the pressure digestion process. If this problem cannot be eliminated, an alternate method of treatment may be required. A new section using a different leaching technique is being added to the plant to provide an additional capacity of 250 tons per day. This addition should assure maintenance of the present production rate, and if the corrosion problem can be solved, production will increase to about 700 tons of ore per day.

The Verna shaft, located about 6,000 feet east of the main Ace ore body, has been sunk to 900 feet to explore mineralization disclosed by surface drilling. Size, grade, and value of the deposit will not be known until underground operations are completed later this year.

Eldorado has signed a contract with Gunnar Mines, Ltd., for the purchase of 8.1 million pounds of U_3O_8 over a five- to seven-year period. Gunnar expects to produce 600 to 700 tons of U_3O_8 per year beginning in early 1956 from the new mill which they will construct on their Crackingstone Point property near Beaverlodge.

Blind River. Exploration has been favorable in the Blind River district of Ontario, where the geology of ore deposits is somewhat similar to that in South Africa. Pronto Uranium Mines has started to sink a shaft to 575 feet and plans call for a plant which would treat 1,000 tons of ore per day. At the Quirke Lake and Nordic properties, Algom Uranium Mines will sink a five-compartment shaft to develop an estimated 7 million tons of ore. Several large mining companies are studying an arrangement for financing and operating facilities to be constructed on these properties, which probably would process at least 2,500 tons of ore per day.

Belgian Congo

Receipts of uranium concentrates from the Belgian Congo, as shown in Chart I-D, declined slightly to 1,410 tons in fiscal year 1954. The high-grade pitchblende ore bodies which made the Shinkolobwe mine the world's largest uranium producer have been exhausted. For many years over the past decade the Shinkolobwe mine alone supplied more than 90 per cent of this nation's uranium receipts, and since the beginning of the atomic energy program under the Manhattan District has provided more than two-thirds of all uranium acquired by the United States.

The future of Shinkolobwe rests on the mining of relatively low-grade ore and on the development of new ore bodies such as that about 1,500 feet east of the present producing area. Expanded processing facilities for low-grade ore, scheduled for operation in July 1954, may maintain production at least at present levels. Underground development of the eastward extension is being pushed, but a firm estimate of its potential will not be possible until 1956 or 1957. To accelerate these efforts the Combined Development Agency has agreed to finance a $14 million exploration and development program in the Shinkolobwe area in the hope that sufficient ore will be found to allow continued production at current levels.

Portugal

During the year all stocks of Portuguese concentrates in the Combined Development Agency stockpile were transferred to the United States, which is also receiving all current

production from that source. The export of uranium concentrates from Portugal is still limited to 110 short tons per year under the present agreement between Portugal and the United Kingdom. Efforts to remove this limitation are continuing. Recent estimates of ore reserves at Urgeirica indicate that at least 2,500 tons of U_3O_8 are available from concessions now held, and geologists believe that extensive exploration would increase these reserves.

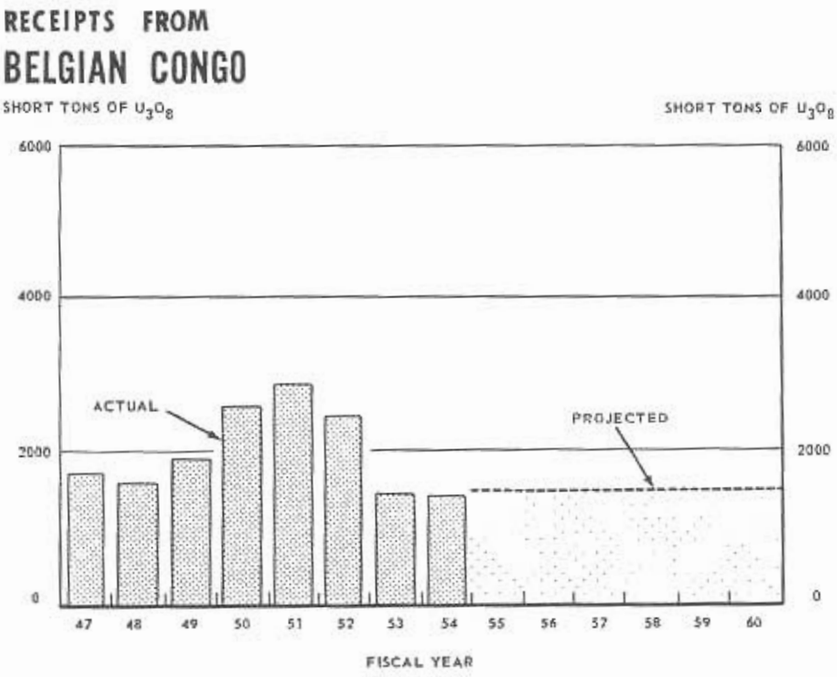

CHART I-D

Australia

No important uranium deposits have been developed in Australia since the original production contract was negotiated in 1952. The Rum Jungle deposit will adequately supply the mill now under construction, but earlier indications of a large rich ore body have not yet materialized. However, further prospecting in the Rum Jungle area and many uranium occurrences already found in the Northern Territory may yet make Australia an important producer. Recently private industry has taken an increased interest in uranium, and both prospecting and underground development are likely to be much more active than in the past.

The mill at Rum Jungle, scheduled for completion in September, will process about 200 tons of ore per day and produce 200 tons of U_3O_8 per year. Until the mill is completed, ore is being stockpiled above ground.

In South Australia, the chemical plant under construction at Port Pirie to treat ore from the Radium Hill property is expected to be in operation in the spring of 1955. The Radium Hill shaft has been completed and ore from development operations is being stockpiled.

At Myponga, southeast of Adelaide, a small deposit of uranium ore is being investigated by diamond drilling and exploratory headings. A very low-grade deposit at Crocker's Well, west of Radium Hill, is also being explored for possible development as a large, low-cost operation.

FOREIGN EXPLORATION

AEC geologists are now participating in joint exploration of possible uranium sources in French Morocco, Peru, Bolivia, and Australia. These joint efforts include reconnaissance for radioactive deposits as well as technical and financial assistance. Negotiations are now under way for similar exploration programs in Brazil and Argentina.

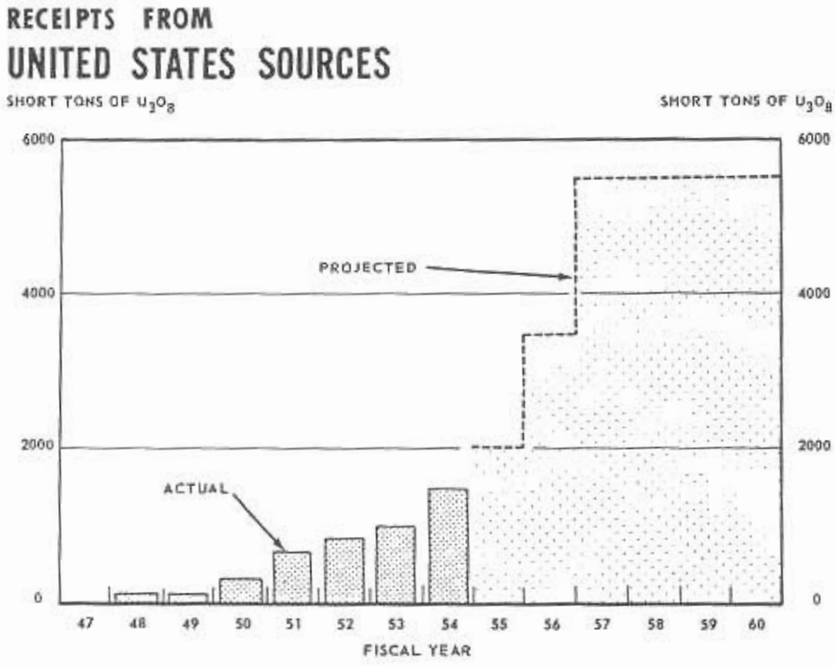

CHART I-E

DOMESTIC OPERATIONS

United States production of 1,453 tons of U_3O_8 in fiscal year 1954, as shown in Chart I-E, slightly exceeded the 1,410 tons received from the Belgian Congo. By the end of the year, however, the production rate in South Africa was higher than in the United States, and honors

for first place in uranium production may shift back and forth between the two countries. Whereas the output from South Africa can be projected for many years to come on the basis of tremendous known reserves of low-grade ore, the United States must depend upon a high rate of ore discovery to maintain the production schedule projected for 1957 and beyond.

Projected Increase in Production

Important discoveries during the past year on the Colorado Plateau, including a large deposit developed quite recently, have led to sharp upward revision of production estimates. Annual production for the United States is now expected to reach 5,500 tons of U_3O_8 by 1957 or 1958, compared with earlier estimates of approximately 3,000 tons. Maintenance of this high rate of production for more than a few years is not assured, but the results of exploration by private industry and the Commission continue to be encouraging.

Domestic ore receipts during fiscal year 1954 were at an all-time high of over 900,000 tons, resulting in a current ore stockpile of about 775,000 tons. In addition, known ore reserves by June 30, 1954, amounted to some 9,000,000 tons with an average grade of 0.30 per cent U_3O_8, compared with an estimated 4,000,000 tons a year earlier. These increases afford the basis for a major expansion in mill capacity.

The current daily milling rate on the Colorado Plateau is approximately 1,800 tons of ore. Already under construction is an additional 300 tons of daily capacity, and during the next six months another 2,000 tons of daily capacity is scheduled to be under construction, including the expansion of existing mills. In the following six months it is planned to begin construction of new mills representing 1,200 to 2,000 tons of daily capacity. With their completion, present daily mill capacity will have been expanded about threefold to some 5,500 or 6,000 tons.

Principal Mill Projects

The major projects comprising this expansion of mill capacity are as follows:

1. Kerr-McGee Oil Industries, Inc., is building a 300-ton-a-day mill at Shiprock, N. Mex., scheduled to be in operation by January 1955. An increase to 400 tons capacity is being considered.

2. Anaconda Copper Mining Co. is completing design of an acid-leach plant for Bluewater, N. Mex., with a capacity of 1,200 to 1,500 tons per day. Construction is expected to be completed late in calendar year 1955.

3. Construction of a 300-ton-a-day addition to the AEC plant at Monticello, Utah, is scheduled to begin this summer.

4. Negotiations are in progress for additions to the capacity of the Durango and Naturita mills of Vanadium Corporation of America, the Uravan mill of U. S. Vanadium Co., the Grand Junction mill of Climax Uranium Co., and the Salt Lake City plant of Vitro Uranium Co.

5. A preliminary design of a mill for the Big Indian Wash district near Moab, Utah, is being prepared for the Commission by Knowles Associates. It is now expected that the mill will be constructed by Uranium Reduction Co. which has a contract with the owner of the principal ore supply. Anticipated capacity is 1,000 tons a day.

6. Newmont Mining Co., Climax Uranium Co., and others are negotiating with the owners of the Happy Jack mine for the purchase or lease of the mine with a view to construction of a 200-ton-a-day mill at Hite, Utah. The experimental plant operated there for a number of years has been dismantled. The Commission has established a temporary ore-buying station and ore is being stockpiled.

7. Homestake Mining Co. is developing uranium properties in the Big Indian Wash area and, depending upon the availability of ore from their properties, may soon propose construction of a mill.

Domestic Exploration

The increase of 5,000,000 tons in known ore reserves during fiscal year 1954 is the direct result of active exploration. Government drilling by the AEC, Geological Survey, and Bureau of Mines reached 1,250,000 feet, and private drilling during this period probably amounted to about 2,500,000 feet. Airborne radiometric surveying is also widely used. A number of ore bodies now in production were discovered by this technique.

The area of known uranium occurrences has been substantially broadened. For example, discoveries late in 1953 may result in important uranium production in Wyoming, and earlier discoveries in the Black Hills area of South Dakota are already in production.

Uranium from Phosphate Rock

Four recovery units have been constructed in the phosphate industry to produce uranium as a by-product of phosphate chemical plants. Two of these, Blockson Chemical Company, Joliet, Ill., and Texas City Chemicals, Inc., of Texas City, Tex., are already producing annually about 18 tons and 12 tons of U_3O_8, respectively. Near Tampa, Fla., International Minerals and Chemical Corporation and Virginia-Carolina Chemical Corporation will begin production shortly in plants having annual capacities of 25 tons and 18 tons, respectively. Additional production contracts are under discussion.

Thorium

The advantages of uranium 233 for certain weapon applications emphasize the urgency of increasing the Commission's thorium supplies. The approved goal is 2,500 tons of contained thorium by the end of calendar year 1957. Meeting this goal will require that the Commission purchase over the next several years all available supplies of thorium from domestic processors, recover the thorium contained in the monazite held in the National Stockpile, and obtain additional quantities from such foreign sources as Brazil, India, and possibly France. (End of SECRET section.)

PART II

Fissionable Materials

(SECRET)

Recent emphasis in the fissionable materials program has been concerned with plans and initial steps to expand sharply the production of thermonuclear materials. Of especial significance is the shift in requirements for these materials resulting from analysis of weapon test data from Operation CASTLE. The requirement envisaged a few months ago for continuing, large-scale production of tritium has been reduced, and reactor capacity can instead be used to increase more rapidly the output of plutonium. On the other hand, the need previously anticipated for lithium 6 has increased. As a result of these developments, the principal measures being undertaken for the production of thermonuclear materials can be summarized as follows:

1. Further enlargement of the facilities at Oak Ridge for production of lithium 6.
2. An increase in the capacity at Savannah River for production of deuterium gas.
3. Completion of tritium production already in progress at Hanford.
4. Production of plutonium with a low neutron background for use in thermonuclear weapons, with less stringent specifications continuing to apply to plutonium for fission weapons.
5. Enlargement of facilities for producing uranium feed for both reactors and gaseous diffusion plants.

In producing plutonium in reactors, the most economical procedure is to irradiate a given quantity of uranium to as high a level as can be utilized in the weapons. Prior to the advent of the large-scale thermonuclear program, the standard was established at 600 megawatt-days per ton. Material irradiated to this level has a ratio of plutonium 240 to plutonium 239 sufficiently high that background neutrons emitted spontaneously by plutonium 240 increase the possibility of predetonation. It is therefore necessary to produce substantial quantities of plutonium at lower irradiation levels. To do this, the exposure of uranium slugs is being limited to less than half the standard previously in effect. To produce a given quantity of "low background" plutonium requires the irradiation of more than twice as much uranium as is required to produce the same quantity of plutonium meeting the standard for fission weapons. The additional uranium thus required for reactor feed necessitates additions to the feed plant capacity at Fernald and St. Louis. The larger volume of irradiated material to be chemically separated will tax Redox and Purex plant capacity and require continued use of the Hanford bismuth phosphate canyons and the TBP uranium recovery plant, which are more costly to operate. (End of SECRET section.)

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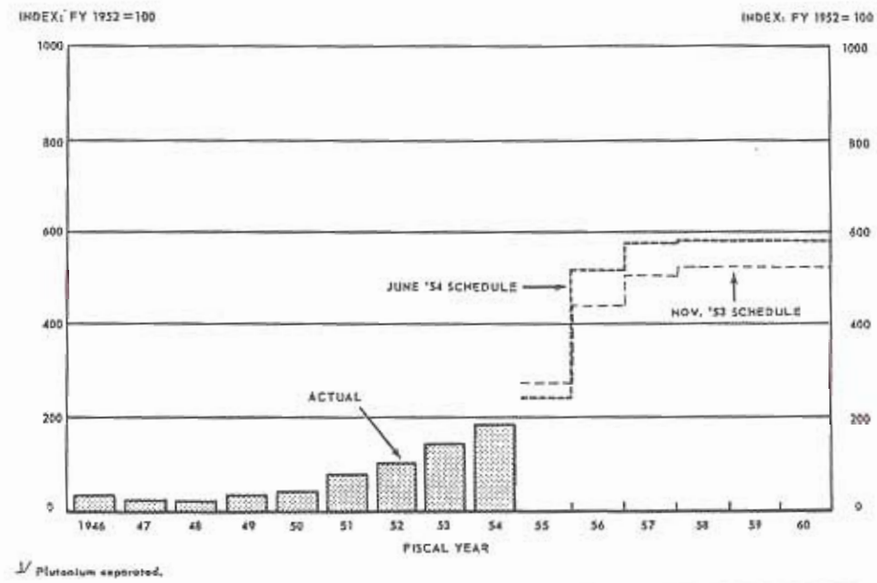
PLUTONIUM PRODUCTION 1/



1/ Plutonium separated.

[redacted]

CHART II A

(End of TOP SECRET section.)

(SECRET)

Chart II-A shows that appreciably greater output is now projected for both plutonium and uranium 235, as compared with six months ago. Contributing factors are higher reactor power levels, curtailment of tritium production, and the improved outlook for uranium procurement.

FEED MATERIALS

Reactor Feed

Plans to produce plutonium with low neutron background have increased requirements for metal feed produced by the Feed Materials Production Center (FMPC) at Fernald, Ohio, and the older feed plants at St. Louis. Plant performance at Fernald has improved with operating experience; however, difficulties in the sampling plant will make it necessary to continue sampling operations at Middlesex until the end of September.

The hexafluoride reduction plant at Fernald was turned over to operations on May 20, 1954. Depleted uranium withdrawn as UF_6 gas from the gaseous diffusion plants will be reduced in this plant to UF_4, which will then be converted to uranium metal for certain uses in weapon components. To the extent that reactor requirements for metal feed may for a time exceed the amount of normal uranium available from ores, the plant will also be used to process uranium which has been reenriched in the diffusion plants to UF_6 of normal isotopic content.

Recovery of Uranium from Hanford Waste Tanks

The TBP plant at Hanford has been used successfully to process materials at increasing levels of radioactivity as stocks of older wastes have declined. Processing difficulties described in the preceding report have been largely overcome, and the rate of production has exceeded design capacity.

UF_6 Feed Production

The production of UF_6 feed at Oak Ridge and Paducah for the gaseous diffusion plants has been limited by the amount of reactor depleted UO_3 which the Hanford plant is able to supply. The Paducah feed plant has been operated at capacity whenever sufficient material from Hanford was available; the Oak Ridge plant has been used only for material in excess of the Paducah plant's capacity.

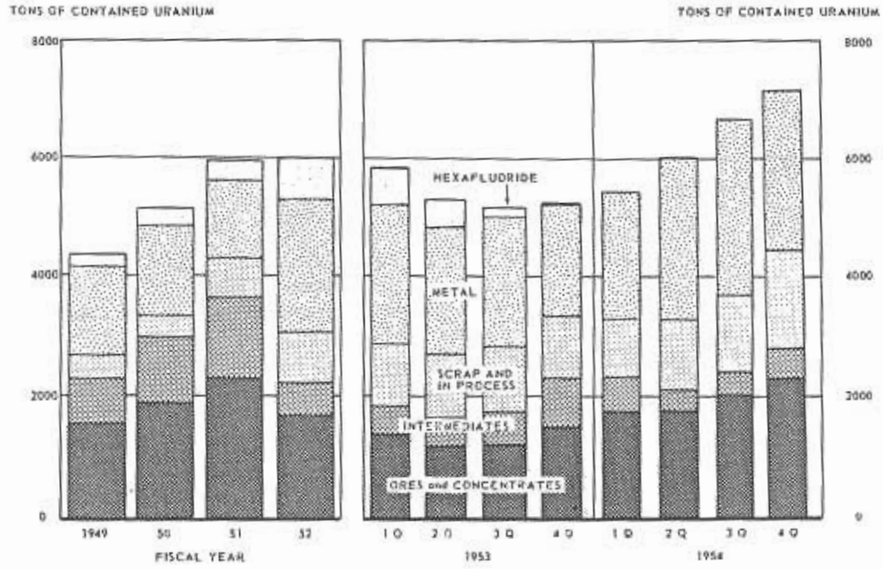
Total Feed Stock

Amounts of uranium feed available for reactor and gaseous diffusion plant operation are shown in Chart II-B. The quantity of normal uranium available for reactor feed has increased in each quarter of the past fiscal year and on June 30 reached 7,141 tons of contained uranium. As reactor-depleted uranium from Hanford's underground storage tanks is recovered and used, the total quantity available for gaseous diffusion plant feed decreases.

Assistance to Canada

Eldorado Mining and Refining, Ltd., has approved the modification of its Port Hope Refinery to provide a capacity of approximately 200 tons per month of UO_3 of purity sufficient to meet AEC specifications for material going into metal feed. The work is being done by Catalytic Construction Co. with Commission approval, and is scheduled for completion in July 1955.

FEED STOCK OF NORMAL URANIUM END OF PERIOD



FEED STOCK OF REACTOR DEPLETED URANIUM END OF PERIOD

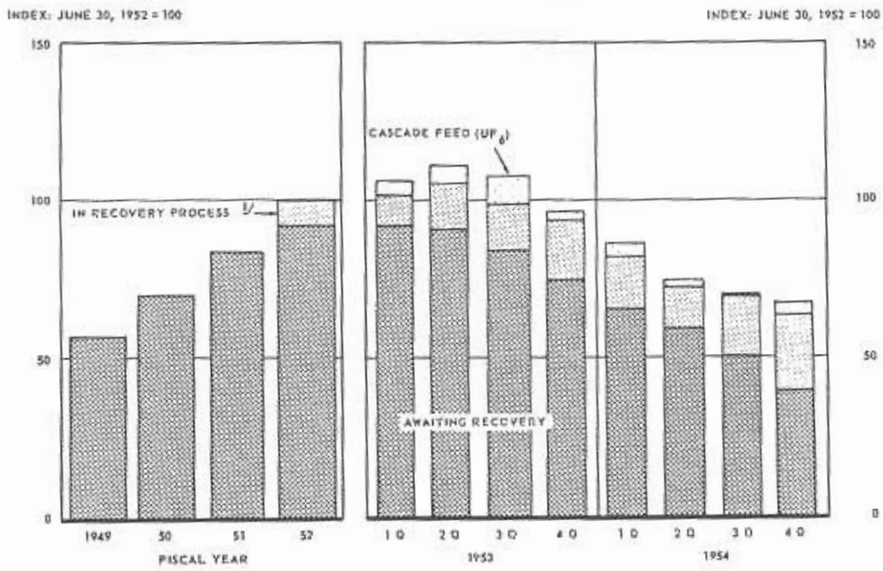


CHART II-B

1/ Includes slugs in cooling basins, material in Redox separations and TBP recovery processes, and subsequent steps in the manufacture of hexafluoride.

Organizational Change

Responsibility for feed materials production was transferred on July 1, 1954, from the New York to the Oak Ridge Operations Office. This reorganization will reduce the combined personnel requirements in the two offices by more than 100 positions.

PLUTONIUM

In-Pile Formation

Savannah River. Plutonium formation at Savannah River began on December 28, 1953, when the first reactor went critical. Three of the reactors are now in operation and all five will be operating in the third quarter of fiscal year 1955. Actual or projected initial operating dates are as follows:

Reactor	Initial Operating Date
R	December 28, 1953
P	February 20, 1954
L	July 2, 1954
K	September 17, 1954
C	February 15, 1955

Reactor power levels have been increased slowly during the first months of operation. Peak power levels to date are 78 per cent of the design level for R reactor and 97 per cent for P reactor. Discharge of the initial loading in R reactor was completed during June; discharge operations at P reactor started on June 25.

Hanford. Plutonium formation in the Hanford reactors was 4.5 per cent greater in the second half of fiscal year 1954 than in the first half. Higher operating power levels were a major factor in this increase. The effect of the higher power levels on plutonium production was offset in part by the loss of operating time resulting from the increasing number of slug failures, and by the allocation of a significant portion of reactor capacity to the production of tritium.

A substantial portion of the irradiated uranium at Hanford is being discharged after relatively brief exposure in order to produce plutonium of low neutron background. To offset in part the fact that increased quantities of uranium must therefore be fed, discharged, and chemically separated, the remaining portions are being irradiated to greater exposures than have heretofore been attempted.

Construction of the large-sized KW and KE reactors is well advanced. The KW reactor is expected to begin operation by October 1, 1954, and the KE reactor may be in operation as much as three months earlier than the scheduled date of April 1, 1955.

Slug Failures

Increasingly severe irradiation conditions, resulting from higher power levels and longer exposure periods for plutonium for fission weapons, are probably responsible for the record number of slug failures occurring in the Hanford reactors during the last quarter of the fiscal year. The number of failures of normal uranium slugs has increased steadily from 7 in the fourth quarter of fiscal year 1953 to 14, 21, 40, and 60 in the successive quarters of this year,

as shown in Chart II-C. Accordingly, lost time due to slug failures has increased from 1.5 per cent of the total operating time a year ago, to 11.6 per cent in the quarter just ended. Intensive effort is being given to solving this problem. Considerable improvement in the techniques of fuel element fabrication will be required to reverse the recent trend, in view of the severe demands made on fuel slugs by present and proposed levels of slug exposure and reactor power.

SLUG FAILURES
AND ASSIGNED TIME LOST

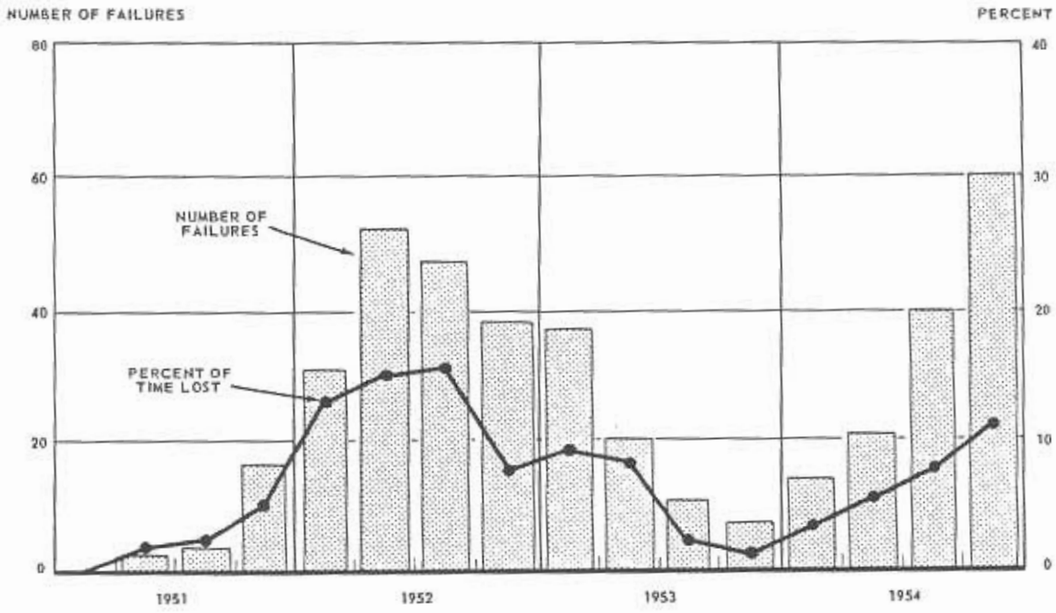


CHART II-C

Plutonium Separation

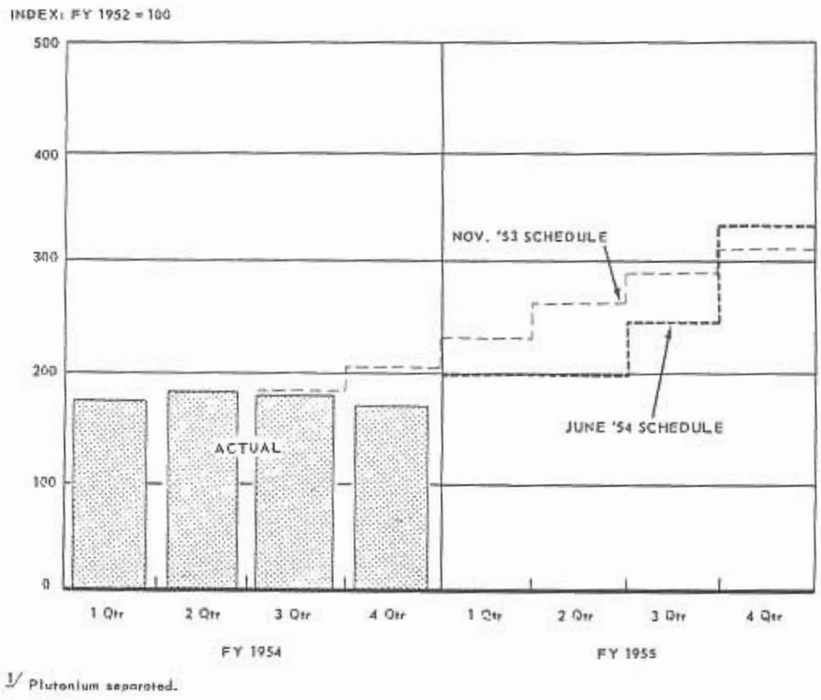
Plutonium separation during the third and fourth quarters of the fiscal year was at rates of 180 and 170, respectively, in terms of the index used in Chart II-D (fiscal year 1952 = 100). These were below the rates of 184 and 204 projected in the preceding report.

Hanford. The Redox plant at Hanford separated a record amount of plutonium during December when it processed the backlog of material accumulated during the November shutdown. Operational and equipment difficulties caused major outages for maintenance in January, February, and April. The plant was shut down in June for modifications which are expected to increase its capacity significantly. Operation was resumed in mid-July. In April the T canyon (bismuth phosphate plant) was converted to separating low-background plutonium.

The Hanford Purex separation plant is more than half complete and will begin operation late in fiscal year 1955.

Savannah River. The first of the two Purex separations plants at Savannah River was turned over to operations on May 3 and will be ready to separate plutonium late in September when the first slugs discharged from R reactor will have cooled adequately.

PLUTONIUM PRODUCTION [1]



[1] Plutonium separated.

CHART II-D

Plutonium Production Forecast

Chart II-D indicates that the projection for plutonium production during the first half of fiscal year 1955 is somewhat lower than in the preceding report. The principal cause is continuing tritium production in pile DR. Beginning in the third quarter of the fiscal year, the rate of production is expected to rise sharply as the first significant amounts of material discharged from the new reactors at Savannah River and Hanford reach the separation plants. The index rate of 577 shown for 1958 and subsequent years is 11 per cent higher than the projection in the last Progress Report. The increase is based on greater confidence that higher power levels can be maintained, as well as on the assumption that all Savannah River reactors will be devoted to plutonium production. The preceding report contemplated that one reactor would be devoted entirely to tritium.

URANIUM 235

Uranium 235 Production

The production rate for enriched uranium 235 continues its steady increase.

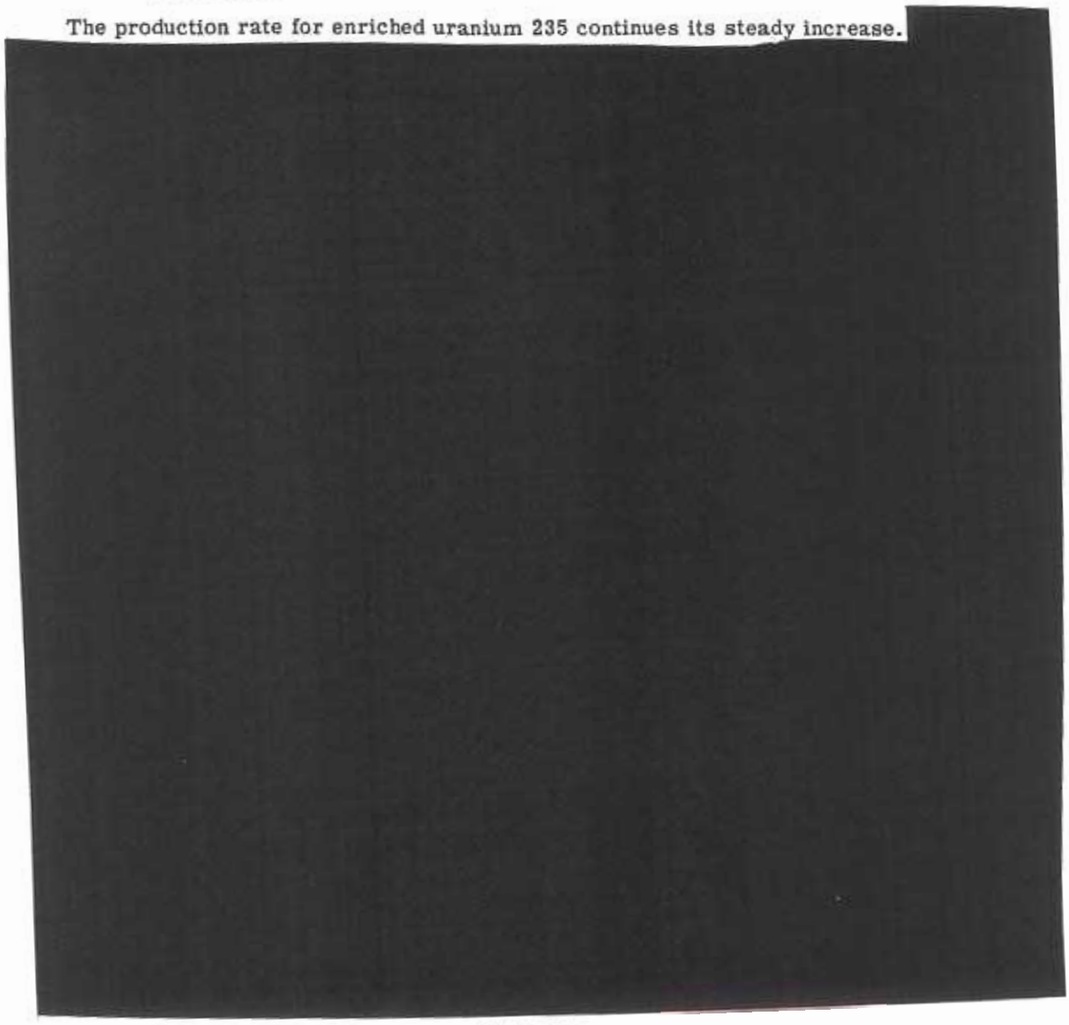


CHART II-E

The steady rise in production is mainly the result of adding new units to the gaseous diffusion cascade. At Oak Ridge, the first of eight units in the K-33 plant was placed in operation on April 12, the second on May 7, and the third on June 15. All eight units are expected to be in operation by November 1, 1954. The successive on-stream dates for the four units of the Paducah C-35 plant were January 16, February 20, March 20, and April 10, about seven weeks ahead of schedule. The first unit of the Paducah C-37 plant began operation on July 2, and the first unit of the Portsmouth plant is expected to be placed on-stream in September. All cascades are scheduled to be in operation by the end of fiscal year 1956.

Uranium 235 Production Forecast

The projection of U^{235} production shown in Chart II-A and Chart II-E is consistently higher than that shown in the preceding Progress Report. The production level shown for 1958 and subsequent years represents an increase of 20 per cent. The more optimistic outlook is based primarily on the expectation of larger receipts of uranium concentrates, which will permit the use of greater amounts of normal uranium as feed for the cascades. Earlier completion of new plants is also expected to boost U^{235} production, particularly in fiscal year 1955.

Electric Power Supply

Oak Ridge. Additional steam generating units are under construction or have been completed by TVA at various locations to provide electric power for the Oak Ridge diffusion plants.

Paducah. On January 8, the date of commercial operation of the fourth generator of the Shawnee plant, TVA began furnishing the power requirements of the base plant at Paducah (C-31 and C-33) at the permanent power rate. Electric Energy, Inc., began operation of the third unit of its original four-unit plant on April 18.

Portsmouth. On June 1, the Ohio Valley Electric Corporation's Kyger Creek generating station was 16 per cent complete and its Clifty Creek station was 14 per cent complete.

OTHER MATERIALS

Lithium 6

Operation of the Oak Ridge ADP plant, the first to produce lithium 6, has been most satisfactory. The failure of certain mechanical parts, the chief potential operating difficulty, has been less serious than expected.

Equipment adjustments to increase the amount of power supplied to the plant bring its production capacity to a value of 111 in terms of the index used in Chart II-F (fourth quarter of fiscal year 1954 = 100).

The second lithium plant, called Alpha 5, is now under construction at Oak Ridge. The first of its 10 units will be in operation by January 1955 and the last by July 1956. Accordingly, the production rate for lithium 6 is expected to rise sharply in the second half of fiscal year 1955, as shown in Chart II-F. To meet current weapon requirements lithium 6 is now being produced at two levels of isotopic enrichment. The production index includes both types of material, with proper adjustment for the different levels.

Tritium

As a result of the recent CASTLE weapon tests, tritium requirements projected for thermonuclear weapons have been sharply reduced. Special charges now being irradiated in the DR pile at Hanford to produce tritium will be sufficient to meet all current requirements. Future needs for tritium can be met by using excess neutrons available in the Savannah River reactors.

Heavy Water and Deuterium Gas

Heavy water. During the past six months total production of heavy water at Dana and Savannah River was 148 per cent of the combined design capacities of the two plants. It appears that heavy water production will remain well ahead of requirements, except possibly for a short period in early 1955 when the last Savannah River reactor is charged.

LITHIUM 6 PRODUCTION

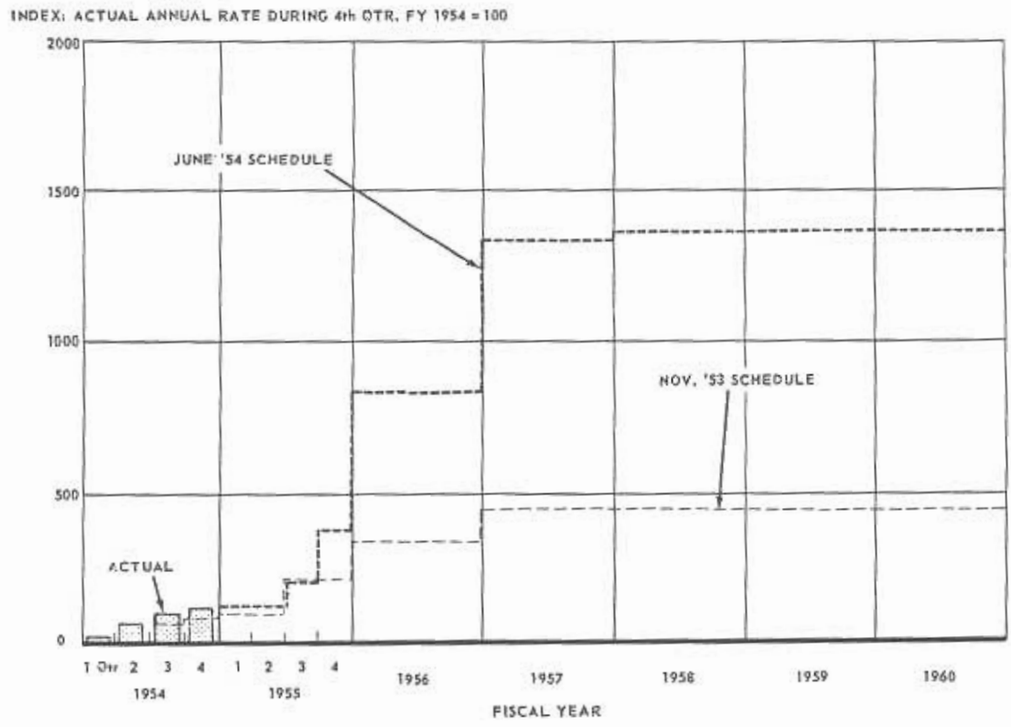


CHART II- F

Deuterium gas. All requirements to date for deuterium gas have been met by the original plant at Savannah River, which separates the gas from heavy water. The addition of the new plant just placed in operation will enable substantially larger requirements to be met.

Uranium 233

Until additional requirements are more clearly determined, the Commission has adopted a production test program calling for the irradiation of approximately 40 tons of thorium to produce U^{233}, a substitute for low-neutron-background plutonium in thermonuclear weapons.

The purpose of the tests is to determine reactor operating characteristics and to explore separations and other problems which would be encountered in a large-scale production operation. Thorium slugs are being fabricated at Fernald for a partial loading of one Hanford reactor in August 1954 and the equivalent of a full loading of one Savannah River reactor in December. Neutrons for the irradiation will be supplied by special fuel slugs containing substantial quantities of enriched U^{235}. The U^{233} will be separated from the irradiated thorium in the Thorex pilot plant at Oak Ridge.

Boron 10

Construction of the Boron Metals Plant at the Lake Ontario Ordnance Works has been largely completed. The plant was designed to produce boron 10 for use in certain types of thermonuclear weapons, and should be in full operation by January 1955. (End of SECRET section.)

PART III

Weapons

This part of the PROGRAM STATUS REPORT has been transmitted as a separate document.

PART IV

Reactor Development

(SECRET)

In the five-year program of industrial power development, it has been possible to get private investment to the extent of about one-fourth of the cost of the Puressurized Water Reactor (Duquesne) and the Sodium Reactor Experiment (North American) projects.

It is a good beginning; but, for any larger industrial nuclear power project in which industry meets all or a major part of the cost, a new arrangement is needed. To this end the AEC has prepared a tentative schedule of charges for source and fissionable materials used in power reactors and credits for fissionable materials produced. The schedule is being discussed with the industrial participation study teams, the serious but unsuccessful bidders for operating the PWR, and with others. By making possible more accurate evaluation of reactor economics and reducing the cost and risk to that which can be afforded, the price schedule may open the way for industry to use its own money to finance large-scale construction and operation, and hence speed progress toward fully economic power reactors.*

In fact, serious interest is being shown, especially by utility concerns, and it is expected that private companies will develop and make to the AEC a number of competitive proposals. It is hoped that the most attractive of these can be chosen in time for government funds, if any are required, to be budgeted in fiscal year 1956. If a series of attractive proposals are received, it is likely that the Commission will recommend that at least one project be started annually for several years.

INDUSTRIAL POWER PROGRAM

In response to a request by the Joint Committee on Atomic Energy, the Commission submitted to the Committee in March a plan for the development of industrial nuclear power plant technology over a five-year period. This plan is based on five technical approaches to the problem of attaining economically competitive power from nuclear fuels. Comprehensive descriptions of the projects were furnished the Committee last February in a classified report. Unclassified descriptions have been published in the Commission's Sixteenth Semiannual Report

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* Plans for exploring industry's interest in such by-product power reactors were discussed with the Joint Committee on June 2 (Hearings on Amendments to the Atomic Energy Act, Part II, pp. 570-71).

to the Congress and in a report by the Joint Committee's Subcommittee on Research and Development. Consequently, this report contains only the following summary table of significant data on each of the projects and brief descriptions of recent accomplishments.

The Five-year Program for the Development of Industrial Power Reactors

					Homogeneous Reactors	
	Pressurized Water Reactor	Experimental Boiling Water Reactor	Sodium Reactor Experiment	Experimental Breeding Reactor No. 2	Homogeneous Reactor Experiment No. 2	Homogeneous Thorium Reactor
Developer	Westinghouse Electric	Argonne Nat'l. Laboratory	North American Aviation	Argonne Nat'l. Laboratory	Oak Ridge Nat'l. Laboratory	Oak Ridge Nat'l. Laboratory
Location	Shippingport, Pa.	Argonne Nat'l. Laboratory (tentative)	Santa Susanna, Calif.	Not selected	Oak Ridge Nat'l. Laboratory	Oak Ridge Nat'l. Laboratory
Reactor Power (kw-heat)	232,000	20,000	20,000	62,500	5,000	65,000
Power Output (kw-elec.)	60,000	5,000	0	50,000	300*	17,500
Fuel						
Material	alloy of uranium and molybdenum	alloy of uranium zirconium and niobium (tentative)	alloy of uranium and zirconium	uranium 235, uranium 238, and plutonium	uranyl sulfate	uranyl sulfate
U^{235} enrichment	slight; or normal, spiked with 93%	normal, spiked with 93%	slight	(approx. 30% fissionable material)	93%	93%
Amt. of U and Pu	12 tons	3.2 tons normal 4 kg. 93%	2.8 tons	about 100 kg.	3.6 kg.	2.3 kg.
Moderator	ordinary water	ordinary water	graphite	none	heavy water	heavy water
Coolant						
Material	ordinary water	ordinary water	sodium	sodium	circulating fuel	circulating fuel
Pressure (psi)	2,000	500	atmospheric	atmospheric	2,000	2,000
Outlet Temp. (°F)	542	470	874	1,000	577	572
Blanket	none	none	none	rods of depleted U	heavy water	thorium solution
Est. Cost† (millions)	$85	$17	$10	$40	$47 (total)	
Est. completion Date (calendar yr.)	1957	1956	1956	1958	1956	1959

*Limited by available turbogenerator capacity.

†Includes research and development, construction, and operation for fiscal years 1954-59, inclusive.

The program includes an additional $40 to $50 million for general research and development.

Estimates are conditioned on technical developments and Congressional appropriations.

Pressurized Water Reactor (PWR)

In April the Duquesne Light Company of Pittsburgh was selected to participate in the construction of the Pressurized Water Reactor, the first large-scale nuclear power plant in this country. Westinghouse is performing the development work and will construct the reactor for AEC. Duquesne will finance and build the turbogenerator portion of the plant, operate the entire plant, and buy reactor-generated steam from AEC. Duquesne will also furnish the site and contribute $5 million toward development and construction. It is estimated that this arrangement will reduce by $30 million the cost which the Government would otherwise have to assume in constructing and operating the reactor at an existing AEC site. The plant is expected to be in operation by 1957 or 1958.

Stone and Webster Engineering Corp., the architect-engineering contractor for Westinghouse, has commenced studies of piping layouts, shielding, and the underground structure housing the reactor. Detailed nuclear experiments to provide basic physics data for core design are being performed at Bettis Plant, Pittsburgh, and at Brookhaven National Laboratory. Bettis and Argonne National Laboratory are conducting heat transfer experiments which will influence the mechanical design of the core. Fuel elements will be rods of uranium-molybdenum alloy clad with a zirconium alloy. Techniques for fuel element manufacture are being developed.

Experimental Boiling-Water Reactor (EBWR)

The boiling-water experiments conducted at the National Reactor Testing Station (NRTS) in the summer of 1953 demonstrated that the presence of steam in a water reactor is not necessarily a hazard but in fact may provide a large measure of self-regulation which prevents a reactor runaway even with high excess reactivity.

The favorable results of these experiments led the Commission to include in its Five-year Program plans for an Experimental Boiling-Water Reactor, probably to be constructed at Argonne before the end of 1956. As designed by the Argonne staff, the EBWR will generate 20,000 kilowatts of heat and use light water as the moderator-coolant. Plate-type zirconium-clad fuel elements of natural uranium-zirconium-niobium alloy have been chosen tentatively for the core, which will be "spiked" with highly enriched U^{235} to provide criticality. The EBWR is expected to furnish essential information on fuel elements arrangement, on the control and operation of boiling-water reactors, and especially on the feasibility of supplying steam from such a reactor directly to a turbine.

Tests similar to those conducted last summer at the National Reactor Testing Station began in July. Plans call for submitting the Borax core to instantaneous power surges even more rapid than those of last year's test and greater than would conceivably occur in a reactor accident. It is expected that the tests may damage the core and that some radioactivity may be released. Following this experiment, a new core and pressure vessel are to be installed for further tests during the summer at much higher pressure and power.

Sodium Reactor Experiment (SRE)

North American Aviation, Inc., completed preliminary design work and is preparing final drawings and specifications for a sodium-cooled, graphite-moderated reactor experiment (SRE) which will be constructed at its Santa Susanna field laboratory near Los Angeles. The company agreed to contribute $2.5 million of the $10 million needed for research, development, construction, and operation, and to provide the site. Since the major areas for development are in

the reactor itself, no equipment will be provided for the generation of electric power. Features of sodium-graphite technology have been described in preceding reports.

Experimental Breeder Reactor (EBR)

The first core of the Experimental Breeder Reactor was removed early in 1954, because the enriched uranium fuel rods had lengthened and were straining their stainless steel jackets. In March the reactor went into operation with a new core of enriched uranium alloyed with 2 per cent zirconium for longer life. Twenty samples of uranium 233, 235, and 238 and plutonium 239 were distributed throughout the core and the blanket so that new measurements can be made for a more accurate determination of breeding data. Plutonium fabricated at the Rocky Flats, Colo., plant will be used as the fissionable material in the third core which will be installed early in 1955.

Argonne is proceeding with the preliminary design of EBR No. 2. The laboratory has put into operation a heat transfer loop, pumping sodium at 750°C. and 40 gallons per minute through two-inch piping. Detailed design has begun on a large 10,000-gallon-per-minute electromagnetic pump, much larger than the SIR electromagnetic pumps.

The rebuilt Zero Power Reactor (ZPR II) at Argonne has just been loaded with U^{235} and U^{238} simulated fuel elements and is being operated as an exponential experiment to acquire information needed for a ZPR III, which will simulate a critical assembly first for the EBR No. 2 and later for a power-breeder reactor. Construction of a building for the ZPR III began in May at NRTS in the EBR No. 1 area and the design of the machine itself is in progress.

The design and specifications for most of the special equipment needed for a Plutonium Fabrication Facility at Argonne have been completed and bids on construction work have been solicited. This facility will be used to develop techniques for fabricating uranium-plutonium alloy fuel elements and to make such elements for EBR No. 2.

Homogeneous Reactors

In May dismantling of the original Homogeneous Reactor Experiment (HRE No. 1), its radiation shield, and its supporting equipment was completed at Oak Ridge National Laboratory to make way for HRE No. 2, which should be in operation by the summer of 1956.

HRE No. 2 will be larger than its predecessor and will provide operating experience over a long period. It will be the first homogeneous reactor plant to contain chemical facilities for processing the fuel solution. Large-scale components are being developed. Samples of zirconium, which will be the core material for HRE No. 2, and other reactor materials have been tested under irradiation for corrosion by static fuel solutions. More revealing dynamic tests are planned in which the samples will be exposed to fuel solutions circulating in a closed loop of piping placed inside the Low Intensity Test Reactor at Oak Ridge.

Design work has already been started on the next larger homogeneous reactor, the Homogeneous Thorium Reactor (HTR), which will have a heat output of 65,000 kilowatts. In addition to being closer to the size of a full-scale power plant, the HTR will consist of a two-region reactor—a highly enriched core surrounded by a blanket of thorium oxide suspended in heavy water. The core solution will be contained in a sphere of zirconium through which neutrons will pass into the thorium blanket to produce U^{233}. The reactor will be started up with U^{235} in the core, but later the use of U^{233} is expected to produce the small breeding gain of a U^{233}-thorium system.

NAVAL REACTORS

Submarine Thermal Reactor (STR)

Since the STR Mark I land-based prototype went critical at the National Reactor Testing Station in March 1953, the reactor has been operated by Westinghouse at design pressure and temperature for more than 3,700 hours for tests at various power levels. On May 27 the reactor completed 600 hours of equivalent full-power operation, the original life specification for the first core. This performance in the *Nautilus* would have propelled the submarine some 19,000 nautical miles under water.

Operation and testing, including determination of the life of the first core, will continue. A factor in determining core life is the measurement of the reactivity in the core available to overcome temporary xenon poisoning which would prevent start-up of the reactor for various periods after shut-down.

The USS *Nautilus*, to be powered by the STR Mark II, was launched by Electric Boat at Groton, Conn., on January 21. On June 5 the reactor core was transferred to the Navy and installed in the submarine. Dock trials are expected to begin in August and sea trials before the end of the year.

Submarine Intermediate Reactor (SIR)

The prototype submarine reactor, SIR Mark A, being constructed at West Milton, N. Y., by General Electric, is more than 90 per cent complete. The reactor is scheduled for operation in December 1954.

The USS *Sea Wolf*, which will be propelled by the SIR Mark B, is about 30 per cent complete at the Electric Boat yards in Groton. The present schedule calls for launching in April 1955, dock trials in the autumn of 1955, and sea trials in early 1956.

Submarine Advanced Reactor (SAR)

For some years the Navy has been interested in development of a submarine reactor which could utilize the technological advances made in reactor engineering since the specifications for the STR and SIR were frozen. During the past year Knolls Atomic Power Laboratory (KAPL) continued to investigate several possible designs for a Submarine Advanced Reactor (SAR) and has selected the pressurized water type. On April 9, 1954, the Military Liaison Committee informed the Commission that the Navy had established a requirement for a nuclear powered radar picket submarine to be propelled by an SAR power plant. The design chosen provides for a twin-reactor plant which would develop about 34,000 horsepower, more than twice as much as the STR and the SIR. To assist in the design of the SAR, KAPL is now constructing an experimental critical assembly, called the Advanced Test Reactor, which will begin operation about September 1954.

Submarine Fleet Reactor (SFR)

With the Commission's approval the Navy will finance the design and development of a Submarine Fleet Reactor (SFR) at Bettis Plant, Pittsburgh. An outgrowth of the STR, the new reactor power plant will be of less than half the power of the STR, to meet Navy requirements for a fleet "attack" submarine smaller than the *Nautilus* and not so fast.

AIRCRAFT NUCLEAR PROPULSION PROGRAM

A new design concept may hasten the day when nuclear powered aircraft will be practical for military purposes. The main feature of this design is a turbojet engine which can use nuclear heat alone or both nuclear heat and chemical heat. A supersonic, high altitude airplane equipped with such engines could be smaller than a similar plane powered completely by nuclear energy.* The additional power provided by chemical fuel would be for takeoffs and landings and for a very high altitude supersonic "sprint" over the target area. For the long cruise to and from the target at lower altitude and speed the plane would use nuclear power alone. The "cruise and sprint" tactics for nuclear powered aircraft would eliminate the need for refueling during long flights. This performance can probably be attained in a plane in which the reactor temperature would not have to exceed 1,500°F.

The major effort in developing aircraft reactors continues to be concentrated on two basic approaches. The first is the air-cooled direct-cycle concept being developed by General Electric. Work on the second approach, the fluid-fuel cycle, is the responsibility of Oak Ridge National Laboratory with assistance recently by the Pratt and Whitney Division of United Aircraft Corporation.

Air-cooled Cycle

A ribbon-type fuel element will be used by General Electric in the first of a series of air-cooled, direct-cycle cores to be tested at low power in the Initial Engine Test facility now under construction at Idaho. The 1.5-inch fuel ribbon consists of a thin (0.012 to 0.025 inch) "sandwich" with a nickel-chromium alloy as the "bread" and a mixture of this alloy and U^{235} oxide as the "meat." The core is a 30 × 30-inch aluminum hexagon pierced by 37 four-inch tubes containing the fuel ribbon.

Fluid-fuel Cycle

By June 1, Pratt and Whitney Division of United Aircraft Corp., Hartford, had closed out work on the supercritical water approach and joined its engineering support with Oak Ridge National Laboratory in developing the fluid-fuel type.

Assembly at Oak Ridge of the Aircraft Reactor Experiment (ARE), the first reactor to employ a fused fluoride salt fuel, was completed and operation in the near future is anticipated. Information from operation of the ARE and from other research and development work will be applied to a 60,000-kilowatt Circulating Fuel Reactor Experiment (CFRE) of the promising homogeneous "fireball" type.

Other Facilities

The Tower Shielding Facility, consisting of a 100-kilowatt water-cooled reactor and shield suspended from four steel towers, is now in operation at Oak Ridge to study shielding at sufficient heights to be free from ground effects of radiation. A similar reactor on the ground is

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*The Research and Development Subcommittee of the Joint Committee on Atomic Energy was briefed on this subject on March 17 by Major General James E. Briggs and on April 28 by Brigadier General D. J. Keirn.

being used by Consolidated Vultee Aircraft Corp., Fort Worth, Tex., to study the effects of radiation on various airplane parts. Corresponding tests will be made later in the year with a 1,000-kilowatt reactor in a conventionally powered plane.

STATIONARY MILITARY REACTORS

All three military services have expressed growing interest in small reactors which would produce electric power in remote locations and thereby eliminate the need for transporting bulky fuel. The Corps of Engineers has recently been given general responsibility in this field for the Department of Defense, and Army Engineer personnel assigned to the AEC were organized into the new Army Reactors Branch, which is coordinate with the Naval and Aircraft Reactors Branches in AEC's Division of Reactor Development.

The first reactor of this type will be constructed at an estimated total cost of $4 million at Fort Belvoir, Va., the training center for the Army Engineers. Expressions of interest in such an undertaking were solicited. Of those companies which expressed a firm interest in the project several were advised by the Contract Selection Board that it did not believe their qualifications were adequate to undertake the prime contractorship. Invitations to submit proposals on the design and construction of the power reactor will be sent to the remaining firms or groups and the award of a lump-sum contract will be made to the one whose proposal most favorably combines lowness of price, excellence of design for the purpose, and responsiveness to other factors in the invitation.

The basic design, as developed by Oak Ridge National Laboratory, calls for ordinary water as both moderator and coolant. But unlike the STR, the fuel plates of the package power reactor will be clad with stainless steel rather than zirconium in order to reduce costs of the over-all system. The core will contain 720 flat plates, each being a "sandwich" with stainless steel as the "bread" and a mixture of powdered, highly enriched uranium oxide, stainless steel, and boron carbide as the "meat." As in the next STR Mark I core, the presence of boron carbide as a burnable poison in the fuel elements will make possible a larger fuel charge and a longer core life. The reactor is designed to produce approximately 1,700 kilowatts of electricity. Pressure of coolant water will be 1,200 pounds per square inch. The reactor core, containing about 18 kilograms of U^{235}, is expected to have a life of about two years if operated at a 70 per cent load factor.

GENERAL ENGINEERING AND DEVELOPMENT

Idaho Chemical Processing Plant

Work has been started to increase by several times the capacity of the Idaho Chemical Processing Plant so that it can recover uranium from larger quantities of enriched fuel to be irradiated at Hanford and Savannah River. In addition, modification to provide for processing STR and SIR fuels and improvements indicated by the first year's operation have been in progress for some time. The improvements will be completed and the plant put back in operation in September.

Materials Testing Accelerator (MTA)

The MTA Mark I was dismantled following the final test runs in November. In the light of more optimistic forecasts of uranium receipts and the growing belief that accelerators will

not be able to compete with reactors in producing fissionable materials, the Commission is considering closing out production accelerator development by June 1955. The contract with California Research and Development Co. was terminated on June 30, 1954. The University of California Radiation Laboratory is preparing the first A-54 accelerator cavity for operation in October 1954; the second cavity will not be completed. In addition to operating the A-54, the Laboratory will conduct other limited research on accelerator development at Livermore until July 1955. (End of SECRET section.)

PART V

Physical Research

Project SHERWOOD (SECRET)

Just after the war scientists at Los Alamos and in a later independent effort scientists at Princeton began preliminary investigation of the possibility of achieving a controlled thermonuclear reaction for the purpose of producing useful power and neutrons for the production of fissionable material. Since that time the project has grown and now includes different approaches to the problem at Los Alamos Scientific Laboratory, at the University of California Laboratory at Livermore, and at Princeton.

The central problem is to develop methods of heating an ionized gas or "plasma" of the fusionable materials, deuterium and tritium, to temperatures of 10 to 100 million degrees Centigrade. To achieve such temperatures, the plasma must be confined by electromagnetic fields in vacua rather than by material containers. Although none of these groups has yet achieved a plasma temperature which would permit a detectable release of nuclear energy, encouraging results have been reported during the last six months. More manpower is now being devoted to Project SHERWOOD, and hopes for ultimate success are greater than at any time in the past.

The Los Alamos approach has been to confine the plasma to the axis of a toroidal tube by means of a magnetic field produced by a current flowing in the plasma itself, which is also heated by the current. A completely ionized plasma has been produced by this method at a temperature of nearly 50,000°C., more than ten times that at which a tungsten filament would be completely evaporated but still cool in terms of the temperatures required for the nuclear reaction. Further research on high-temperature phenomena will be directed toward achieving the higher temperatures required.

At Livermore a low-density plasma at a temperature of about 1,000,000°C. has been formed and sustained for several milliseconds by injecting ions into a cylinder where they are confined by the magnetic mirrors at either end. These encouraging results have suggested feasible measures for achieving substantially higher temperatures and greater densities.

The Princeton group has had some success in confining the plasma to the axis of a closed cylindrical tube, twisted into the form of a figure 8, with a magnetic field produced by a coil wound around the tube. The plasma is heated first by currents flowing in the plasma and later by a high-frequency device called a magnetic pump. An earlier experiment proved the validity of the figure 8 tube; current experiments are expected to produce temperatures at about 500,000°C.; and a later experiment will be designed for much higher temperatures, possibly sufficient for detectable nuclear reactions.

On the assumption that present experiments will produce favorable results, an engineering study based upon the Princeton method indicates that a thermonuclear plant equivalent to Boulder Dam in power output would be economical. (End of SECRET section.)

High-energy Accelerators (UNCLASSIFIED)

Operation of the Brookhaven cosmotron, and more recently the Berkeley bevatron, clearly demonstrates the tremendous research opportunities afforded by high-energy accelerators. The bombardment of various materials with fundamental particles accelerated to multi-billion-volt energies has revealed the presence of extremely intricate phenomena. Research with the cosmotron has already led to the detection of a great variety of particles heretofore found only in small numbers in cosmic rays. Only further research can answer the questions these experiments have raised concerning the fundamental nature of each newly observed particle. The heavy demand by scientists for research time with the cosmotron can be expected to grow indefinitely. For example, 54 experiments are in progress on the cosmotron, 29 of which involve the participation of other laboratories. New areas of research can also be expected to develop from work with the Berkeley bevatron, which operates in a somewhat higher energy range. To provide the means for a still broader attack on these problems, plans are going forward for a number of new accelerators, including a linear accelerator for electrons at Stanford University, the large alternating gradient synchrotron at Brookhaven, a high-energy accelerator in the Midwest, and heavy-particle accelerators at Yale University and at the University of California Radiation Laboratory.

Bevatron. Initial operation of the bevatron at the University of California Radiation Laboratory began in February. Performance continued to improve and by April 1 a proton beam energy of 6.1 Bev had been attained, about twice that of the cosmotron. Bombardment of targets with 6-Bev protons is expected to produce in abundance many particles heretofore never detected in a laboratory. There is particular interest in intermediate-weight mesons which have been found in a bewildering variety in cosmic rays, but only in small numbers. Also planned are absorption and scattering experiments involving protons, neutrons, and mesons.

Alternating gradient synchrotron. The use of the alternating gradient principle in the synchrotron to be constructed at Brookhaven is expected to permit proton energies of 25 to 35 Bev to be attained, about ten times those reached in the cosmotron. Before attempting to establish the final design for the full-scale machine, estimated to cost about $20 million, the Brookhaven staff will explore certain problems with a smaller scale experimental device. Because it will accelerate electrons, whose mass is a tiny fraction of the mass of a proton, the estimated construction cost for this device, known as an electron analogue, is only $640,000. Certain scientific development and preliminary design work on the full-scale synchrotron have also been authorized at a cost of $971,000.

Midwest accelerator. For more than a year scientists from the Midwest have been seeking AEC support for the design of a high-energy accelerator to serve the research interests of that region in the same way that Brookhaven serves the East. In June the Commission authorized Argonne National Laboratory to begin design studies for a multi-Bev accelerator, and to encourage university scientists of the region to join in the work. While no decision will be made in the near future concerning construction, the Commission has indicated its belief that Argonne is the logical location for such an accelerator and that its construction there would strengthen the laboratory's position as a regional center for unclassified research.

Linear accelerators. The 20-foot model of a high-energy linear accelerator to be constructed at Stanford University and two heavy-particle linear accelerators to be constructed at Yale University and the University of California Radiation Laboratory have been described in the Sixteenth Semiannual Report to the Congress.

Research Reactors

The interest of universities in constructing research reactors was stimulated by the University Research Reactor Conference held at Oak Ridge in February. As a result of the conference AEC has received many requests for further information from a number of universities and colleges. Over the past few years several universities and Government agencies have taken direct steps toward construction and operation of their own research reactors.

The only off-site research reactor now in operation is located at North Carolina State College in Raleigh. This 5-kilowatt "water boiler" reactor went critical in September 1953 with uranium 235 fuel loaned by AEC.

Pennsylvania State University and the University of Michigan will be loaned uranium 235 for their proposed "swimming pool" reactors presently under construction and in advanced design stage, respectively.

Washington State College, Texas A&M College, and Massachusetts Institute of Technology have made preliminary plans for reactor projects.

In designing its new 10-megawatt research reactor, Oak Ridge National Laboratory has selected a design similar to the Materials Testing Reactor in Idaho. Construction will begin in fiscal year 1955 at a total cost of $2.7 million.

The CP-5, a one-megawatt research reactor at Argonne, went critical in February. It was built at a total cost of $2.4 million to replace the CP-3 built in 1944. (End of UNCLASSIFIED section.)

Electrolytic Production of Thorium Metal (CONFIDENTIAL)

Horizons, Inc., has developed, under an AEC contract, an electrolytic process for making metallic thorium in powder form. The quality of the metal compares favorably with that produced by the calcium reduction process developed at Ames and now being used at Fernald. An economic evaluation of the process indicates that at a rate of about 1,000 tons per year powdered thorium could be produced more cheaply by this method than by the Ames process. (End of CONFIDENTIAL section.)

Ion-exchange Isotope Separation (SECRET)

An isotope separation process using ion-exchange resins has recently been devised by a group working under Dr. F. H. Spedding at Ames Laboratory. First experiments with this new method were successful in partially separating nitrogen 15 from the more common isotope, nitrogen 14. An experiment using the process for separation of uranium isotopes gave results consistent with those for nitrogen.

The important question which remains to be answered is whether the method can be used economically as a production process. The Ames group will continue its work by using the process to separate a relatively large quantity of nitrogen 15. Dr. Spedding will also continue experiments with uranium and will initiate others on isotopes of the rare earths. These

experiments may indicate whether the method would be feasible for plutonium separations, especially in the separation of the isotope 240 from plutonium used in weapons.

Plutonium Separations

Plutonium hexafluoride exists as a gas at ordinary temperatures. For that reason it is potentially useful in volatility processes for separation of plutonium from uranium, or possibly in the separation of plutonium isotopes by either the gaseous diffusion or centrifuge method. The properties of plutonium hexafluoride and methods of preparing it are under intensive study at Argonne. Similar work on a smaller scale has also been started at Knolls Atomic Power Laboratory in Schenectady. The compound has been prepared in gram quantities at Argonne by a technique developed at Los Alamos.

Elements 99 and 100

In little more than 10 years, research in atomic energy has resulted in the discovery of 12 new elements, including eight beyond uranium in the periodic table. The most recent discoveries were elements 99 and 100, which were first observed at the Argonne, Los Alamos, and Berkeley Laboratories in debris from the MIKE shot in the IVY test series of November 1952.

More recently isotopes of these elements have been produced by other methods. Isotope 247 of element 99 was produced in the 60-inch cyclotron at the Radiation Laboratory by bombarding uranium 238 with nitrogen ions. Both elements have also been identified independently by scientists at Argonne and Berkeley in samples of plutonium and other heavier isotopes irradiated in the Materials Testing Reactor at Idaho. (End of SECRET section.)

PART VI

Biology and Medicine

(CONFIDENTIAL)

Activities of the biology and medicine program are directed primarily toward the control of and protection against radiation hazards, as well as exploitation of the beneficial applications of atomic energy. Significant results of unclassified portions of this work are described in the Commission's Sixteenth Semiannual Report to the Congress. Two important classified aspects of the program have been selected for inclusion in this report: the collection of fall-out data from weapons tests and research on the long-term effects of fall-out.

World-wide Monitoring

During the 1954 spring test series at the Pacific Proving Grounds, the network of stations for world-wide monitoring of fall-out activity was expanded to resume full-scale operations. To the world-wide network were added collection stations aboard ships on regular travel routes in the Pacific Ocean and ten fixed monitoring stations on islands surrounding the Pacific test site. Samples collected by stations throughout the world were forwarded to the Commission's Health and Safety Laboratory in New York for measurement of radioactivity. In addition to the fixed network of stations throughout the United States, ten AEC installations also participated by collecting fall-out and forwarding data by telegraph to Washington for immediate evaluation and correlation with existing information. Evaluation of fall-out data provides the basis for establishing policies to ensure protection of the public, for answering public inquiries, and for furnishing prompt information to public health officials, the press, and affected industries such as the photographic industry.

Fall-out from March 1 Detonation

Exposure of test personnel. Following the detonation of March 1, heavy fall-out occurred after the explosion when winds carried radioactive particles toward the atolls of Rongelap, Ailinginae, Rongerik, and Utirik. Twenty-eight American test personnel of the Task Force were stationed on the island of Eniwetak in the Rongerik Atoll. All their film badges registered exposures of 40 to 50 roentgens, except that 98 roentgens were recorded on one badge representing exposures for three of the men. These three were stationed on another part of the island where fall-out was heavier. In addition to the 28 weather personnel, three Task Force members engaged in decontamination activities of small Task Force ships wore film badges showing readings of 85, 95, and 96 roentgens. There was some question whether these readings represented true body exposures since the badges might have been contaminated during ship-cleaning activities.

All of the 31 test personnel were evacuated to Kwajalein for physical examinations and medical observations. They were later transferred to Tripler General Hospital at Honolulu and have since been returned to military duty. While 11 of these men had barely perceptible burns apparently due to beta radiation, none experienced symptoms of radiation illness. Medical observations to date do not indicate that any permanent harm to their health will result from the exposure.

Exposure of Marshallese. All of the persons on Rongelap, Ailinginae, and Utirik were evacuated by the Task Force to Kwajalein. The estimated whole-body gamma dose to which these people were exposed was as follows: Rongelap (64 persons) 150 roentgens; Ailinginae, transients from Rongelap (18 persons), 75 roentgens; and Utirik (154 persons) 15 roentgens. These estimated doses do not take into account the contributions of soft gamma rays and beta radiations, which are difficult to estimate but were probably significant. Although the estimated lifetime exposure from the radiation levels observed at Utirik was not considered hazardous, it was decided to evacuate the people in order to minimize their exposure. Thus, possible maximum exposures of 60 roentgens were limited to about 15 roentgens.

Of the 82 persons whose home island was Rongelap, 74 experienced slight to moderate radiation burns, principally on the scalp and neck. In 39 of these cases hair fell out in patches. However, normal hair regrowth is taking place. Urinalyses for radioactivity indicated that fission products had been ingested or inhaled. In no case do preliminary data show a body burden for the various radioactive isotopes in excess of the permissible limits.

At Kwajalein the evacuees were provided immediate comfort and care by the Naval Station medical staff. These people were later attended by the 21-man joint AEC-DOD team of medical specialists under direction of the U. S. Navy Medical Corps Commander, with logistical support from the Naval Station personnel. Routine sick call and medication, physical examinations, and serial blood counts were continued throughout their stay. Results to date indicate there is no reason to expect any permanent after-effects on their general health. Nevertheless, AEC will continue periodic observation and physical checkups to reassure these people.

Resettlement. The inhabitants of Utirik have all been returned to their home islands. The Rongelap people were moved to new dwellings built for them on the island of Ejit, in the Mojuro Atoll, where it is expected they will remain for six months to a year before being reestablished on their original home islands. They are now being furnished with livestock, provisions, and other supplies necessary to maintain the living standards enjoyed prior to March 1. Similar assistance will be given when they are returned to Rongelap.

Analyses of soils from the islands in the path of fall-out showed that the quantity of radioactive material present was not sufficient to endanger plant growth directly, nor to make the crops inedible. Also, fish in the home island lagoons are safe for human consumption. Since the water supplies in the cisterns were found to contain a greater concentration of radioactivity than desirable, these cisterns are being emptied, cleaned, and refilled with fresh water. (End of CONFIDENTIAL section.)

Radiological Hazard from Fall-out (SECRET)

Although radioactive fall-out in the Marshall Island Atolls from the nuclear detonation of March 1 unfortunately did produce some undesirable results, it also provided the most reliable information yet obtained concerning the distribution and quantity of fall-out from surface-detonated large-yield nuclear devices. For example, fall-out on the northern uninhabited islands of Rongelap Atoll, some 100 miles downwind from the detonation site, was sufficient to have delivered a lethal dose to an unshielded population in less than 24 hours.

The shape of the fall-out pattern produced by the March 1 detonation is shown on the accompanying map (Figure 1). For purposes of illustration, the pattern is superimposed on a portion of the east coast of the United States, with Washington, D. C., as a ground zero and the main path of the fall-out intentionally reoriented northeastward toward other major population centers. The shaded areas on the map are separated by isodose lines which connect locations having equal lifetime radiation doses expressed in roentgens. In the calculation of these radiation doses, it has been assumed that no loss of radioactivity occurs through weathering and that an unshielded population remains in the area until the radioactivity has decayed to insignificant levels.

The positions of the isodose lines are necessarily estimated in areas corresponding to the open sea, where no direct measurement was made. Also, uncertainties exist in the constructed pattern since a device detonated over a small Pacific island may not necessarily produce the same fall-out pattern as a detonation over densely populated land such as a large city. However, the extrapolations in either case would probably not introduce errors of such magnitude as to make a wholly invalid comparison. Thus, assuming the comparison is valid and taking one point of reference on the map, the data indicate that an unshielded population in Philadelphia, for example, would have received a lethal dose (LD-50, i.e., killing half of the population) in the first 24 to 48 hours after the fall-out occurred.

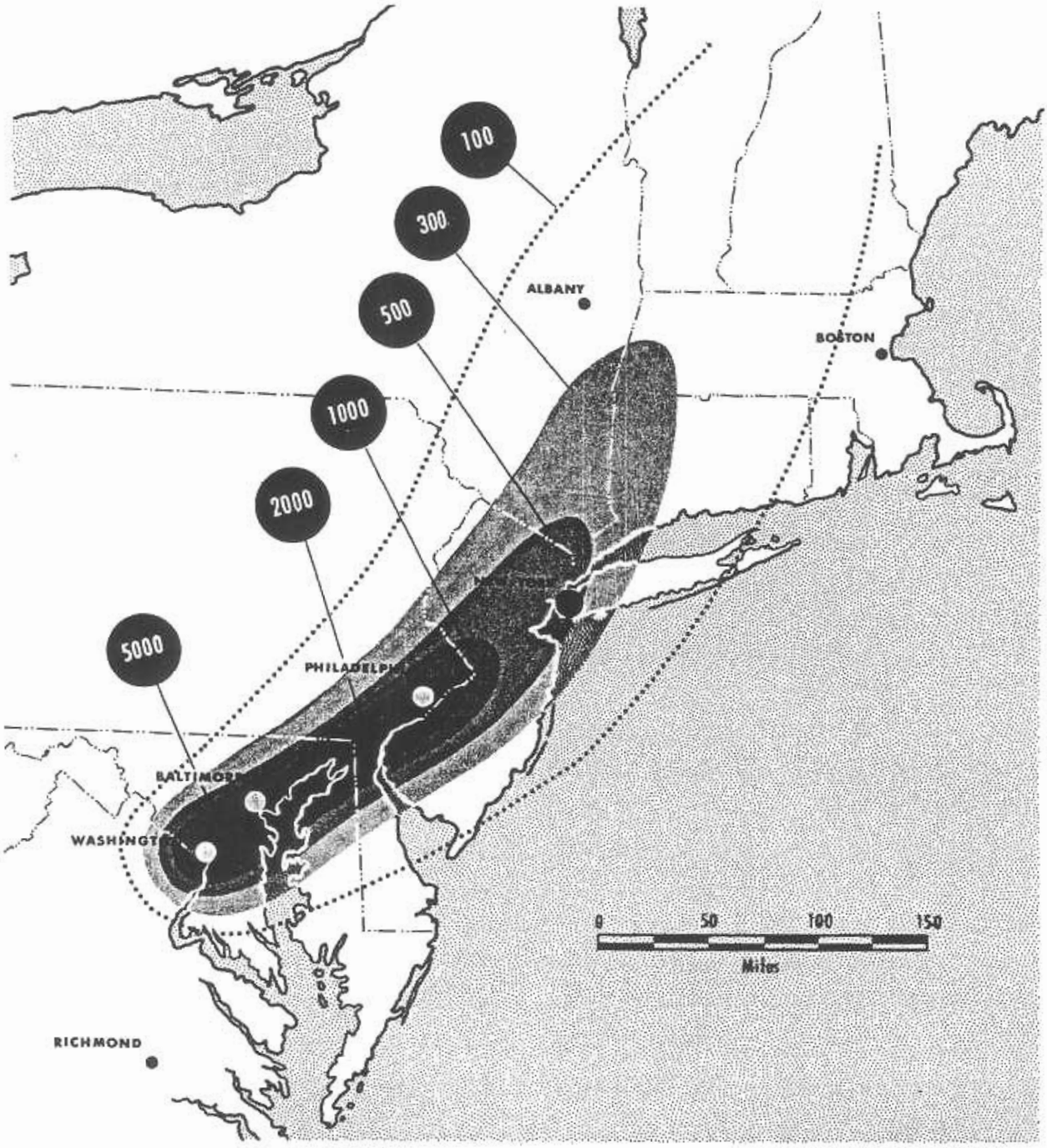
Project GABRIEL

With a view to the possible long-term hazards from the dissemination of bomb debris over large fractions of the earth's surface, the properties and occurrences of various radioisotopes have been carefully reviewed. Evidence still points to strontium 90 as the critical isotope. Research studies conducted by Rand Corporation under Project GABRIEL are nevertheless being extended to include more critical evaluation of the possible hazard from radioisotopes of other chemical elements, particularly ruthenium and iodine. Recent evidence shows that iodine 131 may serve as a very sensitive index to the world-wide uptake by humans of fission products from bomb debris.

Exploratory sampling to determine the occurrence of strontium 90 in soils, plants, milk, animals, and humans from various parts of the world is well under way. With the aid of the Departments of State and Agriculture, samples of one or more of these materials have been obtained from some 20 countries. Assays of most of the foreign samples are yet to be made. In general, quantities of strontium 90 thus far observed fall within anticipated ranges.

Sufficient information is not yet available on the sequence of processes by which fission products from weapons tests become incorporated in the human body. More accurate estimates are needed of the distribution of fission products from the individual events involved; the step-by-step process by which fall-out materials reach the human body; effects of age and diet on human uptake; distribution and retention in the body; and evaluation of radiotoxicity in humans under various conditions. For example, there may be great differences in the world-wide effects of the fission products from a megaton detonation in the Pacific as compared to a number of smaller events giving the same total yield but spread over North America, Europe, and Asia.

Rand Corporation, exploring another phase of the problem during the past two years, is in the process of preparing for publication a report on this portion of their work. The report covers the deposition of radioactive debris for periods beginning a few minutes after detonation and extending up to one week. Data are also included on the formation and rise of the atomic cloud, the nature of the bomb debris, and the fall-out, rain-out, and dispersal of the debris


100
300
500
1000
2000
5000
ALBANY
BOSTON
PHILADELPHIA
BALTIMORE
WASHINGTON
RICHMOND
0
50
100
150
Miles

through the atmosphere. Certain representative situations are discussed, and estimates are presented of the hazards from rain-out and fall-out, together with the methods of making these estimates.

Conclusions drawn in the above report, together with direct observations on near-surface weapons tests, make it increasingly apparent that in the event of war involving nuclear weapons, radiological exposure incurred from gross radioactive fall-out in the several hours or days immediately following near-surface detonations of such weapons may be of major importance to both military and civil defense operations. (End of SECRET section.)

Figure — 1 (On facing page.)

FALL-OUT PATTERN FROM MARCH 1 DETONATION SUPERIMPOSED ON EASTERN UNITED STATES

The fall-out pattern from the March 1, 1954, detonation at the Pacific Proving Grounds was superimposed on eastern United States with Washington as ground zero and the direction of fall-out intentionally oriented as shown. The lifetime isodose lines expressed in roentgens were estimated according to certain assumptions given in the text.

Appendix A

NOTES ON INTERNATIONAL MATTERS

Notes on International Matters

(SECRET)

The Commission's role in international activities has assumed greater importance during the past six months as a result of several developments: foreign interest in the public hearings on the proposed changes in the Atomic Energy Act; the plans for an international atomic energy conference of scientists; the Japanese fishing boat incident; and the reconvening of disarmament discussions in New York and London.

Draft Legislation

The public hearings on the proposed legislation to amend the Atomic Energy Act have been followed closely by foreign observers. If the amendments relating to the Commission's international activities are enacted, a greater number of requests for technical activities may be expected from foreign countries, particularly from the Commission's present and potential foreign ore suppliers.

International Control of Atomic Energy

Pursuant to the United Nations General Assembly resolution of November 28, 1953, a five-power subcommittee representing the United Kingdom, Canada, France, the United States, and the U.S.S.R. was established to continue private discussions on the international control of atomic energy and conventional disarmament. The subcommittee held meetings in London from May 13 to June 22 and was to report to the full Disarmament Commission in late July. In an attempt to force the U.S.S.R. to clarify their objections to the United Nations (Baruch) plan, the United States delegation maintained the position of continuing to support the plan, which had been rejected by the U.S.S.R. in previous discussions. At the same time, United States disarmament policy has been under review by AEC and by the Departments of Defense and State to determine what revisions, if any, in United States policy are required in the light of recent developments in nuclear science and technology.

International Conference of Scientists

As announced by Chairman Strauss in April, the President plans to call an international scientific conference on the peacetime uses of atomic energy. Specific plans have not been developed, but it is expected that the conference will not be held until sometime early in 1955.

Extension of Belgian Agreement

The present intergovernmental agreement with Belgium, the basis for the procurement of uranium from the Belgian Congo, will expire in 1956 unless extended sooner. Negotiations for an extension of the agreement were suspended early in March by mutual agreement pending action by the Congress on proposed amendments to the Atomic Energy Act. In the meantime AEC has continued to give unclassified assistance to the Belgians in connection with their reactor project.

Japanese Fishing Boat Incident

The Japanese fishing boat, Fukuryu Maru No. 5, and its 23-man crew were exposed to radioactive fall-out from the March 1 test. The incident did not become known until mid-March when the report was first published in a Japanese newspaper. According to information subsequently supplied by Japanese authorities the Fukuryu Maru was carrying on normal fishing operations in the vicinity of the Marshall Islands when the crew saw a red flash followed seven or eight minutes later by the sound of an explosion. The position of the vessel at the time of the occurrence as recorded in the log was 11° 53¼'N and 166° 35¼'E. If accurate, this position would place the vessel approximately 19 miles outside the easternmost limit of the danger zone in effect at that time. A white ash, the crew reported, began to fall about three hours later. Fishing operations were discontinued shortly afterwards and the ship headed away from the warning area and started back to Japan. Although the vessel was in almost daily radio contact with Japan, no mention was made of the incident and no report was made by the personnel of the vessel until two days after the ship had returned to its home port in Yaizu. By this time the vessel's catch had been distributed in the fish markets, although it is believed that all of the cargo was subsequently recovered by the Japanese and destroyed.

Japanese reports alleged that the ship and its catch were highly radioactive and that 10 crew members were suffering from radiation injuries. It was reported that two were in serious condition and that all showed symptoms of skin burns and falling hair. Ambassador Allison in Tokyo, at the request of the AEC and with the concurrence of the Department of State, immediately offered the services of United States medical and technical personnel and proposed a joint investigation of the incident. Pending the conclusion of this investigation the Ambassador gave assurances that the United States Government was prepared to reimburse the Japanese Government for such financial assistance as the Government and Embassy jointly might find necessary as an interim measure. The Ambassador proposed that the following concrete steps be taken:

1. That the Japanese authorities allow the United States Navy to decontaminate the vessel or, as an alternative, that the Japanese Government sink the vessel at sea, or prevent access to it;

2. That full access to the patients be given to United States doctors and technicians;

3. That an inventory be taken of all radioactive ash, clothing, etc., and that such materials be placed in the custody of responsible government officials; and

4. That a central authority be established for the review of all official reports scheduled to be published.

To render any assistance requested by the Japanese authorities, Dr. John Morton of the Atomic Bomb Casualty Commission in Hiroshima and Mr. Merrill Eisenbud of the Commission's New York Operations Office were sent to Tokyo.

As an additional precaution against the recurrence of similar incidents in the CASTLE series, an enlarged danger area was announced on March 22. The announcement was carried in *Notice to Mariners*, as had been done in the case of the previously designated area. At the conclusion of the series, the danger area was disestablished.

Repeated attempts to gain access to the patients so that United States medical personnel could advise appropriate therapeutic treatment were unsuccessful. United States doctors were allowed to see the patients on a few occasions. They were not, however, permitted to make complete clinical examinations, according to United States standards, although Dr. Morton was permitted to examine two of the crewmen in the Tokyo University Hospital on March 19. At the request of Japanese officials urine samples were dispatched to the Commission's New York Operations Office for analysis and the results were transmitted to the Japanese. The medical information available to the Commission, therefore, consists of limited data from the urinalyses performed in New York and other incomplete data derived from clinical observations and laboratory tests made by the Japanese themselves and transmitted to the Commission. On the basis of these incomplete data Commission doctors would not be warranted in drawing any conclusions regarding the conditions of the patients or in making any predictions as to the ultimate outcome of these cases. However, Dr. Masao Tsuzuki, a leading Japanese physician, reported to Chairman Strauss during a visit to Washington in May that the patients were making satisfactory progress toward recovery.

Offers by the United States to decontaminate the Fukuryu Maru or to buy it were refused by the Japanese authorities, and the vessel was eventually purchased by the Japanese Government, reportedly for investigation by their own scientists. United States technicians were never allowed to make a complete examination of the vessel, and only a small amount of deck sweepings was made available for analysis.

The Japanese press reported widely that the fish from the Fukuryu Maru were heavily contaminated, but little information is available to the Commission to verify the fact or the degree of radioactivity for this or for later fish cargoes also reported to be radioactive. All fish brought to Japanese ports from the test area were monitored by the Japanese for several weeks, and the U. S. Food and Drug Administration is continuing to monitor fish shipments to west coast ports of the United States on a spot-check basis. Although Japanese newspapers have continued to report incoming shipments of contaminated fish, no fish monitored in Japan have, to our knowledge, been found to be contaminated in edible fish parts. What low level radioactivity has been detected has been on skin surface or in the intestinal tracts, and even these counts have been of no health significance. In west coast monitoring operations three fish have been found to contain traces of radioactivity but not in amounts constituting a health hazard.

The Commission deposited with the Department of State the sum of $25,000 for the purpose of making such interim compensation payments as the Embassy and the Japanese Government might agree upon, pending the outcome of the joint investigation. Because of the lack of cooperation on the part of some Japanese authorities, however, the joint investigation of the incident was never made. When it became clear that there would be no cooperative investigation, Ambassador Allison proposed that the United States immediately attempt to negotiate a lump sum, *ex gratia* settlement with the Japanese Government and thus bring the incident officially to a close. This proposal was accepted by the State Department and the Commission, and the negotiations for the settlement have been undertaken by the State Department and Ambassador Allison. The President has determined that Mutual Security Agency funds up to $1,000,000 can be made available for the settlement with the Japanese Government.

The intelligence aspects of this incident were taken up by Ambassador Allison with the Japanese Government, and detailed information on the background of the crew members was transmitted to the United States. In addition, a number of searching questions were put to the Japanese authorities, but no evidence of espionage activities has been established.

Marshall Islands Petition

On April 20, 1954, a petition was addressed to the United Nations by residents of the Marshall Islands which lay in the path of the fall-out from the March 1 test. The Marshallese requested that no further experiments be held in the area. They further urged that all possible precautionary measures be taken if additional tests are found necessary, and that the residents in the area be instructed in safety measures. Adequate compensation was also requested for persons who might have to be moved from their homes. The petition came before the United Nations Trusteeship Council for discussion on July 7.

The U.S.S.R immediately took this opportunity to submit to the Council a resolution declaring that hydrogen bomb experiments in trust territories were inconsistent with the United Nations Charter and with United States obligations under the trusteeship system. The resolution called for the cessation of United States tests in trust territories, full compensation to persons affected by recent tests, and restoration of the full right of the inhabitants to all land used for testing. The Indian delegate stressed the legal aspects of the problem and called for an advisory opinion by the International Court of Justice on the legality of using trust territories for nuclear tests. The United States took the position that the Marshall Islands were selected for nuclear test experiments only after the most careful examination of every possible alternative site. Furthermore, it was pointed out that the trusteeship agreement of 1947 was predicated upon the fact that the United Nations clearly approved these islands as a strategic area in which atomic tests had already been held. From the very outset, therefore, the United States interpreted the right to close areas for security reasons as including the right to close them for atomic tests, and had so notified the United Nations.

Although giving renewed assurances that every precaution and safeguard would be taken in conducting future experiments, the United States refused to surrender the right to conduct further tests in this area. This position was firmly supported by the delegations from Belgium, France, and the United Kingdom especially. These three governments introduced a joint resolution which expressed the Council's regret over the incident and noted with satisfaction the steps taken by the United States. It was further recommended that, if future experiments were undertaken in the area, the United States take all possible precautionary measures, including those requested in the Marshallese petition.

In the final outcome the Russian and Indian resolutions were defeated and the joint Belgian-French-United Kingdom resolution was adopted. The Indians have indicated that they intend to reintroduce their resolution referring the question to the International Court of Justice when the General Assembly reconvenes in September. (End of SECRET section.)

Appendix B

TABLE OF EXPENDITURES

EXPENDITURES FOR ATOMIC ENERGY PROGRAM

Fiscal Years 1953-1956 (in Millions)

	Actual FY 1953	Estimate FY 1954*	Estimate FY 1955	Preliminary Estimate FY 1956
OPERATING EXPENSES				
Operating Costs:				
Raw Materials	$ 81.4	$ 145.0	$ 213.0	$ 306.6
Fissionable Materials	199.6	272.0	518.3	641.0
Weapons	228.0	219.0	273.3	323.7
Reactor Development	92.4	83.3	93.5	111.5
Physical Research	38.4	38.9	40.7	48.0
Biology and Medicine	24.9	24.5	27.0	27.0
Community Operations	1.3	(1.5)	(1.7)	(1.7)
Program Direction and Administration	34.0	33.3	33.0	33.0
Security Investigations	12.5	12.5	9.6	10.0
Total Costs	712.5	827.0	1,206.7	1,499.1
Working Capital & Inventory Changes	(5.6)	(17.0)	(0.7)	22.4
Operating Expenditures	706.9	810.0	1,206.0	1,521.5
PLANT AND EQUIPMENT				
Costs Incurred	1,125.5	1,166.0	1,057.0	575.0
Working Capital Changes	(41.5)	(26.0)	12.0	3.5
Plant and Equipment Expenditures	1,084.0	1,140.0	1,069.0	578.5
Total Expenditures	$1,790.9	$1,950.0	$2,275.0	$2,100.0

* Expenditures for month of June estimated. Final report for fiscal year not available.

Appendix C

CONSTRUCTION PROGRESS SCHEDULES

CONSTRUCTION STATUS OF PRINCIPAL TECHNICAL FACILITIES

Project Name and Location	Per Cent Construction Completion							Construction Dates		Estimated Cost[a] (in Millions)
	Fiscal Year 1954 (Actual)			Fiscal Year 1955 (Scheduled)						
	Dec. 31	Mar. 31	June 30	Sept. 30	Dec. 31	Mar. 31	June 30	Start	Scheduled Completion	
FISSIONABLE MATERIALS										
Hanford Operations										
Graphite reactors (KW and KE)[b]	42	63	83	*90*	*97*	*99*	*100*	Sept. 10, 1952	May 1, 1955	$ 175.5
KW reactor	50	71	90	*99*	*100*			Nov. 13, 1952	Nov. 1, 1954	Included in above
KE reactor	28	52	75	*81*	*94*	*99*	*100*	Dec. 22, 1952	May 1, 1955	Included in above
Separations plant	18	31	51	*86*	*99*	*100*		Feb. 3, 1953	Feb. 1, 1955[b]	75.0
Oak Ridge Operations										
Oak Ridge:										
Gaseous diffusion plant (K-33)	41	65	85	*94*	*98*	*99*	*100*	July 16, 1952	June 1, 1955	317.4
Alpha 5 plant	[c]	2	11	*33*	*51*	*66*	*78*	Oct. 22, 1953	Sept. 1, 1956[d]	260.0
Paducah:										
Gaseous diffusion plant (expansion)[b]	36	54	70	*82*	*93*	*98*	*99*	Aug. 26, 1952	Nov. 1, 1955	379.6
C-35 process building	60	94	99	*99*	*100*			Aug. 26, 1952	Dec. 1, 1954	Included in above
C-37 process building	20	31	50	*70*	*88*	*97*	*99*	Sept. 8, 1952	Nov. 1, 1955	Included in above
Portsmouth:										
Gaseous diffusion plant[b]	6	12	21	*37*	*51*	*66*	*80*	Oct. 20, 1952	Nov. 15, 1956	1,101.4
X-30 process building	9	22	37	*65*	*82*	*95*	*99*	Mar. 24, 1953	Sept. 1, 1955	Included in above
X-26 process building	1	4	8	*22*	*34*	*51*	*71*	July 1, 1953	July 1, 1956	Included in above
X-33 process building	[c]	1	6	*12*	*28*	*45*	*64*	Sept. 29, 1953	Sept. 1, 1956	Included in above

Savannah River Operations										
Savannah River production plants[e]	80	86	90	*95*	*96*	*97*	*98*	Jan. 18, 1951	Jan. 1, 1956	$1,398.0
Production reactors	75	84	91	*98*	*99*	*99*	*100*	June 1, 1951	May 1, 1955	652.7
R area	99	100						June 1, 1951	Jan. 1, 1954	Included in above
P area	98	100						July 27, 1951	Mar. 1, 1954	Included in above
L area	85	98	99	*100*				Oct. 3, 1951	Aug. 1, 1954	Included in above
K area	62	80	95	*99*	*100*			Oct. 29, 1951	Nov. 1, 1954	Included in above
C area	26	42	62	*88*	*96*	*99*	*100*	Feb. 27, 1952	May 1, 1955	Included in above
Separations facilities	64	70	75	*81*	*89*	*97*	*99*	June 8, 1951	Oct. 1, 1955[bf]	371.7
F area	90	96	98	*99*	*100*			June 8, 1951	Dec. 1, 1954	Included in above
H area	29	36	45	*62*	*77*	*94*	*99*	Sept. 24, 1951	Oct. 1, 1955[bf]	Included in above
REACTOR DEVELOPMENT										
Idaho Operations										
Aircraft nuclear propulsion (Phase I)	25	38	56	*77*	*84*	*91*	*99*	Sept. 16, 1952	July 15, 1955[b]	16.7
Schenectady Operations										
West Milton:										
Submarine Intermediate Reactor (Mark A)[b]	73	84	94	*100*				Apr. 8, 1952	Sept. 25, 1954	27.8

[a] Based upon the fiscal year 1955 budget as approved by Congress.
[b] Construction schedule or date revised since previous report.
[c] Less than 1 per cent.
[d] Completion date revised because of increase in scope. Date is tentative.
[e] Excludes Dana heavy water plant.
[f] Date is tentative.