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Remarks by

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at the

25th Anniversary of Argonne National Laboratory

Argonne, Illinois

June 19, 1971

ARGONNE: A TRADITION OF ACCOMPLISHMENT

As atomic energy has come of age, there have been several opportunities to celebrate twenty-fifth anniversaries, and I have already taken part in some memorable ones. It is a special pleasure, however, to be with you here at Argonne today. In the first place, I count myself as something of a charter member of the Argonne team. As I shall mention in a moment, I joined the Met Lab long before the idea of the Argonne laboratory was even thought of. I was still with the Met Lab staff during those months after World War II when the new laboratory was being organized, and I left Chicago only a few days before Argonne came into existence.

Secondly, over the past thirty years I have established many personal friendships and professional contacts with the people of Argonne. It has been you and many others, rather than the buildings and equipment, who have made Argonne one of the truly great scientific research centers in the world. So in speaking of those who made Argonne what it is today, I am referring not just to a group of talented scientists and technicians, but in many cases to personal friends and long-time associates.

There is a third sense in which this anniversary has a special meaning for me—and I am speaking here in the broad historic dimension rather than in personal terms. The creation of Argonne marked the first attempt in the United States to establish a new type of scientific laboratory, one which would unite in one institution the strong tradition of academic research, which had long been a part of our universities, and the extraordinary advantages of a Government- sponsored laboratory which our experience during World War II has demonstrated. This new institution, called a *national* laboratory, has emerged in large part from the Argonne experience and the magnificent accomplishments over the past twenty- five years have proved the vitality and creativity of this new type of research organization. In this sense, the anniversary we are commemorating today has a meaning that goes far beyond the lives of those present and even Argonne itself.

On an occasion such as this, perhaps I may be pardoned for succumbing to the temptation to reminisce. But in thinking over the history of Argonne, I could not help but recall those exciting days early in World War II when Argonne had its origins in the Metallurgical Laboratory at the University of Chicago. Thanks to the foresight and energy of such men as Vannevar Bush, James Conant, Arthur Compton, and Ernest Lawrence, the United States was ready to launch its effort to build a nuclear weapon when the nation entered the war in December, 1941. Within a few days after the attack on Pearl Harbor, Bush and Conant gave Compton responsibility for the research needed to produce a chain reaction and the bomb.

A few weeks later Compton decided he would have to centralize on the Chicago campus much of the research then going on at several universities. Because my group at Berkeley had discovered the element plutonium, which would be the fissionable material produced in the chain reaction, I was invited to Chicago in early February 1942, to discuss our work with Compton, Norman Hilberry, John Wheeler, Enrico Fermi, and others. The Chicago leaders wanted to discuss the production of plutonium and the possibility of devising a chemical method of separating it from uranium and the various fission products of the chain reaction. At this meeting I first fully realized the magnitude of the bomb project and the central importance of our newly discovered element in that enormous effort. I must have appeared confident when I assured Compton that we could develop a separation process for plutonium, but I do recall that I had some private misgivings.

Because it would take some time to organize the new laboratory in Chicago and prepare research facilities, most of the research teams at other universities were scheduled to arrive later in the spring. In the meantime, Fermi and Leo Szilard, with the assistance of Wally Zinn and Herb Anderson, would continue their studies of exponential piles at Columbia. I concluded that my own group would probably stay at Berkeley, where we would be close to the 60-inch cyclotron, which was still our only source of the ultramicroscopic quantities of plutonium we were using in our research. I changed my mind, however, during a luncheon meeting with Norm Hilberry in Berkeley on March 23. I realized that, despite my preference for remaining in Berkeley, I would have to take some of my group to Chicago to develop the separation process.

I will never forget that Sunday afternoon of April 19, 1942, when Isadore Perlman and I stepped off the "City of San Francisco" in Chicago to begin our new adventure. It was my thirtieth birthday, which we celebrated by going to a movie and dinner in the Loop. The next morning we returned to our study of the separation process. Within a few days we were assigned several rooms on the fourth floor of the Jones Chemical Laboratory which we used as our offices and laboratory. With the arrival of Spofford G. English, one of my graduate students, we had what constituted the entire plutonium chemistry group for more than a month. During these weeks I arrived at the rather novel idea that we might be able to produce enough plutonium-239 through the bombardment of uranium with cyclotron neutrons and the use of ultramicrochemical techniques so that we could study the chemistry of the new element in its pure form. That effort was to demand most of our energies during the spring and summer of 1942.

As the result of two recruiting trips during May and June I had increased the size of our chemistry group. Michael Cefola from New York University and Louis B. Werner and the late Burris B. Cunningham from Berkeley had agreed to join us in Chicago. I also managed to recruit a wife on that Berkeley trip, and Helen returned to Chicago with me to begin married life in a small apartment near the Chicago campus. By that time many other scientists and their families were arriving from universities in all parts of the country. One of the pleasures of being a part of the Met Lab was the opportunity to know and to work with so many people whom we had scarcely seen before. I recall, for example, a picnic which Helen and I attended on the Fourth of July weekend in 1942 with the Harrison Browns, the Milton Burtons, and the Perlmans. We went out to the Argonne Forest Preserve to look over the site proposed for the world's first nuclear reactor. Although we had a fine picnic, we never did succeed in finding the reactor site.

During July and the first part of August, 1942, the new members of our plutonium chemistry group assembled the specialized equipment for working with extremely small volumes (10^{-5} to 10^{-1} milliliter) and weights (0.1 to 100 micrograms) and developed their techniques with trace quantities of plutonium in microgram amounts of carriers. "Carrier" was the term we used to describe the material which when precipitated has the power to sweep out of a solution trace amounts of a desired substance too dilute to be precipitated by itself.

By August, 1942, these techniques had been developed to the point where we could attempt an isolation of pure compounds of plutonium. After a week of work, Cunningham, Werner, and Cefola finally obtained a solution of pure plutonium compound in a volume of 0.015 milliliters. On August 20, they carefully evaporated this solution until the plutonium concentration became high enough to precipitate as a compound plutonium fluoride. This was man's first sight of plutonium and in fact of any synthetic element.

As the summer of 1942 waned, the activities of the Met Lab took on a more serious tone. The results of Fermi's research on the critical mass of uranium and our own success in isolating a pure plutonium compound made the idea of developing a nuclear weapon something more than a theoretical possibility. By this time the Army had taken over the project, and we had begun the transition from purely scientific research to engineering development. For our chemistry group that meant planning much larger facilities in the New Chemistry Building on Ingleside Avenue and in a portion of the West Stands. I must admit that for a group of young chemists the idea of the Government spending $200,000 for a building and equipment for our use was an exciting one indeed.

The transition to engineering development caused a similar expansion of thinking in all parts of the laboratory. Some of you may remember that at that time there were tentative plans to build not only the first reactor but also the entire plutonium pilot plant in the Argonne Forest Preserve, where we had our July picnic. On September 11, 1942, I again visited this site with Compton, Conant, and other members of the S-1 Executive Committee. I vividly remember Conant's conviction that the site was too close to Chicago for a pilot plant. What we needed, Conant said, was an entirely new perspective. We were, in his opinion, trying to kill elephants with pea-shooters. As most of you know, the committee then decided that the pilot plant would be built at Oak Ridge.

As it turned out, of course, construction difficulties at the Palos Park site made it impossible to build even the first experimental pile there, and Arthur Compton, with General Grove's support, made the daring decision to initiate the world's first nuclear chain reaction in the heart of Chicago. I well remember the grimy appearance of the workers (some of them are probably here today) who fabricated and assembled the greasy blocks of graphite under the West Stands. In the afternoon of December 2, 1942, that now historic day, I happened to me rawford Greenewalt, the young Du Pont executive, in Eckhart Hall, just after he had left the West Stands. Greenewalt did not have to say a word to me: I could tell from the glow on his face that Fermi's experiment had succeeded beyond our hopes.

The year 1943 brought a new intensity to our effort to design the plutonium pilot plant to be built at Oak Ridge and ultimately the huge production plants at Hanford. While Eugene Wigner and others concentrated on the design of the X-10 reactor, we in the plutonium chemistry group were more than preoccupied with the separation process. When we moved into the New Chemistry Building in December, 1942, we at last had space to test the various separation processes which had been proposed. Although our knowledge of plutonium chemistry grew at an impressive rate, our research did not indicate that any one process had a clear-cut advantage.

Early in 1943 we decided that we would use an oxidation- reduction process in aqueous solution, but it was not at all clear whether lanthanum fluoride or bismuth phosphate would be the best carrier of plutonium. Until we made that decision, Du Pont could not fix the design of the Oak Ridge pilot plant. I remember we discussed the alternatives at a meeting in Chicago on June 1, the deadline which Du Pont had established for the decision. Because the engineering data did not indicate a clear choice, Greenewalt turned to me for an opinion. With the fate of the whole wartime project hanging on my judgment, I said I was willing to guarantee at least a 50-percent recovery of plutonium from the bismuth phosphate process, developed by Stanley G. Thompson of our group. With that assurance, Greenewalt focused most of the engineering talent of his organization on bismuth phosphate. It would be eighteen months before I could be certain that my decision had been the right one.

Before the end of 1943 the Oak Ridge pilot plant was in operation and Du Pont engineers had taken over most of the responsibility for the production plants at Hanford. Supporting work for Hanford and Los Alamos continued but those of us who remained at the Met Lab also began turning our attention to the many intriguing possibilities for scientific research which the fission process and the discovery of transuranium elements had opened up. The Palos Park site, which was not used for the first chain reaction, did eventually become the home for the laboratory's experimental reactors–not only the reconstructed version of the original West Stands CP-1 (then called CP-2), but also of CP-3, the world's first heavy-water moderated reactor, designed by Wigner and built by Zinn. At this site Zinn also did further studies on fast-neutron reactors and completed the first designs of what was to be the historic Experimental Breeder Reactor No. 1. As the original Met Lab expanded to sites off the Chicago campus, the research facilities at Palos Park took the name of Argonne after the forest preserve, and in 1944 Fermi, with Zinn as his assistant, became director of the Argonne Laboratory, which was part of the larger Mettallurgical Project under Compton. Thus the now familiar name Argonne Laboratory was born.

Those of still in the chemistry group in 1944 continued our research in "New Chem" with a program that included a search for transplutonium elements. These efforts did not bring any success until we formulated a new theory postulating the existence of a group of "actinide" elements in the heavy element region with properties similar to the lanthanide rare-earth series in the traditional periodic table. Experiments during the summer and fall of 1944 and extending into the beginning of 1945, uring both cyclotron- and reactor- irradiated plutonium, led to the detection of element 96, which we later called "curium" and of element 95, which we named "americium." During the remainder of the war, in addition to supporting activities at Hanford and Los Alamos, we investigated the processes which made possible the isolation of these new elements in pure form, americium in the fall of 1945 and curium in 1947. As I look back on these events, I realize that some of the most exciting moments of my scientific career occurred in the flimsy laboratories of the Met Lab.

The laboratory's rapidly declining responsiblities in 1944 not only made possible some basic research of the type I have just described but also forced us to focus some thought on the role we as nuclear scientists might have in the postwar world. In the face of distressing rumors that 90 percent of the Met Lab staff would be fired by June 1, 1944, Arthur Compton asserted a steadying influence. He won some concessions from Army authorities in Washington and encouraged us to begin some constructive planning and thinking. He also arranged to have Henry D. Smyth begin some long-range plans. At a meeting of the Project Council on February 16, 1944, there was even some discussion of the various types of laboratories which might be engaged in nuclear research after the war. One of these, described as a "cooperative laboratory," should, according to the Council, be established where the scale of research would be "too large to be financed by Universities." The buildings and equipment would be furnished by the Government and research administered "by cooperation of educational institutions." This was clearly an early conception of the national laboratory.

These discussions soon led to consideration of the wider social and political implications of nuclear energy. Under the leadership of Zay Jeffries, a laboratory committee set about preparing what Jeffries called a "Prospectus on Nucleonics." Completed in November, 1944, the Jeffries report reviewed the possible applications of nuclear science in the near future and the outlook for nuclear power (which seemed good at that time). The committee also recommended that the Government support the kind of "cooperative laboratories" mentioned the previous winter in laboratory meetings. Going beyond the technical aspects of nuclear technology, Jeffries and his committee urged the creation of a world organization to prevent widespread destruction from nuclear war. They also stressed the importance of postwar research in maintaining the United States' lead in nuclear science and technology.

The Jeffries report had no immediate impact on national policy, but it did help to sensitize many of us at the Met

Lab to the difficult policy questions we would be facing as the war ended. This experience made it all the easier for us to take up the discussion of whether and how to use the first nuclear weapon when that issue came before the Interim Committee in the spring of 1945. Historians may never agree on whether the recommendation of the Franck committee at the Met Lab (to provide a demonstration rather than direct use) ever reached those who made the final decision to use the bomb, but as a member of that committee, I can assure you that we made a conscientious effort to fulfill our responsibilities as citizens as well as scientists. It was no accident that the Atomic Scientists of Chicago became the leaders in the national debate over postwar atomic energy policy during the summer and fall of 1945.

The Met Lab, then, provided a strong and valuable heritage for the new Argonne National Laboratory, which would come into existence in July 1946. First of all, Compton's idea of bringing to Chicago the best available scientists from all parts of the nation created a laboratory on a truly national scale. The Met Lab experience engendered a sense of mission and a standard of excellence which every great laboratory must have. Exceptional scientists like Fermi, Wigner, Szilard, and Compton set a pattern of skill, accomplishment, and imagination which we younger scientists tried hard to emulate. That experience trained others like Zinn and Hilberry to carry on the Met Lab tradition and in turn enabled them to impart it to succeeding generations of scientists at Argonne. Furthermore, the concern over postwar policy created a tradition that has inspired Argonne to take a broad perspective in approaching scientific and technical problems. Thus from its very origins Argonne has operated from a principle that others are only now beginning to understand– namely, that the scientists' responsibilities extend far beyond the technical data of the laboratory. These are worthy traditions, and it is to your credit that they are still so much a part of Argonne today.

I do not mean to suggest by these sweeping statements that these traditions or even the laboratory itself have enjoyed an unthreatened or automatic existence. In fact, I recall that we were anything but certain in the early months of 1946 that the laboratory would continue to exist. Although, as we have seen, the idea of a national laboratory circulated in rather nebulous form early in 1944, it was not the kind of idea that could gain ready acceptance at that time. Before World War II, universities and private foundations were virtually the only sources of support for scientific research. The few Government-supported laboratories, such as those operated by the National Advisory Committee on Aeronautics and the Navy, were largely restricted to applied studies. Only the enormous pressures of the war had forced American scientists to abandon the traditional forms of support, and many expected science to revert to the pre-war pattern.

The idea of a "cooperative" or national laboratory, however, had taken firm root at the Met Lab since the first months of 1944. Although the precipitous decline in the laboratory's personnel strength from about 2,000 in July 1944 to scarcely more than 1,500 in January 1945, caused Compton to recommend that the remnants of the Met Lab be transferred to the University of Chicago, others, including Zinn, Szilard, Hilberry, and Farrington Daniels proposed that the laboratory be managed by a board comprised of some twenty universities in the Mid-West. The new laboratory would be but one of several "regional cooperative laboratories" which would undertake projects too large for single institutions. They would be financed by the Government but would not necessarily be Government laboratories.

It is much to the credit of General Groves and his assistant, General Kenneth D. Nichols, that this hope came to fruition in July 1946, in something like its original form. Although many of us at the Met Lab at the time considered the Army somewhat unresponsive to our aspirations for continuing basic research, the fact was that the Army had little authority and even less practical motivation for keeping the laboratory alive. In the chaotic period following the end of the war in 1945, the Army more than had its hands full in coping with the strong reaction against military institutions and particularly against its legislative proposals for the postwar control of atomic energy. Despite these difficulties, General Nichols did seek out representatives of the Mid-West universities and asked them to prepare a plan "for continued operation of the Argonne facilities on a cooperative basis between the government and various universities." Nichols then asked the University of Chicago to consider taking over operation of the laboratory on July 1, 1946 "for cooperative research in nucleonics." Argonne National Laboratory came into existence on that date with Walter Zinn as the first director.

Thanks to the Army's cautious but effective support, the laboratory had survived the dangerous transformation from a temporary wartime organization to an essentially permanent research institution. That did not mean, however, that Argonne's troubles were over. Because Argonne was already in existence before the Atomic Energy Commission was established, Zinn and the new Board of Governors had no way of knowing what would be the laboratory's relationship to the Government. The delay in appointing the new Commissioners after the Atomic Energy Act became effective in August 1946, and then the prolonged struggle over the confirmation of the new Commissioners by the Senate beclouded that relationship for another year.

This uncertain status was a serious handicap for the new laboratory, especially because Argonne as yet had no permanent home. Still housed in a dozen buildings on the Chicago campus, the laboratory could not much longer presume on the university's hospitality. Originally there had been some hopes of acquiring more land in the Argonne Forest Preserve, where the laboratory's two reactors were already operating, but the Cook County Board of Supervisors opposed that idea. Zinn favored condemning land at the existing reactor site; the Board of Governors favored acquiring 3,700 acres of farmland about five miles west in Du Page County. When the new Commissioners took over late in 1946, they were reluctant to give up on the Argonne site, with the result that the decision to come to Du Page County was delayed until late in January, 1947.

Equally important was the still unresolved matter of the laboratory's function as a part of the Commission's research and development program and as a regional research center. For the moment that question was settled more by pressing demands than by deliberations over policy. Until the new laboratory could be constructed, there was not much opportunity for the broad, multidiscipline research in which the participating universities would be interested. At the same time the Commission had several urgent assignments for Argonne, primarily in the area of reactor development.

The hard fact was that in 1947 the Commission had to rely almost entirely on Zinn and Argonne for its reactor development program. The Commission had only one member of its Washington staff with any reactor experience. The Clinton Laboratories at Oak Ridge had some of the best reactor talent in the nation, but by the spring of 1947 many responsible figures in the atomic energy program doubted that Clinton could survive as a national laboratory. At that time I was a member of the General Advisory Committee, and I remember we seriously debated whether, in the face of all the difficulties confronting the Clinton Laboratories, it might not be better to close it down and move the scientific talent elsewhere. We in the GAC were particularly concerned at that time about the shortage of scientists and engineers with any practical knowledge of nuclear technology. To some members of the General Advisory Committee, it seemed dangerous to spread the available talent too thin over several laboratories. In the end, of course, the Oak Ridge laboratory was saved, but not until the Commission had decided in the closing days of 1947 that it would center all reactor development work at Argonne.

The enormous responsibility placed upon Zinn and Argonne by this action left little time for the kind of cooperative research in the nuclear sciences which the Board of Governors had contemplated. The Commission had already called upon Zinn to draft a reactor development program for the nation, and Argonne was now faced with the task of participating in the design and construction of all but one of the experimental reactors in Zinn's proposal. These included not only the fast-neutron breeder reactor which Zinn had been developing at the Argonne Forest site, but also two reactors being designed at Oak Ridge. The high-flux testing reactor, the creation of the Clinton Laboratories, would be continued as a joint effort with Argonne. The Clinton scientists and engineers who had been working on a pressurized-water reactor for submarine propulsion moved to Chicago during the summer of 1948, and from that time on, Argonne had a major role in developing the propulsion plant for the world's first nuclear powered submarine.

All these plans for experimental reactors operating at significant power levels raised in a new and serious way the question of finding an adequate site far enough from populated areas to avoid hazards in case of an accident. Zinn and others at Argonne had a key part in discussions which led to the selection of the National Reactor Testing Station (NRTS) in Idaho early in 1949, and the first three reactors built at the Idaho site were in a major sense Argonne products. The Materials Testing Reactor, first operated in 1952, was for more than a decade an indispensable tool for reactor engineers in designing new types of plants and testing components. The Submarine Thermal Reactor, Mark I, was in operation less than a year later and provided much of the basic technology for pressurized-water reactors.

The Experimental Breeder Reactor No. 1 was uniquely an Argonne creation and achieved so many "firsts" in the history of reactor technology that I do not have time here today to list them all: It was the world's first reactor to produce a useful amount of electric power from atomic energy (December 20-21, 1951), the first to demonstrate the possibility of breeding (in 1953), the first to achieve a chain reaction with plutonium instead of uranium as fuel (November 27, 1962), and the first to demonstrate the feasibility of using liquid metals at high temperatures as a reactor coolant. EBR-1 also provided the occassion for the first visit to the National Reactor Testing Station by a President of the United States. I recall with great pleasure my trip to Idaho with President Johnson on August 26, 1966, to dedicate EBR-1 as a National Historic Landmark.

In addition to this work on experimental power units, Argonne was deeply involved during the early 1950s in developing heavy-water-moderated reactors. This activity grew out of the Argonne experience during the war with the CP-3. When the Commission decided in 1950 to undertake a major expansion of its production reactor facilities, Zinn proposed a design using heavy water. This proposal was accepted, and Argonne began a major development effort on an improved heavy-water reactor. This work produced CP-5 at Argonne and the production reactors which were built at the Commission's new plant on the Savannah River in South Carolina.

Taking these assignments in stride, Argonne continued to expand its reactor development activities in the middle and late 1950s. Perhaps of greatest short-run significance was the Experimental Boiling Water Reactor, which again was largely a product of Argonne. First operated in 1956, EBWR proved that a direct-cycle boiling water reactor system can be operated without serious radioactive contamination of the steam turbine. Operating experience over more than a decade showed the system to be surprisingly stable even at power levels five times its rated heat output. As the forerunner of numerous full- scale nuclear plants now producing electric power on a commercial basis, the EBWR has a permanent place in the history of reactor development in the United States.

Through most of the 1950s Argonne under Zinn's direction was primarily a center for reactor development, but by the middle of the decade new forces were beginning to have an impact on the laboratory. Thanks in large part to the pioneering efforts of Argonne in reactor development, American industry had begun to show a real interest in nuclear power. The Eisenhower Administration, looking for ways to give private industry a place in nuclear power development, took the lead in efforts to revise the Atomic Energy Act of 1946, which made atomic energy virtually a Government monopoly. Under the liberalized provisions of the 1954 Act, nuclear science and technology became a part of American life. The national laboratories were no longer small islands of technical information sealed off from the rest of society. Perhaps more than any other one event, the first Geneva conference in 1955 demonstrated that atomic energy was beginning to move beyond Government offices and laboratories into the universities and private industry. As a national laboratory, Argonne could play a new and broader role than in the past.

A major force in the changing tides of the 1950s was the growth of Argonne, both in terms of staff and facilities. The scattered buildings of the Met Lab on the Chicago campus and the small warehouse-like structures in the Argonne Forest Preserve were now only memories. Argonne had even moved beyond the temporary Quonset huts which the Commission had hastily erected in 1947 to the three separate areas we know today. With an annual operating budget in 1958 of nearly $34 million and a staff of more than 3,000, Argonne was attaining physical dimensions and a stature scarcely foreseen a decade earlier. Even more important, the laboratory was no longer heavily concentrated in the reactor sciences, but had grown dramatically in physics, chemistry, and the life sciences. Argonne was now becoming a multidisciplinary laboratory more closely tied to basic research than ever before in its history. Zinn's departure as director in the spring of 1956 was, I think, more a symptom than a cause of the profound changes that were occurring in Argonne. In 1958 the laboratory, under the direction on Zinn's successor, Dr.

test the concepts in zero power reactor experiments, and to establish the fundamental character and design of the reactor itself. As I mentioned before, this procedure had been followed in the development of the pressurized water submarine thermal reactor to the point where Westinghouse was able to complete the detailed engineering design resulting in the Nautilus submarine reactor. And the boiling water concept had originated and developed at Argonne in the BORAX series of experiments, culminating in the construction and successful operation of the EBWR in the middle Fifties. Further studies led in 1966 to the operation of EBWR with a largely plutonium core which provided the first valuable information on the question of plutonium recycle operation of water reactors. The last of the BORAX series, BORAX-V, was completed in 1964. This highly successful experiment was designed to permit the evaluation and study of nuclear superheat concepts and to demonstrate actual nuclear superheat operation.

Shortly after the successful development and operation of EBR-I, as noted earlier, design was begun on EBR-II, an experimental fast breeder reactor power station of 20 MWe capacity whose purpose was to demonstrate the potential technical and economic feasibility of using fast reactors for central station power plants. This was to be done by both producing electricity and demonstrating the feasibility of the closed fuel cycle.

The EBR-II concept of arranging the reactor and primary system components—pumps, heat exchanger, instrumentation, fuel handling system, etc.—in a large tank where they operate submerged in sodium was a bold departure from traditional reactor system design. This pool or pot concept as it is now called has gained wide acceptance, and plants of this design are now under construction in the U.K., France, and the U.S.S.R. in sizes ranging from 250 to 600 MWe.

National Reactor Testing Statio. .n Idaho. Building such a complicated facility 1,800 miles from home base posed problems quite aside from the technical ones as those who were associated with the project well remember. However, the decision to retain the managment of the EBR-II project at the Argonne site was a sound one and, even today with the changed mission of EBR-II, retaining the management here in Illinois leads to intimate coordination between the rest of the reactor program and the experience being obtained in EBR-II.

The reactor began operation in 1964 and the turbine generator was synchronized and first delivered power to the NRTS power loop on August 7. By the end of 1970 more than 250 million kilowatt hours of electricity had been produced by EBR-II. The EBR-II pool concept has been shown to be entirely feasible and the fuel cycle was demonstrated to be entirely reliable and practicable. All of the fuel for EBR-II was processed and fabricated in the Fuel Cycle Facility (FCF) until July 1969 when it began exclusive use in support of the experimental irradiation program. During the approximately five years that the FCF provided the fuel for EBR-II, 38,000 fuel elements were processed and fabricated and 366 subassemblies and 66 control and safety rods were assembled. The fuel completed 5 cycles through the reactor and fuel cycle.

With the focusing of the AEC's and the nation's civilian power reactor program on the Liquid Metal-Cooled Fast Breeder (LMFBR) and with the decision to build the Fast Flux Test Facility, or FFTF, at Hanford, the role of EBR-II was changed to that of a fast neutron irradiation facility. It is rare indeed that a facility built for one mission can accomplish it very well and then can be converted to fulfill another which was not visualized in the original design, but that is what was done with EBR-II, and most successfully. Some indication of the extent of this success can be obtained from a look at last year's performance. In 1970 at least 17 reactor manufacturers and research organizations had designed experiments on which tests were started in the EBR-II. During the year about one-third of the EBR-II core had been filled with experimental subassemblies. The fuels being tested included plutonium and uranium oxides, carbides and nitrides. One of the goals was to observe the performance of these fuels after long exposure and high burnups in the reactor. The highest burnup attained to date in this experimental program is 13.8 atom percent in an oxide-type fuel. This is significantly higher than the commonly accepted goal of 10 percent for commercial breeder reactor fuels.

In large measure the success of the LMFBR will rest heavily on the information obtained over the years from EBR-II.

Just as the mission of the EBR-II was changed with the concentration of civilian power development on the LMFBR concept, so has the orientation of the rest of Argonne's reactor program changed. The Chemical Engineering Division has in the past developed many methods for the processing of spent fuel from reactors—aqueous processes, the pyrometallurgical process, and the fluoride volatility process. Now under the able direction of Dick Vogel, their attention is turned to the many chemical problems involved in using high temperature sodium as a coolant in fast reactors. The Metallurgy Division in the past decade concentrated on development, and especially fabrication, of fuels for Argonne's reactors. Now, however, under the leadership of Paul Shewmon and Brian Frost and under a new name, Materials Science Division, they are concentrating on acquiring a very detailed knowledge of the behavior of fast reactor fuels and structural materials under the twin conditions of long-term irradiation and high temperatures. The Reactor Engineering Division, responsible for designing, engineering, and constructing so many of Argonne's reactors, has now been restructured into the Reactor Analysis and Safety Division and the Engineering and Technology Division. This reflects the concern with safety and the engineering development of components which is such an important part of the LMFBR program.

To assist in the refocusing and restructuring of Argonne's reactor program to reflect the nation's major reactor development effort, Bob Laney was recently brought in as Associate Laboratory Director for Engineering research and development. His responsibilities will also involve the coordination of Argonne's increasing interaction with industry. I can assure you that in the decade ahead Argonne will continue to play an extremely important role in the AEC's Reactor Development program.

In addition to its responsibilities in the reactor development program, Argonne has from the beginning carried on a very fine and strong program of basic research.

Late in the 1950s the stage was finally set for a major effort which would widely expand opportunities for basic research in high energy physics, not only for Argonne staff members but for high energy physicists from Midwestern univerisites and from many parts of Europe. After four years of planning, ground was broken for Argonne's Zero Gradient Synchrotron, a 12.5 GeV particle accelerator. On Dec. 4, 1963, it was my pleasure to participate in dedication ceremonies for this new tool which was destined to contribute so much to the scientific life of the Midwest.

The ZGS was constructed in response to a longstanding need. Although large particle accelerators were available on the East and West coasts, none was in existence in mid-America, and the high energy physics departments of the Midwestern universities were losing both faculty members and graduate students to institutions on the coasts.

The ZGS was designed to supplement, not compete with, the machines already in existence here and abroad. Although its energy would not be as great as that of other accelerators, its intensity would be much greater. Among other advantages, this higher intensity would permit more experiments to be completed in a given period of time, an attractive situation in view of the fact that investigators must queue up to obtain time on major machines like ZGS.

One design feature of ZGS is responsible for its name. The strength of the magnetic field in the 200-foot ring is uniform–it does not have a gradient–across the poles. In other synchrotrons a magnetic field gradient is built in to keep the circulating beams of particles focused. As a result of this design, the ZGS ring can guide the high-energy protons in a smaller circle and this in turn resulted in a significant reduction of construction costs.

Another feature contributes to the high intensity capability of the facility. The ZGS incorporates a comparatively large aperture through which particles can pass. This "window frame" design combines with the high magnetic field to make possible the acceleration of large numbers of particles, providing a shotgun rather than a rifle approach to the creation of interactions which are of interest to the high energy physicist.

The years following the dedication of the ZGS saw a steady increase in intensity, ever-greater reliability, and a flow of alterations which improved both performance and reliability.

Two important achievements resulted from the need for experimental apparatus which matched the capabilities of the ZGS. One was the design, construction, and successful operation of the 12-foot bubble chamber, largest of its kind in the world, and another was the use of a superconducting magnet to power this huge chamber. Gale Pewitt presided over the birth of the 12-foot chamber and John Purcell brought the big magnet into existence.

A very large step forward in the size of superconducting magnets had been accomplished here by Charles Laverick, but the magnet needed to operate the 12-foot chamber was so large it represented a high-risk venture into engineering areas with which no one had had experience.

But the foresight of Argonne staff members paid off and the magnet has worked as it was hoped it would, resulting in monetary savings in the operation of the chamber–at a time when such savings are indeed welcome.

The value of the 12-foot chamber was demonstrated in November 1970, when for the first time in history, a neutrino was observed in a hydrogen chamber.

In the six years ending Dec. 31, 1970, 125 experiments were carried out at the ZGS. Physicists from 50 universities had used the machine and they had joined with Argonne staff members in the publication of 164 papers in professional journals.

The list of those who made important contributions to the development of the ZGS and the Argonne High Energy Physics Complex is a long one, and all cannot be noted. My early co- worker and long-time friend Jack Livingood did the initial planning. Albert V. Crewe came aboard in 1958 to direct completion of the design and much of the construction. When Al became Laboratory Director in 1961, Lee Teng took over and under his aegis the machine was completed. Ron Martin and the late John Fitzpatrick directed scientific and engineering activities; Martin Foss designed the magnet ring.

Through the decade of the Sixties, the buck stopped at the desks of three Associate Laboratory Directors for High Energy Physics: Roger Hildebrand, Bob Sachs, and Bruce Cork.

During the Sixties, under the leadership of Crewe and later Robert Duffield, the results obtained in the areas of chemistry, physics and materials research continued Argonne's reputation for high quality research and added significantly to our fund of basic knowledge.

The Chemistry Division is an outgrowth of the Chemistry Section for which I had responsiblity back in Met Lab days. Many of its present members were my wartime colleagues during my four years' stay in Chicago. Under the directorship of, first, Winston Manning who was named Associate Laboratory Director for Basic Research in 1966, and under Max Matheson, and currently under Paul Fields, this Division has been responsible for several important advances, among them:

...The discovery of the noble gas compounds. In 1962 John Malm, Henry Selig, and Howard Claassen succeeded in combining xenon with fluorine to create xenon tetrafluoride, a relatively simple compound. The importance of this discovery derives from the fact that the noble gases had been thought to be inert and nonreactive.

...In 1963 Edwin Hart and his British colleague Jack Boag reported the discovery of the hydrated electron. The discovery and analyses of the roles of the hydrated electron and other short-lived fragments are leading to a better understanding of radiation chemistry.

...Joseph Katz and his group pioneered research in "Isotopic substitution" in organic compounds, including the first complete substitutions of deuterium (heavy hydrogen) for ordinary hydrogen in living organisms, both plant and animal cells.

...Argonne chemists, notably Paul Fields and Martin Studier, participated in the discovery of some of the heavy transplutonium chemical elements. They also made unique contributions to the production, separation, and characterization of these elements and their isotopes.

Although in the past decade low energy physics research has been carried out under three different Division Directors, Lou Turner, Mort Hamermesh, and currently Lowell Bollinger, it has had the common thread of searching for a greater understanding of atomic structure. Among the first to initiate fundamental studies using the Mossbauer effect was Gil Perlow who has built the technique into a powerful experimental tool in such diverse fields as nuclear structure, solid state properties and general relativity theory. There have also been the angular momentum distribution discoveries of Schiffer and Lee which have been of great impo...ance in developing the field of nuclear spectroscopy: the discoveries of Erskine and others leading to a better understanding of the nuclear properties of the actinides; and recent heavy ion elastic scattering studies which are contributing significantly to nuclear structure theory.

An understanding of the properties of materials has obviously been a strong interest of the atomic energy program dating back to the Met Lab days and it has become of increasing importance with the passage of time. Argonne has been, and continues to be, a leader in this field, having one of the largest combined basic and applied materials programs in the Western world. It started with the need to know the physical and chemical properties of fuels and structural materials under conditions encountered in reactors. Such work was initiated by personnel within the Metallurgy Division and the Chemistry Division. More recently the increased importance of a fundamental understanding of materials has been emphasized by Mike Nevit, Paul Shewmon and Norman Peterson, and is also reflected in the recent renaming of the Metallurgy Division as the Materials Science Division. During the Sixties the pure research phase of this work finally came of age with the formation of the Solid State Science Division, and it now occupies the newest of the major buildings constructed at Argonne. Under the direction of my Met Lab colleague Oliver Simpson this work has taken on new importance.

Advances in the understanding of materials cover the extremes of low and high temperatures and range from the highly theoretical studies of structure to the very important studies of radiation damage and crystalline defects. Out of this work has come information of the greatest importance in thermal and mechanical behavior. Studies of the properties of alloys and compounds of uranium and transuranium elements have led to a far better understanding of materials in this unique part of the periodic table. Also, our understanding of radiation damage is now far enough advanced that we can in many cases predict in advance the behavior to be expected. Much of Argonne's current materials research is directed toward obtaining this information.

One further word should be said about a new program to be initiated this year in controlled thermonuclear work. Argonne's interest in this program is in the engineering development which would ultimately lead to a workable fusion reactor and grows directly out of the solid accomplishments and experience in basic research and engineering development. While many years of hard work separate us from the abundant energy available from the controlled fusion process, the early signs of ultimate success are increasingly promising. Argonne's participation is welcomed.

Along with the major accomplishments in the Physical Research program, there was one major disappointment which the AEC shares with Argonne. That was the cancellation of the Argonne Advanced Research Reactor, the A^2R^2 project, which would have provided one of the most advanced research reactors in the world. The entire AEC's Physical Research program keenly feels the loss of what would have been a most useful research tool.

The biological research program at Argonne is a natural extension of the biological work of the Met Lab. The potential danger of radiation was early recognized and research into the biological effects of radiation on living organisms was among the earliest work started in the atomic energy program. The biological and medical research program at Argonne still has the same basic objective for which it was started.

But the decade of the Sixties has seen some changes. When in 1962 the Biological and Medical Research Division's director, Austin Brues, sometime artist, humorist, world traveler, but all-time biologist, expressed a desire to return to full-time research, his wishes were respected. He had carried these administrative responsibilities since 1946. His successor was Max R. Zelle, a distinguished academician who, after seven years as director, found a return to the university atmosphere irresistible. In early 1969 John F. Thomson, an 18-year veteran with the division, agreed to wear two hats until a candidate could be found. And a little over a year ago, Warren Sinclair, a biophysicist, began a new era in the division's leadership.

Among the most important achievements of the past ten years in the biological sciences have been comprehensive studies of the long- and short-term effects of a variety of types of radiation, on microbial, plant, and animal organisms. Attempts to modify radiation effects led to the development of the first successful protective agent against X rays, to the systematic exploration of chelating agents for removing radioactive metals from the body, and to basic studies in tissue transplantation and immunity mechanisms. Fundamental contributions have also been made in the study of aging and its relation to the late effects of radiation. These studies established the importance of the brain-to-body weight ratio as a determinant of species longevity. Current emphasis is on neutron effects studies with the Janus reactor, a facility capable of exposing large numbers of animals to neutrons without significant gamma-ray contamination.

The decade also saw a significant refocusing of the work of the Radiological Physics Division. John E. Rose was this division's director until 1963, Leo Marinelli until 1967, and the present director is Robert Rowland. One of the earliest achievements of this division was the development of the first facility for pinpointing radiation in the human body with speed and accuracy. Argonne's "iron room" allows determination of the amounts, locations, and identities of extremely small quantities of radioactive materials in the body—as little as one billionth gram of radium. Similar facilities are now used throughout the world. Also of particular note has been its research on bone, both in the areas of bone physiology and the effects of the radiation dose delivered by radioisotopes fixed in bone.

Early in Dr. Rowland's directorship the division embarked on a study of the sulfur dioxide content of the atmosphere over the City of Chicago. This was the first formal step in what has become a growing commitment to the solution of environmental problems at Argonne.

In August 1969 this division received another very important assignment. A Center for Human Radiobiology was established as the nation's center for the long-term study of all persons known to have radium and other long-lived isotopes within their bodies. During a period around the early 1920s uninformed or careless use of radium, both industrially and for external and internal therapy, was widespread. Through study programs carried out in several U.S. institutions, some 2,000 of such potentially contaminated individuals were found. Of these, 800 with measurable body burdens of radium have been measured, almost 600 of whom are still alive today. These people, merged into the program at Argonne, provide a research resource of which there is no prospect of duplication for the setting of absolute toxicity levels and devising radiation protection guides for man.

In 1967, Congress broadened the Commission's charter to enable the AEC and its contractors to work with other agencies in the protection of public health and safety, and enabled Argonne to undertake a broadened role as a major Midwest research center.

This has resulted in an accelerated interest in accepting new challenges, and in late 1969 the Argonne Center for Environmental Studies was established here. The Center is designed to use an interdisciplinary approach to the achievement of three goals: first, to help gain a better understanding of the extent to which the environment is being changed; second, to define particular effects more quantitatively; and third, to help with the formulation and presentation of various alternative courses of action.

This approach already has resulted in a model for predicting, analyzing, and controlling air pollution. Utilizing studies of pollution emission from stationary sources as well as pollution dispersion patterns, Len Link and his colleagues developed a computerized model applicable to both the managment of air pollution emergencies and the long-range development of air resource management. Their program presents guidelines for the creation of legislation, zoning ordinances, and tax incentives which would foster urban and regional growth in a manner compatible with acceptable air quality.

In 1968, Argonne began a study of heated discharges from power plants into large lakes. This program is establishing a mathematical model of circulation patterns in Lake Michigan, developing models to express the behavior of thermal plumes, and analyzing the mass-energy balance of the lake. The study also outlines the research needed for the understanding of thermal effects on the ecosystem so methodologies can be provided. This work is expected to have a strong bearing on reactor siting criteria.

Two other Argonne programs are of special interest.

One is the development, by the Laboratory's Chemical Engineering Division, of fluid bed techniques in the combustion of coal. Use of these techniques could reduce emission of sulphur dioxide into the atmosphere.

The second is work on lithium anode secondary cells - also being carried out by the Chemical Engineering Division. Such cells promise to be useful as a primary source of power for automobiles and have dramatic possibilities as an implantable energy source for individuals with heart defects.

The change in the AEC's charter also made possible "spin-off" activities which give great promise of providing benefits for mankind. These include:

...A hemodialyzer (artificial kidney), developed by Finley Markley of the High Energy Facilities Division and Dr. A. R. Lavender of Hines Hospital, which may revolutionize the care of patients suffering from kidney disease. Victims of kidney failure now must depend upon very complex and expensive hemodialyzers which can be used only at hospitals. The new kidney machine is so inexpensive, small and simple, that it may be possible for the patient to use it himself, at home. The device was made possible through the use of adhesives Mr. Markley developed for application in the construction of the ZGS.

...A Braille machine, developed by Arnold Grunwald of the Engineering and Technology Division. Smaller than a portable typewriter, it will take symbols recorded on ordinary magnetic tape and play them back on an endless plastic belt in raised dots forming letters in the Braille alphabet. It will reduce by a factor of 250 to 500 the bulk of Braille materials to be produced, handled and stored, permitting much wider use of Braille literature by the sightless. This development is being supported under a grant by the U.S. Office of Education.

When Argonne first was established as a national laboratory, the Commission and the Argonne administration agreed that interaction with the academic community would be a primary responsibility of the Laboratory.

Unfortunately, efforts to carry out this mission were severely hampered in the early years because so much of Argonne's work remained classified. Lack of housing for visiting university faculty members also impeded the program. The principal thing Argonne had to offer, use of unique facilities, could not be exploited by university personnel unless they could be here for extended periods of time.

In 1950, Joe Boyce attacked the problem, and the foundation he established in the following five years made possible a program which fluorished in the decade of the Sixties.

The initial organization through which the Laboratory sought to interact with universities and colleges was the Participating Institutions Committee, organized very early in Argonne's history. Thirty-t Midwestern universities were members. Through several intermediate steps, this organization evolved into Associated Midwestern Universities, Inc., (AMU), incorporating in its membership 30 universities.

At this time Frank Myers gave up his post as Dean of the Graduate School at Lehigh University to become Argonne's Associate Director for Education. Shortly afterward, John Roberson took over as Executive Director of AMU.

These events resulted in new impetus to educational activities which brought into closer association Argonne and the academic community.

Still another change occurred in 1966—one which would give universities an even stronger role in the activities at Argonne. In that year Argonne Universities Association (AUA) came into existence, and a new five-year contract for the management of Argonne stipulated that AUA, The University of Chicago, and the Commission would share in management responsibilities.

Under the terms of the contract, AUA formulates, approves, and reviews Laboratory programs and policies. The University of Chicago, which had operated Argonne from the time it was founded in 1946, continues to be responsible for its management and operation in accordance with the policies established by AUA. The Commission, of course, has provided a major share of the Laboratory's financial support and participates in major decisions affecting Argonne's welfare.

Thirty universities now hold membership in AUA.

The most recent change in the mechanism for fostering Argonne-university interaction occurred in 1968. In that year, all of Argonne's educational activities were placed under the direction of a Center for Educational Affairs, and Shelby Miller came to Argonne from the University of Rochester to become Associate Laboratory Director for Educational Affairs and Director of the Center.

Progress in this area has been so rapid that the Center was able to report that last year 2,600 university and college representatives—college juniors up through faculty members—participated in activities at Argonne.

College juniors and seniors participate in summer or inter-term programs which permit them to work for university or college credit with Argonne staff members or in honors programs sponsored by Associated Colleges of the Midwest and Central States Universities, Inc.

Graduate students perform their research for Master's or Doctorate degrees. Post-graduates are attracted to the Laboratory by the opportunity to enrich their backgrounds before they accept professional appointments and launch their careers.

All of these representatives contribute significantly to the life of Arg ne. They carry out research programs in areas of special interest and they bring to the Laboratory new ideas, new enthusiasm, and their own special knowledge and skills.

The record would not be complete without my recalling one of the most dramatic ventures in education this nation has ever undertaken. In 1953, President Eisenhower used the vehicle of his famous "Atoms for Speech" talk to suggest that this country establish means for sharing with many nations of the world our rapidly-growing understanding of the peaceful uses of nuclear energy. Argonne considered this a mandate and launched a crash program to bring into existence the International School of Nuclear Science and Engineering. Norm Hilberry, Elmer Rylander, and Rollin Taecker did yeoman work and before the year was out the school was in operation.

Its objective was to attract young men from abroad and to provide them with sufficient training to enable them to return home and establish nuclear energy programs appropriate to the level of technology existing there.

In 1961 the International School became the International Institute. In the institute, the emphasis was on programs tailored for each participant, to make maximum use of the background and the skills he already had acquired. And it was the continued success of the IINSE which caused its demise in 1965. So many of its graduates, scattered about the globe, had developed strong nuclear energy programs in their home countries that the kind of training offered at Argonne no longer was needed.

As most of you here today will recall, Al Crewe decided to step down from his position of Laboratory Director in December of 1966. And early in 1967 Dr. Robert Duffield, whom I have known since his association with me during his student days at the University of California at Berkeley, succeeded him as Director. Bob Duffield has continued the fine tradition of leadership here at Argonne. He has guided ANL through a significant and productive era of its history.

My remarks to this point have concerned the history of Argonne National Laboratory—the Argonne of the past. I will close with several thoughts about the years ahead—the Argonne of the future.

First let me emphasize that the projections which the Commission has developed indicate an undiminished need for use of Argonne National Laboratory for Atomic Energy Commission programs for as far ahead as we can make projections. I foresee no lessening in the national importance of the sort of work Argonne has been carrying out for the AEC. I understand that, in addition to the support we provide, the support for work at Argonne funded by other agencies will total about $2,500,000 this fiscal year. The Commission will continue to encourage its laboratories to provide assistance to others in areas in which they have special competence and facilities up to the limits set by statute and the priority we need to give our own work.

Argonne will continue to play a central role in what I see as perhaps the most fruitful and, in many ways, the most exciting technological challenge facing the nation today - the development of the breeder reactor. Further, I believe that pioneering research at Argonne in both the physical and biological sciences will gain continued recognition as a major source of long-term national strength.

I realize that these are trying days for Argonne, as they are for all of our National Laboratories. And any clear assessment of the future must take present difficulties into full account. But the response of our laboratories to these difficulties has been encouraging and impressive; they have remained steadily productive under painful stress. I believe the long-term prospects at Argonne, as at other laboratories, will depend strongly on the ability of the entire staff to maintain innovative, creative science in the face of budgetary fluctuations.

The drive for excellence in any laboratory is fueled most simply by rapidly expanding requirements and budgets. For now, we must find how to keep our momentum with different fuel. This is a time of testing for many scientific institutions. Some will be seized by the mincing caution which chokes inventiveness. Some will wander and wither, seeking the favors of fashionability instead of capitalizing on their own virtues. Certainly the future of Argonne will be affected by decisions made elsewhere and by the priorities others attach next year and the year after to specific efforts. For the long run, however, I view decisions by individuals here about their own work as of even greater importance. The best assurances for the future will come from present rededication to the drive for excellence which Argonne National Laboratory has displayed throughout its first 25 years.