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MINUTES

Forty-second Meeting of the General Advisory Committee
to the U. S. Atomic Energy Commission

November 3 and 4, 1954
Washington, D. C.

[redacted]

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CLASSIFICATION CANCELLED
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BY AUTHORITY OF DOE/OC
Carl Wilson 5/22/84
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Minutes, Forty-second Meeting, GAC

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FIRST SESSION
(November 3, 1954)

The meeting began at 9:10 a.m. All members, the Secretary, and Mr. Tomei were present.

Executive Session

Dr. Rabi, presiding, first raised the question of the Chairmanship of the Committee. In view of the existence of an interval during which he was not a member of the Committee (after the expiration of his previous appointment) the status of the Chairmanship was not clear. Mr. Whitman moved that Dr. Rabi continue to serve as Chairman. There were several seconds, and unanimous affirmative acclamation.

Chairmanship of the GAC

In view of the new membership it was necessary to reorganize the Subcommittees. Dr. Rabi asked the members to serve as follows.

Reorganization of Subcommittees

Subcommittee on Reactors, Materials and Production: Mr. Whitman, Chairman; Mr. Murphree, Dr. Warner, Dr. Wigner, Dr. Johnson. Subcommittee on Research: Dr. Wigner, Chairman; Dr. McMillan, Dr. Johnson, Dr. Fisk, Dr. Warner, Dr. Beams. Subcommittee on Weapons: Dr. Fisk, Chairman; Dr. McMillan, Dr. Beams, Mr. Murphree, Mr. Whitman.

Dr. Wigner said he was sure he would not make a good Chairman of the Subcommittee on Research, but was persuaded to serve for at least one meeting on a trial basis. There were no other objections to the constitution of the Subcommittees.

The Chairman next called for the report of the Reactor Subcommittee on the reactor development program. Mr. Whitman began a review of the report, which was partly available in draft form. (Secretary's Note: The complete report was ultimately adopted by

Report of the Reactor Subcommittee

the full Committee, and was transmitted to the Commission as part of the Report of the 42nd Meeting. Appendix D. Hence the point-by-point review is not recorded here.)

Dr. von Neumann and Dr. Libby joined the meeting during Mr. Whitman's presentation.

At 10:00 a.m. Mr. Campbell and Mr. Nichols joined the meeting; and Mr. Whitman's report was interrupted for the scheduled session with the Commissioners and General Manager. Mr. Strauss and Mr. Murray were not present for this session.

Meeting with the Commissioners and General Manager

Reactor Training School

The first subject brought up was the proposed reactor training school for foreigners. Dr. Libby said that the school would involve data which are now classified as Secret, and that there was a pressing question whether the school could operate in the Gray Area, or whether declassification would be necessary. There was some discussion of the concept of the school. The nature of the need appears to cover a broad range. Some peoples, e.g., Latin America, would find a course of lectures on the theory of reactor technology very useful. Such a course might be unclassified. Technologically more advanced nations, e.g., the Germans, would be more desirous of actual experimental work in the field -- experiments with hot slugs, etc. This type of instruction could not be given on an unclassified basis.

Mr. Nichols observed that the Commission could run an unclassified school for anybody, but that a classified school, including

instruction in the Gray Area, would require Congressional recognition of the International Agency, or the negotiation of a bilateral agreement with the nation concerned. Bilateral agreements would probably be different with different nations. This would sharply raise problems of treating people differently at the same site. Dr. Johnson said that whereas it would appear feasible to treat materials on a bilateral basis it would be very difficult to treat information in this way. There was some discussion of the problems which arise in connection with the Gray Area, the Reactor School, and the President's Plan. Dr. Libby said that the advice of the GAC would be appreciated.

Next, Dr. Libby referred to personnel security policy as a serious matter. He said that the Commission intended to form a committee of the Laboratory Directors in January to consider it. In the meantime, the comments of the GAC would be appreciated. He went on to say that the present thinking was (1) to maintain a policy of peace and quiet for a while, and (2) about the first of the year to consider any changes rather seriously.

Personnel Security Policy

Mr. Nichols raised the question of the release of information on fall-out, which, he said, was a serious problem, with international aspects. How such information would affect our relations with allies was very important. Dr. Rabi asked whether we are actually guarding any information -- how much is already known by our allies? Dr. Libby said that the British have constructed a good and accurate map of a

Fall-out

fall-out ellipse from a hypothetical burst by scaling up data from the Jangle test. He also referred to an article in the Bulletin of Atomic Scientists, in which fall-out estimates too low by a factor of five to ten were given. Apparently the information is not completely in the public domain; whether it is worthwhile to restrict it is another question.

Other matters on which the Commission would like advice were the Fermi prize, and recent intelligence information. Also, the question of whether the krypton program should be maintained, in view of the magnitude of the Kr contribution from weapon tests, would come up soon. Mr. Nichols said the main questions about the krypton program were (1) is it worth continuing, and (2) how important are the British in the program, and can we in fact exchange the relevant information with them without divulging weapons information.

Meeting Schedules

Mr. Nichols informed the Committee that the Commission was trying to organize its schedules on a monthly basis. He had asked the GAC to cooperate by having its meetings during the first week of the month when possible. The third week would be almost equally satisfactory. The main thing would be to miss the second week. Dr. Rabi said the Committee would try to schedule its meetings as suggested but that this might not always be possible because of the other commitments of the nine members.

A few matters pertaining to the reactor program received comment by Mr. Nichols. To implement the "Reactor-of-the-Year" concept would

require that the reactor program be accelerated. The ANP program has a high priority. The military can keep a high pressure on this program. The problem was how to keep the same type of pressure on the peacetime program. In answer to a question from Dr. McMillan he said the AEC has not yet set up any official projects on nuclear propulsion for rockets but was not discouraging the development of interest at Los Alamos, Livermore, and elsewhere.

At 10:55 a.m. the visitors, except for Dr. von Neumann, left the meeting. At 11:00 a.m. Dr. Reichardt met with the Committee to discuss intelligence matters.

Intelligence Matters

The main item was the very recent series of Russian explosions. The information and technical inferences available at the time are given in the following table.

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Possible Interpretations of Russian Tests

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At 11:35 a.m. Dr. Reichardt left, and Dr. Libby and Dr. T. H. Johnson joined the meeting. Shortly thereafter, Mr. A. Tammaro and Dr. W. J. Knox also entered.

Fermi Award

Dr. Libby stated the Commission's intention to establish an award in Enrico Fermi's name for the purposes of honoring Dr. Fermi, furthering the cause of international cooperation, and discharging the statutory responsibility of the AEC to encourage scientific research and development in the nuclear field. The Commission had authorized the first award to Dr. Fermi himself. It would be called the AEC award in this instance, since the establishment of a continuing award in Dr. Fermi's name has not yet been acted on. The award would include a citation, a medal, and the sum of twenty five thousand dollars. The Atomic Energy Act requires the recommendation of the GAC and the approval of the President for each such award. The Commission wished to have the advice and recommendations of the GAC.

Mr. Whitman moved that the GAC recommend that the first award be given to Dr. Fermi; Dr. McMillan seconded the motion. The motion was passed unanimously, all nine members voting. (Secretary's Note: This action was transmitted to the Commission by letter of I. I. Rabi to Lewis L. Strauss, November 5, 1954. Appendix C. See also, Appendix B, item 8.)

There were expressions of very favorable commendation on the concept of the award and on the selection of its first recipient.

Dr. Knox displayed various formats which had been drawn up for the award citation. Dr. Libby asked for the Committee's advice on the wording of the citation.

There was some discussion of whether it would be desirable for the National Academy of Sciences to take a part in the granting of these awards. No conclusion was reached, but the sentiment seemed to be that it would not be desirable.

At 11:50 a.m. the visitors left, and the meeting continued in an executive session.

Executive Session

Mr. Whitman continued the presentation of the report of the Reactor Subcommittee, discussing the ANP program, the SGR, the fast breeder, and the homogeneous reactor. A point which emerged in the Committee's discussions was that it would be desirable to review the progress on the various ANP projects in about six months. It was suggested that the Committee ask for such a review to be set up, and that the review include plans for an integrated power plant system.

Report of the Reactor Subcommittee

At 12:30 p.m. this session was adjourned.

SECOND SESSION
(November 3, 1954)

At 1:30 p.m. the Committee met with Gen. K. E. Fields, Dr. P. C. Fine, and Dr. von Neumann. All members and the Secretary were present. Mr. Tomei was not present.

Weapon Matters

Gen. Fields reviewed the status of the thermonuclear program,

Status of Thermonuclear Program

with particular reference to a paper (letter K. D. Nichols to Gen. Herbert B. Loper, October 25, 1954, LXI-2918) on the subject. Some of the items were as follows.

Since July the [redacted] design has been firmed up. It will weigh 8500 lb and give [redacted] Some units should be at Sandia in late February or early March, and the weapon should enter the stockpile in April. The design release on the [redacted] 17,500 lb) is anticipated by year's end, and the weapon should enter the stockpile by August. The normal [redacted] will be produced to supplement the production of the [redacted] is in short supply.

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The Department of Defense has asked about the possibility of reducing the fission yield in the large thermonuclear weapons. This is being investigated.

Fission Weapons

In the field of fission weapons the MK-13 has been cancelled, with DOD agreement. This was the improved MK-6 60" weapon.

TEAPOT Test

The AEC has proposed and the President has approved Test Operation TEAPOT, scheduled to start February 15, 1955 at the Nevada Proving Ground. Tentatively, twelve shots are proposed, four of them over 25 KT. Gen. Fields reviewed the list (given in a document before the Committee, memorandum Gen. K. E. Fields to Chairman, GAC, September 16,

1954.) He said that detailed shot programs had been requested from Los Alamos and Livermore for early December review. It was hoped that the GAC would review them as soon as possible.

At 2:00 p.m. Col. V. G. Huston and Col. R. D. Gahl entered the meeting.

With regard to possible duplication in the three case tests scheduled for TEAPOT, Gen. Fields said that Dr. Bradbury and Dr. York had discussed them and felt all three were warranted.

To minimize fall-out incidents, the large shots will be interspersed between small shots. Shots will be made only when rigid weather criteria are met. The operation will be difficult, and long delays (for good weather) in the big shots may be anticipated.

Possible Tests, Fall 1955

Gen. Fields said that a smaller operation may be desired in Nevada in the fall. The purpose would be to test the nuclear safety of sealed designs.

Weapon Effects Presentation

At 2:10 p.m. Dr. Herbert Scoville, of AFSWP, joined the meeting to discuss weapon effects.

Dr. Scoville first displayed curves of "scaled crater radius vs scaled charge depth" (radius/$W^{1/3}$ vs depth/$W^{1/3}$) for TNT and for nuclear explosions. In general the cratering effect of nuclear shots is much less than that of TNT shots of the same energy release, because of the diversion of energy into non-effective forms. At the surface a 10 MT shot is expected to give a 2700 ft diameter crater

in dry soil; at a height of 100 ft the diameter would be 1800 ft. Dr. Scoville pointed out that the difference in these diameters is comparable with bombing errors. The (surface) damage distance is taken as 1.5 crater radii.

Next, "severe damage curves for structures" were presented. The blast scaling laws and parameters are well known, at least up to 15 MT from data on surface shots. Because the drag duration increases with energy the critical damage parameter for heavy steel frame structures also varies, from 12 psi at 20 KT to 8 psi at 10 MT. Damage to brick structures is a straight crushing effect and does not show such trend.

Thermal damage criteria are also, at least in part, a function of energy of burst. Since the heat dose is given over a longer period with the higher yield weapons, more cal/cm^2 are required. However, for producing second degree burns beneath clothing the criteria do not seem to depend on energy.

The effects of prompt nuclear radiation are relatively insignificant for large yield weapons, since other effects predominate.

Fall-out

Dr. Scoville next discussed the delayed radiation effects due to fall-out. He showed a map of isodose contours as inferred from the CASTLE tests. The highest contour shown was 50 r/hr at D + 1 day. He indicated that the highest contamination of Bikini was about the same as that at Rongelap. Induced activity is not important; it all

goes up. The integrated local fall-out accounted for 50-60% of the fission products. Induced sodium activity was only a few percent of the total.

At 2:45 p.m. Gen. Fields and Col. Huston left the meeting.

Dr. Scoville emphasized the lack of very high contamination close in with the big shots. However, there are large uncertainties, since the Eniwetok shots are not truly representative of dry land shots. [redacted] gave a bigger close-in contamination than did the high yield shots. Dr. McMillan said that it would be very important to fire a high yield shot on dry land. Dr. Scoville agreed. He said the central question is how to evaluate near misses on runways. It is not known how the contamination scales close to the crater.

There was some discussion of the protection afforded by foxholes. One measurement indicated that a man in a foxhole would get 10% of the dose he would have received without this protection.

Integrated doses to H + 50 hours, based on CASTLE data, were given as follows.

2500 r	over	1400	square miles	(largest dose you get anywhere)
1000 r	"	3400	"	"
500 r	"	5400	"	"
250 r	"	8500	"	"
100 r	"	13000	"	"

These results lead to two conclusions which are very important from the standpoint of civil defense: (1) one should take cover during

this period, and (2) at no place is the dose so high that it cannot be protected against. A frame house affords a protection factor of about two, a basement about ten.

Dr. Scoville presented a table of estimated areas for various doses in different types of terrain. The extreme entries were as follows for the integrated dose from a 15 MT shot at H + 2 days.

	in rural areas	in open in city	in average shelter in city
205 r	8800 sq. mi.	7500 sq. mi.	2100 sq. mi.
630 r	4600	3500	320

The next effects item was atomic weapons for air defense. For a 2 KT burst at 40,000 ft the 2000 and 5000 rem radii are greater than the maximum lethal gust radius. The 2000 rem radius is about 1500 yd. The relative contribution of nuclear radiation effects changes markedly with altitude. The preliminary estimates of effects on ballistic missiles are discouragingly small.

WIGWAM Test

For the next topic, Capt. John H. Lofland, USN, who was present during part of Dr. Scoville's talk, discussed the WIGWAM test, planned for the middle of May, 1955. This will be an underwater effects test at deep submergence. A 31 KT [redacted] will be detonated at 2000 ft depth in 12,000 ft of water. The test will take place about 315 miles west and southwest of San Diego. Three submarines will be at 250 ft depth in order to obtain information on maximum lethal range against submerged targets (expected to be 6500-10,000 ft). These vessels will

have stronger hulls than our own submarines, [redacted] Various measurements of shock wave parameters, surface effects, and radioactivity will be carried out, with AEC collaboration. The operation will cost $13,280,000.

At 3:35 p.m. the visitors left; and Dr. L. R. Hafstad, Dr. W. H. Zinn, Mr. W. K. Davis, and Gen. D. J. Keirn met with the Committee to discuss reactor matters.

Reactor Matters

Dr. Hafstad began by saying that the current power program is rolling in good shape. The problem area is the homogeneous reactor at Oak Ridge and its rate of progress. The problems are tied in with the fluid fuel program at ORNL.

Civil Power

Dr. Wigner mentioned a question, earlier raised by Mr. Murphree, that in the aircraft program Pratt & Whitney seemed to be working on reactors instead of jet engines. Gen. Keirn answered that P & W feel they must participate in the reactor effort in order to boost their general competence. The program is not yet far enough along to set down the exact division of effort. P & W have made paper studies of the engine machinery.

ANP

Dr. Wigner also mentioned Mr. Whitman's doubts on the time schedule for the fluid fuel reactor, and the proposal to review the program in about six months. He said that what could be judged would be a more or less integrated arrangement. Would a judgment be possible in six months? Dr. Rabi interpolated the remark that Dr. Wigner

felt that P & W's engine development had not gone far enough that one could judge the whole. Dr. Hafstad remarked that P & W could move fast if they had the pertinent information on the reactor, but he doubted that enough new information would become available to make a review in six months.

Mr. Whitman commented on the lack of integration between the two teams (reactor and engine) at Oak Ridge. It seemed to have developed less than at Lockland. Dr. Hafstad said that the apparent lack of enthusiasm on the part of Pratt & Whitney was real. They had entered joint operation with Oak Ridge at the insistence of the AEC, and regarded the arrangement as a shot-gun marriage, against their own preference.

There were several comments on the heterogeneous, sodium cooled reactor concept (NDA proposal). Mr. Murphree, in particular, was worried that this approach was being neglected. Dr. Hafstad said it would be hard to defend three parallel approaches, and indicated he felt that undertaking this approach should be deferred until it was possible to decide against one of the other two. He felt that a choice between the direct cycle and the sodium cooled heterogeneous reactors might be made (with the aid of the GAC) by next summer after more information was developed on the direct cycle reactor. Dr. Wigner observed that one would never want to throw out the direct cycle approach; and, in reference to the idea of waiting to see before

activating a project on the sodium-heterogeneous design, said that one year's work in an orderly fashion is better than a half year's work on a crash basis.

At the end of this discussion on aircraft reactors, Mr. Whitman reiterated his belief that the program should be thoroughly reviewed again in about six months.

Civil Power

Dr. Hafstad next mentioned the new expanded power program as one of the new things that were troublesome. The addition of perhaps three more projects is being considered. A certain amount of expansion is possible, but there is a limit on how far it would be profitable. One of the problems is how to get industry into the picture. One method is the "Duquesne approach", in which the AEC decides to build a reactor and invites industry to bid in. Another is for industry to be urged to pick the reactor, and invest capital, with assistance from the AEC. This is the "Reactor-of-the-Year" approach. Six to eight mill power with byproduct plutonium valued at $10/gram does not provide enough incentive to attract private capital. The government must feed in money somehow; the real question is how. It would probably take about a $50/gram price on plutonium to make the picture interesting to private capital. In any case, to avoid "give-away" charges, the AEC must keep its support very clean. Dr. Rabi asked if it would not be cleaner to make a direct subsidy; and several of the GAC members seemed inclined to this view. Dr. Hafstad indicated

that the AEC was swinging toward grants-in-aid, given in connection with demonstrated performance, as a method of encouragement.

Reactor Training School

He next commented on the proposed school for training foreigners in reactor technology. The AEC is committed to setting up such a school; the real problem is to make it a high level affair. Dr. Zinn spoke to this point, saying that what the Europeans need and want is a "graduate school". He referred to independent European reactor projects. These also will act to form world opinion, and the U.S. would find itself in a ridiculous position if it did not offer more than these people already know. Dr. Rabi disagreed. He felt that our problem is to help the Latin Americans and other such technologically undeveloped countries. Why help the countries that are already far along? He felt that in some cases they were putting up a show of knowledge just to force information out of us. Dr. Zinn said it would be fine if the AEC took this view; however, with inclusion of the Europeans in the school, the problems are very difficult. The Europeans are beyond the principles stage. They want technical know-how. We haven't declassified enough, and probably can't, to teach what they want.

There was a rather lengthy discussion along these lines. Dr. Wigner asked what kind of information would have to be declassified. Dr. Zinn indicated metallurgy, radiation damage, engineering, chemical process engineering — not physics. Dr. Johnson said that the school

should be considered separately from bilateral agreements; and Mr. Murphree said that instruction in technical know-how should not be part of the school. It was mentioned that courses of study in the principles of reactor technology already exist in this country, e.g., at the University of North Carolina. What is to be gained by establishing another at the Argonne? Mr. Whitman said that to work with and see the special facilities at ANL would be such a gain. Dr. Hafstad said that we were instructed to set up a school but have not been told what kind of school. What did the President have in mind?

No resolution of these problems was reached.

Dr. T. H. Johnson entered during this discussion, at 4:25 p.m.

Test to Destruction

The next subject considered was the test-to-destruction of the boiling reactor. Dr. Zinn described the Arco experiment, which had been somewhat more spectacular than anticipated. It had been thought that the rapid addition of 4% excess reactivity would cause the release of about 80 megawatt-seconds; actually about 135 MW-sec were released. The estimated fuel temperature rise was 2000-3000°F. The pressure developed was greater than 5000 psi, perhaps greater than 10,000 psi. The conclusion was that such a reactor cannot safely have 4% in k added. About 2% will not cause trouble; more will. This has implications for research reactors of this general type; their flexibility will have to be limited somewhat by making it impossible to introduce too much excess reactivity. Dr. Zinn mentioned that the new

boiling reactor, which has a different H_2O/U ratio, was operating at Arco on October 8, and that excursion experiments were being run with it. It is designed to run steadily at 300 psi and give 6 MW of heat.

At 4:55 p.m. the visitors left, except for Dr. Zinn and Dr. T. H. Johnson who remained for the session on Research Matters. All members of the Committee and the Secretary were present. The topic was high energy accelerators.

Research Matters

Dr. T. H. Johnson reviewed the history of the Cambridge proposal for a circular 6 Bev electron accelerator and the Princeton proposal for a 2 Bev proton accelerator of high intensity (100 x that of BNL's cosmotron). They would cost about \$5 x 10^6 each. They had been budgeted for FY 56, and the budget proposals were currently being reviewed. They would probably be struck from the budget. An appeal would be made if the GAC gave a favorable recommendation on the proposals.

Accelerator Proposals

Dr. T. H. Johnson mentioned other current plans, some of them preliminary, in the high energy field: (1) the Midwest proposal; (2) the Stanford interest in a greater than 10 Bev linear accelerator; (3) latent interest at ORNL; (4) Berkeley plans to increase the 184" cyclotron energy to 750 Mev; (5) Columbia plans to increase their energy to 520 Mev; (6) the heavy ion accelerators at Berkeley and Yale, which are going ahead.

In the discussion which followed the main theme was the Midwest situation and its relation to what should be done about the Princeton and Cambridge proposals.

Midwest Situation

Dr. Zinn said that ANL does not yet have the design of a machine they would like to build. Authorization for design studies was granted only last summer. They have in mind fairly high energy protons, of the order of 15 Bev. The Laboratory's scientific interests in this field are very much like those of the other labs. An important element in Argonne's motivation is to stimulate the Laboratory and catalyze university cooperation.

There was considerable comment on the interest of the Midwestern universities, the existence of an independent proposal from the MURA group (Midwest Universities Research Association, eight members), and the unfortunate failure to establish cooperation between the universities and ANL. Argonne had proposed a cooperative project, but it had not been accepted by MURA.

Dr. Zinn said that the question of location of the accelerator did not seem such a sharp matter; the main issue is whether the universities would have contractual responsibility. It would be impracticable to have two contractors on the same site. Dr. Rabi observed that there are three main difficulties. (1) The universities don't like the Argonne site. (2) They fear red tape, security difficulties, etc. (3) They fear losing their individuality in a set-up at ANL. The security problem bothers them more than anything else.

It was suggested that the GAC might help to resolve the situation by holding a meeting under Committee auspices with the interested parties. Alternatively, informal personal discussions with some of the Midwest physicists were suggested.

Mr. Whitman expressed the view that the Princeton and Cambridge proposals should not be approved before studying their effect on a machine at the Argonne. Dr. Warner felt it was very important to have a machine at the Argonne and that the whole matter could be straightened out very quickly if a half dozen physicists in the MURA group could be convinced that they would have a happy home at Argonne. Dr. Fisk said that the sentiment of other universities, besides the eight in the MURA group, should be ascertained.

Dr. Libby entered during the above discussion, at 5:30 p.m.

Dr. Wigner said he was not fully convinced that the best way to get university-Argonne cooperation was by a big accelerator. Perhaps cooperative programs in metallurgy, radiation damage physics, etc., might be more effective.

Dr. T. H. Johnson mentioned that the NSF had planned to budget the Cambridge machine. He had discussed the matter with Dr. Waterman. It had been agreed that AEC support would be more appropriate and that NSF monies should be reserved for broader things. As a consequence, the NSF withdrew and the AEC put in for the support of this machine. He urged that a GAC recommendation on the Cambridge and Princeton proposals be forthcoming at this meeting.

Dr. Rabi said that he felt the problem should be presented by the AEC in a broader scope. These machines are a high road of physics, and many aspects need to be considered -- including the one of competition for students and staff. Such a facility should be for the use of many. It should be understood from the beginning that the installations are regional national laboratories, in order to avoid upsetting the balance among universities. The fundamental premises under which the government enters into the support of such facilities should be made clear at the outset.

This session was adjourned at 6:00 p.m.

THIRD SESSION
(November 4, 1954)

This session began at 9:30 a.m. All members, the Secretary, and Mr. Tomei were present. Dr. J. C. Bugher, Dr. R. A. Dudley, Gen. Fields, and Dr. Libby were present for a discussion of Project Gabriel-Sunshine.

Gabriel-Sunshine

Dr. Bugher reported that the fall-out picture had become firmer, although more complicated, in the last year or so. Local fall-out can be predicted over a wide range of yields as to amount, area and pattern. With large yield weapons much of the debris goes up into the stratosphere; as a result the world-wide contamination becomes more uniform with larger weapons.

Fall-out

After one of the big shots iodine-131 can be picked up anywhere in the world. Fall-out on plant leaves and direct animal consumption

I-131

thereof provides an ingestion mechanism which by-passes the root route. I-131 can be detected in thyroids all over the U.S., and it maps out the fall-out pattern. It is estimated that everyone in the U.S. received a dose of 1 rep in the thyroid as a result of CASTLE. The Rongelap islanders got 170 r to the thyroid from I-131. A classification problem arises in that many people are detecting I-131 from the Russian shots in sheep and cattle thyroids. Dr. Bugher cautioned against the use of milk from heavily contaminated areas.

The strontium-90 surveys are showing a consistent pattern; in-
Sr-90 creasing study is being required. The body appears to discriminate against strontium in favor of calcium; "we are living in a non-equilibrium situation." Sr-90 in the New York milk supply has increased. There is some evidence from balloon samples for Sr fractionation.

Some overlay maps showing world-wide fall-out (extrapolated to January 1, 1955 by a $t^{-1.2}$ law) were displayed. The numbers ranged from 1 to 60 mc mixed f.p./mi^2. (This unit is approximately the same as dpm Sr-90/ft^2.) The accumulation in the southern hemisphere, Dr. Fisk observed, seems to give evidence for prompt atmospheric mixing between the northern and southern hemispheres. The fall-out in the U.S. during March 1 - May 1, 1954 ranged up to 100 mc/mi^2.

Dr. Rabi asked about plutonium fall-out. Dr. Bugher said that
Pu it had been detected in land samples after the March 1 shot and in the

excreta of the Rongelap islanders. It was too diluted in the seawater to be detectable. Dr. Dudley mentioned that it has not been looked for in the U.S., but since there is not much fractionation a proportionate amount has probably fallen out here.

Japanese Fishermen

According to Dr. Bugher, the Japanese fishermen had about the same radioactivity ingestion as the Rongelap islanders, or a little less. The accumulation on their skin was about the same, but since there was a longer contact time (ca. two weeks) more skin lesions developed. The death of one of the fishermen is believed to have been due to infectious hepatitis resulting from the large number of small blood transfusions.

Dr. Wigner asked if there was any new information on the radiological hazard of airborne radioactive particles accumulating in the lung. Dr. Bugher said that this seemed to be a lesser hazard (by ca. 1/1000) than whole body exposure to gamma radiation. It has not been substantiated that such particles cause lung cancer. In answer to a question from Dr. Johnson, he said that strontium accumulates in the bones and turns over very slowly unless there is extensive demineralization.

At 10:10 a.m. this part of the session was concluded, and the visitors left.

Executive Session

In a very brief executive session there was further discussion on what to say about the reactor school. Dr. Johnson suggested that

Reactor School

the Committee might consider recommending that action be postponed until decision has been reached on: (1) to what extent the AEC will accept the recommendations of the last declassification conference, and (2) to what extent bilateral agreements will be established.

At 10:20 a.m. Mr. John Hall arrived to talk about developments in respect to the President's Plan.

Inter-national Matters

Mr. Hall went over some of the negotiations with the Soviet Ambassador on the subject of the President's plan for international cooperation in peaceful aspects of atomic energy. Many diplomatic notes have been exchanged. The U.S. position was: (1) to discuss the problems of Soviet participation in private with the Russians, (2) to make an overt offer to "keep the door open" to discussions, and (3) to urge Soviet participation in the international conference.

Con-ference

Mr. Hall indicated that the conference would probably be held in Geneva, during the first or second week of August, 1955, under the auspices of the General Assembly of the United Nations.

Reactor School

Dr. Johnson asked what was meant by the statement that an international school would be set up. Mr. Hall said the purpose was to maintain the momentum of the President's proposal and to demonstrate our willingness to cooperate. It would probably be run on an unclassified basis for the first year or so, then go into the Gray Area as bilateral agreements develop.

At 10:45 a.m. Mr. Hall left, and the meeting continued in executive session. All members, the Secretary, and Mr. Tomei were present.

Executive Session

For the benefit of the new members there was a brief discussion of the way the GAC functions. Dr. Rabi said that the GAC is not a committee of special technical advisors; he emphasized the word "General". There continually come to the Committee questions which involve general policy, military questions, economic and international matters. At times the GAC has itself raised such questions. It has not hesitated to go beyond the strictly technical aspects of the problems referred to it into their broader implications.

GAC Functions

Dr. Fisk, referring to the Act, expressed general agreement with this statement. He said the Committee should take care to distinguish between its recommendations as to which category, technical or policy, they fall into.

Dr. Wigner said the category is often in doubt. The AEC staff perforce establishes policy by its actions. The main useful function of the GAC, within the framework of the Act, is to bring up new problems.

Mr. Whitman commented that the reactor staff often feels the need for help in reaching their decisions and obtaining support from the Commission. He felt in a position to give technical advice, but was personally hesitant to venture opinions on the wisdom of actions outside the technical domain.

Dr. Wigner expressed a wish that an executive session of, say, an hour, could be set aside at each meeting to consider agenda items which the individual members might like to propose. Dr. Rabi suggested that any member who wished to propose a topic set it forth in a letter, to be reproduced and circulated by Mr. Tomei and put on the agenda. The suggestion met with general favor; and Dr. Wigner's suggestion was also liked.

Agenda Proposals from Members

The Chairman next enumerated items for the report of the meeting as follows, the first two being important substantive items.

(1) The report of the Reactor Subcommittee, as a response to the request of the Commission for an evaluation of the reactor development program.

(2) The Princeton and Cambridge proposals for high energy accelerators, and the Midwest situation.

(3) Personnel security policy.

(4) Reactor training school.

(5) Intelligence.

(6) Fall-out.

(7) Fermi Award.

Mr. Tomei was excused from the remainder of this session.

The report of the Reactor Subcommittee was considered first.

Report of the Reactor Subcommittee

Dr. Wigner's concern about the lack of integration between Pratt & Whitney and Oak Ridge was further discussed, and it was agreed that this should find expression in the report. (Appendix D, p. 15.)

Mr. Murphree and Dr. McMillan both urged that the sodium-heterogeneous approach should not be neglected. Dr. Rabi suggested the Committee not make a recommendation on this at present. He suggested that the report ask for detailed information, to be supplied by Commission staff, on the possibility of a program along this line. (Appendix D, p. 19.) The desirability of a six-month review of the fluid fuel approach was again brought out. (Appendix D, p. 16.)

Dr. Rabi suggested that the report of the Reactor Subcommittee be adopted as a report of the entire GAC. Dr. Warner moved that this report, as amended and revised in the light of the discussion, be adopted as a report of the full Committee. Mr. Murphree seconded the motion, and the motion was unanimously carried. (Appendix B, item 1; and Appendix D.)

(Secretary's Note: Two definite suggestions in this report will give rise to future agenda items:

Future Agenda Items

(1) The suggestion, p. 16, Appendix D, that a thorough review of the fluid fuel ANP program of Oak Ridge and Pratt & Whitney, directed toward a decision to continue or to modify the approach, be held in about six months -- i.e., in May 1955.

(2) The suggestion, p. 19, Appendix D, that the Reactor Division draft a proposed program on the sodium cooled heterogeneous ANP reactor, including type and scope of work and contractors, which can be presented at the next meeting of the General Advisory Committee.)

The next topic was the accelerator situation. Dr. Wigner excused himself from this discussion. After some preliminary comments were exchanged, the Chairman called for the views of the individual members, in sequence around the table.

Accelerator Proposals

Mr. Whitman felt that the Princeton and Cambridge proposals should not be approved until the Argonne-Midwest matter was straightened out. He would like to see the ANL program definitely begun before decisions were reached on the others. He worried, however, that if ANL-university agreement were not reached this recommendation would simply have delayed developments.

Dr. McMillan said that all of the proposals needed further technical study. He felt that the Harvard and MURA proposals should be considered on the same basis and together, since they were the same kind of thing. In the case of MURA this would involve the relations with Argonne. However, he did not feel sufficiently well informed to give a definite opinion on ANL and MURA. He did not think it right to try to coerce Princeton into becoming a National Laboratory, by making that a condition for the approval of their proposal. The decision on Princeton should be deferred until the Cambridge and Midwest situations were settled. Princeton's proposal was the least forward looking (since it did not enter a new energy range) and hence might be considered on a different basis. A policy should be established to cover these questions.

Dr. Beams said he was not well prepared on the subject, but he believed the need for more of these machines was evident. He would hate to see action delayed too long, but it would be best if MURA and ANL could agree to have the machine at ANL. With regard to Princeton, he agreed with Dr. Rabi that a large machine there should serve a whole group of universities. He also felt that there was need for a general policy.

Dr. Johnson said he could not be completely objective, but he felt that the National Laboratories should be made really strong laboratories. If Argonne does not get a big accelerator which will attract and stimulate people, it is likely to fail as a National Laboratory. He would like to see the National Laboratory problem settled before deciding about individual universities.

Dr. Warner agreed exactly with Dr. Johnson. He felt the ANL imbroglio would have to be settled in six months or never.

Mr. Murphree said the problem was one of policy as to how far one goes in placing big machines at individual universities. The policy might be to set up the larger machines on a regional basis, and the intermediate sizes on a community basis. The Committee might recommend that the AEC produce a policy paper for its consideration.

Dr. Fisk agreed with the general position of Dr. Johnson and Dr. Warner. He felt it would be a mistake at this time to have these items in the budget for single groups, since it would prejudice the

chance of a machine at the Argonne. He would recommend that they not be included in the budget, but that a sum of money be budgeted to give the Argonne a strong go-ahead. (Dr. McMillan did not see why the Cambridge proposal should not be budgeted now.)

This session was adjourned at 12:30 p.m.

FOURTH SESSION
(November 4, 1954)

Executive Session

The Committee met in executive session at 1:20 p.m. All members, the Secretary, and Mr. Tomei were present.

Minutes Approval, 41st Meeting

Consideration was given to the Minutes of the 41st Meeting. The Committee was informed that the three members whose terms expired after the last meeting had read and approved the Minutes. On Dr. Warner's motion and Mr. Murphree's second, the Minutes were unanimously approved.

Dates of Next Meeting

It was agreed that the 43rd Meeting would be held in Washington, D.C. on December 20, 21, and 22, 1954.

The Chairman summarized the consensus on accelerators as follows.

Accelerator Proposals

(1) We would like the Commission to consider and come up with a more complete general policy on accelerators at universities and at the National Laboratories. If large accelerators are to go on university campuses, how will these be handled -- on the basis of the individual university or as facilities for community groups?

(2) We should make a definite recommendation that the Commission proceed to solve the Midwest situation in the direction of budgeting a machine for the Argonne National Laboratory.

(3) We cannot clearly recommend the MIT-Harvard proposal as yet. It is in essence no different from the MURA proposal. Its approval at this time would give MURA ground for pressing its own proposal, which would interfere with the Argonne. Action should be delayed until a policy is formulated and until some decision is made with respect to MURA.

All present assented to this way of commenting on the accelerator proposals. (Appendix B, item 3.)

Fermi Award

Next, ways of wording the citation of the award to Enrico Fermi were discussed. It was agreed to give the Commission several drafts of alternate wordings for their selection. (Secretary's Note: Three suggested wordings were given to Dr. Libby, as follows:

(1) "For his contributions to basic neutron physics which led to the achievement of the controlled nuclear chain reaction."

(2) "For his pioneer researches in nuclear physics, particularly those relating to neutrons, and for his brilliant leadership of the work that led to the achievement of the first sustained nuclear chain reaction."

(3) "For his pioneer researches in basic neutron physics, and for his especially meritorious contribution to the achievement of the first sustained nuclear chain reaction.")

Reactor School

The reactor training school was next further considered. Several different points of view were expressed. In an attempt to clarify the issues, Dr. Fisk said that there are two groups of problems, firstly political ones arising from the aim of using the school to benefit the U.S. in the international scene, and secondly the operational ones of how can the school in fact be conducted. The plans should be examined by the interested Division and Laboratories to determine whether they are consistent with the objectives. The Chairman pointed out, however, that the GAC was requested to comment at this time on the proposed school.

Mr. Murphree took the position that the school should be limited to an unclassified course of instruction in the principles of reactor technology. All else should be "special training", for which special security arrangements could be made.

Mr. Whitman agreed that advanced study would appropriately be set up in the Gray Area, as did Dr. Johnson, who pointed out, however, that Gray Area training could not be set up for at least another year.

Dr. Wigner pointed out that unclassified courses already exist at universities, and that another one, located at a National Laboratory, would not be such a great innovation. He also felt strongly that it would be undesirable to have both a classified and an unclassified school in operation at the same location. Those foreigners who did not have entry to the classified school, or who were "sent home" after an

unclassified first course, would surely have ruffled feelings. Dr. McMillan agreed with Dr. Wigner that difficulties would arise from national pride if different foreigners were treated differently.

Dr. Rabi did not agree with some of the above points. He said that the President has made the proposals for national political reasons, and that the names of BNL, ANL, and ORNL are magic to these purposes. An unclassified school at one of these world-famous laboratories would be viewed in a quite different light and would have greater prestige than an unclassified course at a university. He went on to say that we have a law-of-the-land which states what information can be given to foreigners and what cannot (without bi-lateral agreements). He concluded, therefore, that to serve the purposes of the President's plan a school must be set up, and that for the present it must be unclassified. The only question at present is the location. In the course of time, with development in bilateral agreements and in the Gray Area, instruction in classified technology could be given, possibly in two schools in different buildings or at different places. He did not foresee serious difficulties in treating people differently. This is common practice, e.g., in industry, and it is known that we have agreements with some nations and not with others.

No consensus was reached. (Appendix B, item 2.)

(Secretary's Note: The location of the school did not receive formal consideration at this meeting, since the individual members

had been polled on the question prior to the meeting, and had in general agreed that ANL would be a satisfactory place. See letters: R. W. Dodson to Lewis L. Strauss, October 7, 1954; E. P. Wigner to A. A. Tomei, October 6, 1954; and E. P. Wigner to R. W. Dodson, October 25, 1954.)

Personnel Security Policies

Dr. Rabi next asked whether the GAC had any suggestions to make to the AEC in regard to the latter's review of personnel security policies and procedures. There was some general discussion to the effect that frictions tend to arise not from the rules but from their implementation, that too much attention tends to be focussed on security mechanisms rather than on the integrity of people (where it should be focussed), and that secrecy can never be a long term proposition. One specific question was what to do about the clearances of individuals who have left the project. Mr. Murphree said he saw no security advantage in terminating their clearances; it is surely an advantage to have cleared people with whom classified problems can be discussed. Dr. Johnson said that somewhat earlier the AEC had attempted to establish a reservoir of cleared key people in the universities just for this purpose; now, there seemed to be the opposite tendency. The Committee agreed to say to the Commission: (1) that it was aware of the review and would be glad to consider any problems referred to it by the Commission; and, (2) that it would be healthy and desirable to maintain the clearances of key people after they have left the project. (Appendix B, item 7.)

TEAPOT Test

In regard to the TEAPOT test program, the Committee felt that the plans were not yet firm enough to justify detailed comment. Mr. Whitman moved, and Mr. Murphree seconded, that the GAC give general approval to the tentative program as presented. A formal vote was not taken, but this appeared to be the sentiment of the Committee. (Appendix B, item 4.) Dr. Fisk raised the question whether there was unnecessary duplication in that three experiments were planned which were boosted versions of other shots. He agreed to discuss the matter individually with Gen. Fields.

Intelligence

There was some discussion of the intelligence presentation, and, more generally, of the present status of intelligence activities within the AEC. It was felt that the latter have declined. Dr. Rabi said he felt it was a great mistake not to push harder in this field, and that the Commission should set up a strong intelligence evaluation group. It is very important that technical intelligence be effective at a high working level in the Commission. Mr. Whitman suggested that this question be raised with the Commission. Dr. Fisk suggested that the GAC ask to see the conclusions of the Bethe Committee. (Appendix B, item 5.)

At 2:45 p.m. Dr. Beams left the meeting.

Fall-out

Mr. Whitman mentioned that Dr. Libby had asked the Committee to comment on fall-out. Mr. Whitman said he felt the program was very important and should be strongly pursued. The GAC might well commend

the work to date, as well as Dr. Bugher's presentation. He further commented on the "South Woodley article." He suggested that the fact that some fall-out information has come out in the public domain be noted and further suggested that a recommendation be made that the AEC increase the flow of information to the public in order to facilitate measures of Civil Defense. He said the policy of not telling the facts until complete information is at hand is not a good one. Dr. Rabi asked if these were the sentiments of the Committee, and it was so indicated. (Appendix B, item 6.)

This final session of the 42nd Meeting was adjourned at 2:50 p.m.

Richard W. Dodson
Secretary

Attachments:
1. Schedule for Meeting (Appendix A)
2. Chairman's Report on Meeting
   (Appendix B--IIRabi-to-LLStrauss letter of Nov. 23.
   Appendix C--IIRabi letter of Nov. 5 on Fermi Award.
   Appendix D--Report on Reactor Development Program.)

[redacted]

GENERAL ADVISORY COMMITTEE
to the
U. S. ATOMIC ENERGY COMMISSION
Washington 25, D. C.

November 1, 1954

The following is the tentative Schedule* for the 42nd Meeting of the General Advisory Committee, to be held in room 213 on November 3 and 4:

November 3 (Wednesday):

9:00 a.m. -- Executive Session
10:00 a.m. -- Meeting with the Commissioners and General Manager
11:00 a.m. -- Intelligence Matters
11:30 a.m. -- Award Considerations
12:00 noon -- Executive Session

1:30 p.m. -- Weapon Matters. . . . . Gen. Fields
3:30 p.m. -- Reactor Matters . . . . . Dr. Hafstad
4:30 p.m. -- Research Matters. . . . . Dr. T. H. Johnson

November 4 (Thursday):

9:30 a.m. -- Project Sunshine. . . . . Dr. Bugher
10:00 a.m. -- International Matters
10:30 a.m. -- Executive Session

1:30 p.m. -- Meeting with the Commissioners and General Manager

Richard W. Dodson
Secretary

*Changes in Schedule may be found necessary in advance of or during the Meeting. The offices of the Commissioners, the General Manager, and the Secretary will be informed of any changes.

DISTRIBUTION: Commissioners (4)
General Manager (2)
Secretary, AEC (16)
Secretary, GAC (14)

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42

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GENERAL ADVISORY COMMITTEE
to the
U. S. ATOMIC ENERGY COMMISSION
Washington 25, D. C.

November 23, 1954

Mr. Lewis L. Strauss, Chairman
U.S. Atomic Energy Commission
Washington 25, D.C.

Dear Mr. Strauss:

Herewith is the report of the 42nd meeting of the General Advisory Committee held in Washington on November 3 and 4. All the members were present. Owing to the fact that three new members had recently been appointed, the meeting was shorter than our usual three-day session. We regret that owing to circumstances beyond control most of the members of the Commission and the General Manager were unable to attend, which unfortunately greatly detracted from the value of this meeting.

We considered eight separate items as follows:

1) The Report of the Reactor Subcommittee.

The Reactor Subcommittee visited a number of the more important installations of the Commission and submitted a report to the GAC. This report was approved and adopted by the Committee as its own report to the Commission. A copy of this report is attached to this letter and represents a review of the present situation in the field of reactors and contains certain recommendations.

2) The Reactor School.

The GAC considered further the problem of the Reactor School at the ANL or elsewhere. We reached no consensus. Some of the members felt that the location of a classified and unclassified school at the same location would lead to bad reactions on the part of foreign students who would of necessity be treated differently depending on the particular arrangements with their home countries. Some members thought unclassified reactor courses of study already existed at universities, and the proposed unclassified school at the ANL would only be a duplication. Still others felt that the ANL would make a good site for the Reactor School in view of the excellent facilities and its great international reputation and did

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not agree that resentment would arise over the preferred treatment of some foreign students, with respect to their course, since they had been sent to these courses under arrangements already understood beforehand.

3) The High Energy Accelerators for Harvard-MIT, Princeton and the Midwest.

The Director of the Division of Research informed us that he had budgeted an electron accelerator for the Harvard-MIT group to be located at Harvard, and a proton accelerator to be located at Princeton. He further stated that the situation in the Midwest relative to the construction of an accelerator at the ANL and cooperation of the MURA group of universities is still unresolved.

In our discussions (Dr. E. P. Wigner of Princeton abstaining) we reached what the Chairman interprets as a consensus for two recommendations:

a) In principle the Harvard-MIT proposal is in essence no different from the MURA proposal to construct an accelerator away from the ANL possibly at the University of Wisconsin. The Princeton proposal for the construction of a large accelerator at an individual university raises fundamental questions of policy which have not yet been studied or resolved. How many large accelerators should be built and at which universities? Should these large installations be considered as set up for a group of neighboring universities? How should such a project be organized and administered? Universities are in competition for personnel and facilities. How can the needs of the universities in the field of high energy physics be best fulfilled?

The Committee desires to see a study of this problem which could lead to the formulation of a clear policy for the future.

b) The Committee recommends that the Commission seek an early resolution of the situation in the Midwest, with respect to the construction of an accelerator at the ANL. The further desires of the MURA should be considered in the light of a policy to be worked out as recommended in item (a) above. The GAC has in the past consistently recommended that an accelerator be constructed at the ANL.

4) Test Program.

We were informed that the Commission has proposed and the President has approved Test Operation TEAPOT, to be held in Nevada in the early spring of 1955. The Committee wishes to express its general approval of the tentative program as outlined. We understand that a more detailed description of the individual shots and the reasons for them will be presented to us for review in the near future.

5) Intelligence

The Committee heard an intelligence report concerning the recent series of atomic explosions in the Soviet Union. The information and time available were not sufficient for us to reach a conclusion as to the significance of these explosions. We did, however, understand that a further analysis of Russian shot data is being made by the Bethe Committee, and we would like to study the report of the additional considerations of this group.

We have an impression that the Commission's intelligence group has declined in strength and possibly in the closeness of its relations with other intelligence agencies. In our discussions the opinion was expressed that the Commission should set up a strong intelligence evaluation group. It is essential in our opinion that the technical evaluation of information in this field be able and comprehensive, and that it be effective at a high working level in the Commission.

6) Fall-out

The Committee heard from Dr. Bugher a report of the status of Project Gabriel-Sunshine, and from Dr. Herbert Scoville of AFSWP a discussion of weapon effects which included the subject of radioactive fall-out. We continue to be impressed by the great importance, both short range and long range, of this subject. In the course of the discussions, which included reference to material appearing in the press with respect to civil defense, we reached the view that more information than is currently available to the public is urgently needed for purposes of civil defense. We recommend that the flow of such information to the public domain be accelerated.

7) Personnel Security

We are aware that the Commission is currently reviewing its policies and procedures on personnel security and trust that any questions on which our advice could be helpful will be referred to us. Comment on one aspect of our discussions is appropriate at the present time. It was brought out that there is at present a tendency to terminate the clearances of persons not actively connected with the program, including key individuals whose advice or participation may be needed in the future. It was felt that it would be healthy and desirable to maintain the clearance of such persons.

8) Fermi Award

As you know, the Committee considered the granting of an award, as provided in the Atomic Energy Act for especially meritorious contributions to atomic energy, to Enrico Fermi. The unanimously affirmative recommendation of the Committee was transmitted to you in my letter of November 5, 1954, a copy of which is attached.

At this meeting the Committee asked I. I. Rabi to continue as its chairman until the first meeting of the next calendar year. The subcommittees of the GAC were reconstituted as follows:

Subcommittee on Reactors, Materials, and Production:
W. G. Whitman, Chairman
E. V. Murphree
J. C. Warner
E. P. Wigner
W. C. Johnson

Subcommittee on Research:
E. P. Wigner, Chairman
E. M. McMillan
W. C. Johnson
J. B. Fisk
J. C. Warner
J. W. Beams

Subcommittee on Weapons:
J. B. Fisk, Chairman
E. M. McMillan
J. W. Beams
E. V. Murphree
W. G. Whitman

The 43rd meeting of the General Advisory Committee will be held in Washington on December 20, 21, and 22, 1954. In the meantime, the individual members are, as always, ready to be of service on any questions which may arise.

Sincerely yours,

I. I. Rabi
Chairman

Attachments (2)

[redacted]

GENERAL ADVISORY COMMITTEE
to the
U. S. ATOMIC ENERGY COMMISSION
Washington 25, D. C.

November 5, 1954

Mr. Lewis L. Strauss, Chairman
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Mr. Strauss:

During its 42nd Meeting the General Advisory Committee considered a suggestion that the Atomic Energy Commission confer an award on Enrico Fermi for his contributions to the development of atomic energy. Provision for such awards is made in the Atomic Energy Act of 1954, Section 157, paragraph b(3), which reads in part: "The Commission may also, upon the recommendation of the General Advisory Committee, and with the approval of the President, grant an award for any especially meritorious contribution to the development, use, or control of atomic energy."

The Committee wholeheartedly endorses the suggestion that such an award be granted to Dr. Fermi, and hereby so recommends. This action, a record of which will be found in the Minutes of the 42nd Meeting, was taken on November 3, 1954, with the unanimous affirmative vote of all members of the Committee.

We were advised that the award would include a citation, a medal, and the sum of twenty-five thousand dollars.

Our advice was sought with regard to the phrasing of the citation. Several suggestions were given to Dr. Libby at the time of the meeting.

Sincerely yours,

I. I. Rabi
Chairman

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NOV 2 3 1954

REPORT ON REACTOR DEVELOPMENT PROGRAM

The Subcommittee on Reactors, Materials and Production visited several installations this summer to learn more of the status and plans of the reactor development program. Dr. Libby, Mr. Murphree, Dr. Rabi, Dr. Warner, Mr. Whitman, and Dr. Wigner were at Argonne on July 7, 8, and 9. Mr. Murphree, Dr. Warner, Mr. Whitman, and Dr. Wigner were at Oak Ridge on Sept. 21, 22, and 23, and at General Electric's aircraft reactor center near Cincinnati on Sept. 24 -- Dr. Libby participated on Sept. 23 and 24.

The main topics discussed in these visits were the Boiling Reactor and the Fast Breeder at Argonne; the Homogeneous Reactor, the Sodium-Graphite Reactor (by North American Aviation), the Liquid-Fuel Aircraft Reactor (with Pratt and Whitney representatives participating) and the Sodium-cooled Heterogeneous Aircraft Reactor design of Nuclear Development Associates at Oak Ridge; and the Air-cooled Aircraft Reactor at General Electric. Dr. Staebler of Dr. Hafstad's office accompanied and assisted the Subcommittee throughout. The personnel of the various projects were most cooperative. Gen. Keirn and his staff participated in the aircraft reactor programs, and Gen. McCormack, Deputy Chief of Air Force Development, accepted our invitation to attend these sessions.

Several general observations are pertinent:

1. We were favorably impressed by the enthusiasm and competence of the main groups.

2. Our questioning emphasized a realistic appraisal of the programs and prospects for the next few years and ideas as to how the solution of the most critical problems might most effectively be accelerated. Each of the major development projects was examined as to its possible relevance to the

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"Reactor-of-the-Year" concept. Little attention was devoted to estimates of future power costs since they are so dependent upon assumptions as to the extent to which foreseeable technical obstacles can be surmounted. These pilot-plant experiments are on a scale adequate to provide the engineering and design data needed to go ahead with a large-scale power producer.

3. We feel that our experiment at Oak Ridge of inviting top staff from other projects to attend and freely discuss the presentation on individual projects was definitely productive and that such participation should be fostered throughout the reactor program. The resulting interchange of opinion and experience, under conditions where salesmanship and promotion are minor considerations, can benefit progress on each enterprise.

4. There are some indications that the reactor development projects were not receiving directly some pertinent information in reports from production reactors sites (Hanford and Savannah River) which could be helpful to their programs. This may be correctable at the Division level in Washington.

ARGONNE

General

Argonne is concentrating on small reactors and the immediate problems which they present, believing that they can thus make their best contribution to the immediate national program and to ultimate useful power. Dr. Zinn feels that commitment to a large commercial plant would impair their contribution by restricting freedom for trial and experimentation, and introducing caution to assure meeting performance promises. We agree with this general philosophy for Argonne.

Boiling Water Reactor

The Boiling Water Reactor type continues to look quite promising as an early achievement of nuclear power. The BER (Boiling Experimental Reactor), to be constructed at Argonne, is scheduled to go critical by December 31, 1956. It will be a slightly enriched reactor, rated at 20 megawatts of heat and producing 5000 kw of electricity. The estimated cost of $3.5 million includes a semi-spherical building, 80 ft in diameter, which will hold 15 lbs per square inch pressure.

There are many questions still to be resolved, notably the corrosion resistance and permissible burn-up of the fuel elements, the amount of radioactive contamination of the steam system and its effects on operations and maintenance, and the nuclear stability of the reactor system under a variable demand for steam.

The Borax experiment at Arco this summer which was a deliberate "test-to-destruction" prior to installing a new reactor was apparently most instructive; the "destruction" being far more comprehensive and spectacular than anticipated. However, the results of this test, which was designed to introduce 4% excess reactivity as rapidly as practicable, should not be interpreted as casting doubt on the workability of a boiling reactor.

Considerable progress is occurring in fuel element composition and fabrication, although Argonne does not yet have an element which can assuredly stand the burn-up demanded for reasonably economic operation and has very little indication of the effects of pile irradiation on corrosion and on stability of the elements. The design for the BER element is a sandwich

plate, arranged in a box-type configuration, with a meat of Zr-U alloy and a Zircalloy cladding. Extensive metallurgical research on alloys, in collaboration with other laboratories, has developed additions and treatments which markedly improve stability, until it is now felt that corrosion under irradiation is a more critical question than stability.

Corrosion is an inherent fuel element problem in all heterogeneous water-cooled reactors and calls for intensive research and development throughout early reactor operations as well as in planning and design. Dr. Zinn refers to the Hanford experience in holding down slug failures in spite of great power increases over the years of operation as characteristic. It must be expected that fuel plates will warp considerably with long burn-up in the Boiling Reactor; corrosion resistance which relies on jacketing may be adequate, but efforts to develop a corrosion-resistant "meat" in the sandwich are strongly justified.

Flat-plate sandwiches have been chosen for the Boiling Reactor at Argonne because their use involves less extrapolation from present knowledge, even though they present difficult problems of manufacture. There is some expectation that jacketed tubes may ultimately be preferred, but the necessity for "freezing" the core design and beginning its fabrication by next July to meet the tight schedule of criticality by the end of 1956 dictates the sandwich plate element.

The degree of radioactive contamination of the steam-power equipment and its effect on regular operations and servicing is hardly answerable until the system is operating. Entrainment in commercial steam practice indicates that the liquid carry-over of radioactive water from the reactor in the steam

may be 0.1% to 0.01%. (Volatile fission products would of course go with the steam.) It is anticipated that deposits may be most severe in the condensers.

While the Boiling Reactor at Argonne is being designed, experiments will continue at Arco with a new reactor which will replace the original Borax. This will allow "power excursions" in a stainless steel vessel which will be equipped for continuous operation at 300 lbs pressure and up to 6000 kw of heat and will have a water purification system. The program is exploratory and should contribute to the development of instrumentation, knowledge on the radioactivity of the steam, and other questions which affect the Argonne design. While it was intended to place this reactor in the Borax tank, contamination from the July "test-to-destruction" has required a new site at Arco and has probably somewhat delayed the schedule.

Argonne recognizes that heavy water may be preferable in a Boiling Reactor. It allows a more relaxed core design, reduces fuel inventory and reduces or even eliminates the need for fuel enrichment. The paramount question is whether the loss of heavy water can be kept within bounds. Some power engineers believe that this can be done without much increase in the power equipment cost, e.g. Allis-Chalmers estimates $200,000 extra on the turbines and condensers. Experience with the Boiling Reactor at Argonne should be pertinent. In this connection, we feel that the costs of heavy water which are assumed in comparing potential heavy water and light water reactors are unrealistically high and tend to distort the comparison and invalidate the conclusions.

The Subcommittee members discussed with the Argonne leaders how the Boiling Reactor program might best be further accelerated. The present schedule for the reactor at Argonne, outlined below, seems very tight to us,

and "acceleration" may mean, at best, merely meeting it.

Sept. 1, 1954 . . . Architect-Engineer selected.

Feb. 1, 1955. . . . Designs and Specifications completed by Arch-Eng.

April 1 . . . . . Construction begins.

July 1. . . . . Core design frozen and core fabrication begins.

August 1. . . . . Designs of specific components by Argonne completed.

Feb. 1, 1956. . . . All construction not directly connected with reactor completed.

August 1. . . . . Pre-operational testing begins.

Dec. 31, 1956 . . . Reactor becomes critical.

In our opinion, the most fruitful "acceleration" step would be to allow Dr. Zinn the maximum freedom possible in contracting.* Argonne's program on the Boiling Reactor seems promising, enthusiastic and aggressive. Specific plans will doubtless undergo many modifications, dictated by concurrent developments, up to the deadline when the design must be frozen. Within the time deadlines flexibility is vital.

We have pondered the question of how the Boiling Reactor might fit into the "Reactor-of-the-Year" concept. This concept is not well-defined in our

*Dr. Zinn advised on November 4 as follows:

1. The Architect-Engineer (Sargent and Lundy) started work late in August.

2. A $600,000 lump-sum contract with Allis-Chalmers for turbine and all equipment exterior to the reactor was signed about October 1st. Their equipment is to be leak-proofed just as if heavy water were to be used.

3. The contract for the reactor vessel and all switch-gear is to be let in 4 to 6 weeks.

minds. If it means that another large reactor, of the general magnitude of PWR, is to be initiated now, we do not favor Argonne's assignment to the task. To do so would almost inevitably impair progress by Argonne in the solution of vital technological problems which must be answered and which can best and most quickly be answered by the pilot-scale reactor now planned at the Argonne site. Freedom to experiment and to take calculated risks would, we fear, be replaced by conservatism under the pressure for guaranteed performance. Such an assignment seems incompatible with Argonne's function as a National Laboratory and its proven talent for reactor experimentation and development.

In the event that an industrial company or group should propose to construct a large Boiling Water Reactor, primarily with its own funds and talent, an appraisal of the new situation would of course be essential. However, since Argonne's present program would be a vital contributor to the technology of such a plant, it would seem imperative that the progress of Argonne's program be protected against serious disruptions which might occur if its staff were required to participate heavily in the large reactor project. Successful operation of the Argonne experimental unit should be demonstrated before freezing a large plant design.

We recognize that the Commission may have to weigh additional factors along with sound technology and economics in its decisions. Other than emphasizing the importance of speed in developing the industrial power objective, we have not attempted to include such factors in our judgement.

The Fast Breeder

The possibility of breeding in a fast reactor has been adequately demonstrated in the first Experimental Breeder Reactor (EBR-I). The question now is whether a fast reactor can be designed and built which will be technically operable for producing power and which will still breed. For success, the Fast Breeder must operate at a very high power density, e.g., 1000 KW of heat per liter of total core volume. The effect of "diluting" the core with other materials for the heat extraction function is critical on the neutron spectrum and on breeding performance, and is as yet very uncertain.

The present program is concentrating on a second Experimental Breeder Reactor (EBR-II), to be built at Arco at a cost of about $19 million. It will be primarily a test of engineering components to demonstrate technical feasibility as a power producer. Since feasibility must involve recycling of fuel, it will be an integrated plant, with refabrication of fuel elements by remote control. The heat production will be some 60 megawatts and electric power will be generated.

Current thinking on fuel element design envisages cylindrical pins which are centrifugally cast and only 0.164" in diameter, in long tubes of 0.188" OD, with sodium bonding in the annulus and sodium cooling outside the tubes. An alternate design uses thin perforated wafers, prepared by powder metallurgy, which are held together with tubes pushed through the perforations in the uranium wafer matrix. Sodium coolant flows through the tubes. In either case the mid-section of the length will contain active material and the ends will contain depleted uranium blanket material.

The initial loading requires approximately 150 kg of U-235 at 15% enrichment. If loaded with plutonium about 90 kg are needed, alloyed with U-238. The first charge which uses plutonium will probably be a combination of Pu and U-235. The design objective is 2% burn-up on a 135-day cycle, with a maximum fuel temperature of 1200°F. Maximum sodium coolant temperature is 900°F.

The current schedule for EBR-II is as follows:

Mock-up built by end of 1954.

Calculations and experiment to July 1955, at which time the Architect-Engineer comes in and plant design starts.

Building construction begins at Arco April 1956.

Reactor ready for initial operations January 1958.

Fast exponential experiments are being pushed concurrently and Argonne is building a critical assembly.

In assessing the Fast Breeder program and possibilities, we were impressed by the difficulties and uncertainties ahead. The promise of true breeding inherent in this approach to commerical power justifies strong development effort, and we approve the Argonne program although we feel that its current schedule may be overly optimistic. The Fast Breeder offers little hope for early success in making competitive power -- rather, it seems to be a long-range prospect for the time when other nuclear power plants are short of fissionable material and may be looking for the most efficient uses for the plutonium which they produce. This conservative view should by no means obscure recognition of the great advances in the reactor art resulting from Argonne's past and continuing enthusiasm for the Fast Breeder.

Homogeneous Reactor

Alvin Weinberg stated that Oak Ridge is expending about $17 million a year on reactor development -- fully half of their total budget. Of this, about $7 million is on the Homogeneous Reactor, with $9 million on the Aircraft Reactor and $1 million on miscellaneous projects such as Waste Disposal and the Army Power Package. The objectives of the Homogeneous program are both a thorium power breeder and a producer of high-quality plutonium.

The second Homogeneous Reactor experiment (designated both as HRE-II and as Homogeneous Reactor Test, HRT) is designed for 5 MW of heat and will be installed at the location used by HRE-I. It is scheduled for operation early in 1956. The planned program has three phases: A, in which operability will be developed; B, operating for plutonium with a uranium blanket solution; and, C, operating with a blanket of thorium oxide slurry in heavy water. The next step beyond the HRT is a pilot plant reactor for 65 MW of heat or possibly something much larger.

Corrosion and nuclear stability continue to be critical questions, and the degree of optimism at Oak Ridge is continually fluctuating as new data are secured. At the time of our visit some disturbing corrosion results from small "in-pile" tests had evidently had a depressing effect. Testing under irradiation has not yet progressed very far. We were shown a corrosion "test-loop" ready for insertion in a pile which was stated to represent $750,000 of development expense.

We feel that the Homogeneous Reactor approach has such potentialities that strong and aggressive efforts to develop it as a workable and reliable system are well justified. Whether it will prove practicable in its present

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form is certainly questionable, since there are so many serious unknowns to be resolved. It is probably best classified along with the Fast Breeder as a promising "long-shot".

Sodium-Graphite Reactor

North American Aviation's program was described by Chauncey Starr and associates at the Oak Ridge meeting. NAA's Nuclear Division initially worked on nuclear propulsion for missiles for the Air Force but is now concentrating on industrial reactors for AEC, with a team of about 250 professionals.

Their sodium-graphite reactor experiment (SRE) at Santa Susana is expected to go critical in December 1955. $10 million has been allocated, of which $2.5 million is being supplied by NAA itself. Dr. Starr emphasized that this total does not provide for getting all the requisite data for potential manufacturers to design a plant whose performance can be guaranteed nor for desirable work on the general reactor program, e.g., effects of irradiation on materials, new moderators such as organics and zirconium hydride, new methods of fuel reprocessing by "compact chemistry", and new safety devices.

The SRE, rated at 20 MW, will use uranium at 2.75% enrichment, although less enrichment would be required in larger sizes. It is expected that thorium would later be used as a uranium-thorium alloy. The design embodies a reactor tank 11 ft. in diameter and 21 ft. high containing a 6 ft. by 6 ft. core. The core is composed of zirconium-sheathed graphite hexagons on 11 inch centers, immersed in sodium, with stainless-jacketed fuel rods installed vertically in central holes of the graphite hexagons. Control elements are hung in holes provided at the corners of the hexagons. Sodium coolant passes

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up through the holes and also between the hexagon faces.

There is some encouraging information on fuel elements which indicates that a burn-up of 4000 megawatt days per ton is already attainable. NAA's predictions on economics generally assume 6000 to 7000 — they believe that such burn-ups are approaching an economic asymptote.

We agree that the sodium-graphite reactor is in a relatively advanced stage of development. The 20 MW pilot plant is apparently big enough to answer questions of engineering feasibility and of the probable economics of a large commercial unit, and the development program which NAA hopes to prosecute on it seems generally sound. The present commitments for financing development work for the SRE design and especially during its subsequent operation seem somewhat inadequate and might well be increased.

We see no sound technical reason for now telescoping a larger version of the Sodium-Graphite reactor on the present 20 MW experiment. However, if another large demonstration reactor should be deemed essential at this time, we believe that the Sodium-Graphite approach is the most suitable candidate today. It would incorporate large-scale sodium technology in a commerical power enterprise. It is predicated on a considerable background of reactor experience and detailed design studies and should, therefore, present fewer highly questionable unknowns than most other possible competitors. In our judgement it is technically the most instructive approach which could result in an operating plant within the next five years.

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AIRCRAFT REACTORS

General

Our review of the aircraft reactor program (Aircraft Nuclear Propulsion, or ANP) concentrated on the technical status and prospects of the reactor developments and the associated problems of integration into a propulsion system. We note, however, that the military have evidenced increased responsibility for evaluating the potential military worth of nuclear-propelled aircraft and have explored a concept for long-range bombing operations which appears to capitalize effectively on the inherent characteristics of nuclear propulsion. This is the "nuclear cruise - chemical sprint" concept. Chiefly as a result of stronger and more realistic military planning and cooperation with the A.E.C., the premises of the overall program seem much sounder than before, with the result that reactor development work is proceeding on a more purposeful and urgent basis.

The Air Force regards the nuclear-powered aircraft as a potential weapons system for the 1960-65 period to replace the B52, which will then be outmoded. It will be included in a preliminary design competition next year in which the instructions will call for a study of a nuclear aircraft which will also be able to operate on chemical fuel only and, as a hedge, a study of an airplane which is designed solely for chemical fuel.

The A.E.C. budgets for fiscal 54, 55 and 56 in millions of dollars are:

	1954	1955	1956
Fluid Fuel (ORNL and P&W)	5.5	10.3	15.2
General Support (ORNL), e.g. Shielding, Biology & Medicine	3.0	3.0	3.0
Direct Cycle (GE)	5.9	5.6	9.3
Nuclear Development Associates	0.1	0.3	0.3

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The anticipated A.E.C. figures in 1957 and 1958 exceed those of 1956 and then taper off. Defense Department budgets are somewhat less at present but are expected to far exceed A.E.C.'s as development proceeds. Gen. Keirn estimates that a total of $139 million will have been spent by AEC and the Air Force by July 1955 and that about $325 million will have been expended in bringing the two approaches up to the initial testing of Ground Prototype Propulsion Systems. Additional Air Force funds will be needed before there is a propulsion system ready for flight test.

There are two parallel approaches: the Fluid Fuel reactor under development at Oak Ridge, with Pratt and Whitney collaborating, and the direct air cycle being developed by General Electric at Lockland, Ohio. A paper study on a heterogeneous reactor cooled by sodium has been prepared by Nuclear Development Associates and could constitute another approach if this is deemed advisable.

Fluid Fuel Reactor

The Fluid Fuel reactor which Oak Ridge is developing (also known as the Circulating Fuel Reactor or the Fire Ball) is a beryllium-moderated reactor, fueled by a circulating fused salt mixture containing uranium, and cooled by sodium or NaK. The energy from the reactor is to be converted into propulsive thrust for the aircraft by transferring heat from the sodium to air from the compressor just before it enters the turbine of a reasonably-conventional jet engine. (The first reactor experiment - ARE - went critical Nov. 4th.)

The technical problems are serious, centering around materials and corrosion. One of the fused salt mixtures which had been considered favorably

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before, consisting of 50% NaF, 44.5% ZrF_4 and 5.5% UF_4, may turn out to be too corrosive and it causes trouble due to vaporization of the ZrF_4. The behavior of beryllium under the thermal cycling which will occur is uncertain. The effects of irradiation on materials, especially on corrosion by the fused salts, are difficult to determine and may prove quite serious. Pratt and Whitney, which has been in this program less than a year, seems deeply concerned over the number and magnitude of new problems to be solved outside as well as inside the reactor, including pumps and plumbing for fused salts and radiators for heating air with hot radioactive sodium. We were not sufficiently informed of their studies on the engine and on the integration of the reactor-engine system with the aircraft to be able to judge progress and prospects.

The present schedule is necessarily quite tentative. ORNL has full responsibility for the first Circulating Fuel Reactor Experiment (CFRE), which will be designed for about 60 MW of heat and is scheduled to be operating in 1958. Pratt and Whitney will support this Experiment and will be responsible for the next step, a full-scale ground prototype which is scheduled to operate in 1959. A prototype unit in an airplane is scheduled for 1960-61.

Our impression of this program is rather confused and troubled. The fatal illness of the leader of the project has undoubtedly impaired progress at ORNL in tackling the key difficulties in the reactor system. Furthermore, we gathered that the planned close collaboration of ORNL and P&W is slow in getting underway and that mutual confidence and cooperation are not yet well established.

On the other hand, there are healthy indications that the capability of the aircraft reactor team at ORNL is improving. It was especially heartening to learn that a picked group of experienced engineers from the K-25 plant has recently joined the project. The infusion of this group may well step up the pace, contribute practical resourcefulness and decision, and hasten the effective blending of ORNL and P&W efforts.

In our judgement this program is in a critical state where every effort should be made to determine quickly whether the Fluid Fuel approach is a reasonable gamble to pay off in an operable propulsion system for aircraft within the next eight years. Oak Ridge, aided by P&W, should be the most competent group to establish the foundation for this appraisal. We suggest that a thorough review, directed towards a decision to continue or to modify the approach, be held in about six months. By this time, the augmented staff at ORNL should be familiar with the critical problems and the prospects of solving them and the P&W people should be well integrated into the project. Furthermore, the call for such an appraisal in the near future would itself hasten the unification of various elements towards an agreed objective.

Heterogeneous Sodium-Cooled Reactor

Nuclear Development Associates has made a paper study of a sodium-cooled aircraft reactor using fuel pins of the SIR type, in a 43-inch beryllium right cylinder and with a central beryllium island. Their design uses very high velocities for the sodium coolant and assumes 5% burn-up on a 250-hour cycle. A heterogeneous reactor looks reasonable as an embodiment of the liquid sodium cycle in an aircraft reactor and it may be desirable to initiate active development in the near future.

Direct Air Cycle Reactor

Development at the General Electric's Lockland, Ohio, plant are well into the hardware stage, and fuel elements are being fabricated for the reactor core which will be used in the Heat Transfer Reactor Experiment (HTRE) next year. The schedule calls for installation of this core, with a rating of 20 MW of heat, in the Core Test Facility at Arco late in 1955. The next step is a 40 MW reactor, of the physical dimensions which would go into an aircraft, in late 1956 or early 1957. Following this, a first ground-test prototype is scheduled for 1958 and probably a second one in 1959. By 1960 they hope to have a nuclear power plant suitable for flight testing. This would probably be in the range of 180 MW.

G.E.'s concept of the propulsion cycle involves blowing air from a compressor with a 14-to-1 compression-ratio through the reactor, where it is heated to about 1700°F and then enters the turbine. (Present maximum permissible turbine inlet temperatures are 1700°F.) Chemical fuel is used in an after-burner when high power is needed for take-off, sprint, etc. Chemical fuel may also be bled in between reactor and turbine as desired. (Such uses of chemical fuel are also applicable in the sodium-cooled system.) A typical study results in an airplane of 435,000 lbs gross weight, containing 106,000 lbs of chemical fuel and 170,000 lbs for reactors, engines, reactor shield and crew shield. The shields themselves total about 100,000 lbs. A reactor might feed more than one engine, and some of the engines might be only chemically-fueled.

The fuel elements for the Heat Transfer Reactor Experiment are made by powder metallurgy as a ribbon in which grains of UO_2 are sandwiched in

Nichrome-5. The ribbon is cut to suitable lengths, which are then made into "bracelets" of varying diameters. These are then fitted into a tube so that they fill the tube with a series of spaced circular elements presenting their edges to the air flow. The length of tube which contains active elements is 30 inches. The tubes are spaced in a 45" cylindrical reactor shell of aluminum or zirconium and the volume outside the tubes is filled with light water (or possibly an organic liquid) as a moderator. The water, which will run at 300°F, is expected to pick up about 10% of the total reactor heat and in the "flying model" will be cooled in a radiator so installed that it essentially "flies itself". It is expected that the pressure drop through the reactor and associated air ducts will be 20-30% of the pressure at the compressor outlet.

It was noted that ribbon elements have superseded wire elements as the preferred type. This is due to hydrodynamic difficulties in cooling the wires in the configurations which have been tried to date. It is expected that the design will allow an average air temperature of 1700°F without exceeding 1950°F anywhere in the fuel elements.

Tests for structural integrity of the reactor design with heated air blown through the tubes are in progress.

G.E. does not yet have a fuel element and a design which assures that the performance as described can be realized. However, their progress is quite encouraging, the effort seems to be well integrated towards a practical power plant, and we feel that strong support is warranted. In our judgement, the program might profitably use more personnel and money for additional studies of materials and components.

Conclusions on Aircraft Reactor Program

The overall direction of the program has decidedly improved. There is a real possibility of using nuclear propulsion effectively in operating weapons systems within ten years. In view of the military potentialities as described to us, high urgency is warranted.

General Electric's progress towards a workable propulsion system using the direct air cycle is distinctly encouraging. Even though the solutions to many problems are still outstanding, this program seems to warrant full and increasing support.

The general concept of a sodium-cooled reactor should also be supported with high urgency. The Fluid Fuel approach presents some exceedingly difficult problems and should be critically reviewed soon to determine whether it offers a reasonable chance of producing a workable power plant within the time schedule of weapons systems to which it is now committed. Recent strengthening of the ORNL staff is encouraging, but collaboration of Oak Ridge and Pratt & Whitney seems to be lagging. The active development of a heterogeneous reactor for the sodium cycle may well be justified and we suggest that the Reactor Division draft a proposed program, including type and scope of work and contractors, which can be presented at the next meeting of the General Advisory Committee.

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Dr. Wigner disagrees with the above statements on the Aircraft Reactor Program in the following respect (as expressed to Mr. Whitman):

"The only point where I would like to differ with you is your very different appraisal of the two aircraft reactor programs. While I surely realize that the direct air cycle is a very promising avenue and is quite likely to be the one which ultimately survives, I also believe that the circulating fuel

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reactor has about equal promise to be ready first as a workable engine. My only apprehension in this regard is the lag in the efforts to integrate this reactor with engine and airframe. It seems to me that as far as the aircraft reactor is concerned, the circulating fuel reactor appears as promising as the direct cycle reactor.

"Since apparently we differ sincerely in our evaluation of the promise of these two types of reactors for airplanes, it seems to me best if we admit our difference of opinion and state it clearly."