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The United States Navy's Early Atomic Energy Research, 1939–1946

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The United States Navy's development of a nuclear powered submarine is generally associated with Admiral Hyman G. Rickover's post-World War II initiative. What many are unaware of is that the Navy's research into the use of nuclear power predates Rickover's work by almost ten years, and the creation of the Manhattan Project by seven months. Between 1939 and 1946, the Naval Research Laboratory (NRL) conducted research to determine the feasibility of using nuclear energy for submarine propulsion. During this time Navy scientists developed methods for the production of uranium hexafluoride, and for isotope separation using liquid thermal diffusion. Both of these methods were vital to the production of uranium 235, and were used in the creation of the atomic bomb. However, the Navy's research was carried out in an environment of isolation from and in competition with the Manhattan Project. The research work done by NRL during this period contributed more to the United States' nuclear energy program than the Navy has been credited with.

Even before the end of World War I, the Navy was looking for an improved means of submarine propulsion. By the early 1930s NRL's Mechanics and Electricity Division was looking for a new submarine power plant, experimenting with the fuel cell, the hydrogen peroxide-alcohol steam turbine, and closed cycle diesel engines. The one limiting factor in all of these methods was providing an adequate oxygen source for combustion that the submarine could carry when submerged, and regenerate when running on the surface. As Dr. Ross Gunn, head of the division, noted, the NRL scientists were "alert for a better and more promising submarine propulsion system."[1]

A meeting between physicist Enrico Fermi and the United States Navy on March 17, 1939, was the catalyst for the start of the Navy's nuclear energy research. The meeting had been arranged by Dr. George B. Pegram, dean of the graduate physics department at Columbia University, as Fermi and fellow physicist Leo Szilard were hoping to make the United States Government aware of the potential of nuclear energy. Pegram had contacted Admiral Stanford Hooper, director of the Navy's Technical Division, who in 1937 had made inquiries about nuclear energy at Johns Hopkins University's physics department. The meeting was attended by representatives from the Navy's Bureaus of Engineering, Ordnance, and Construction and Repair, the NRL, and the Army's Ordnance Department. In a little over an hour, Fermi gave a briefing on the success of German scientists Otto Hahn and Fritz Strassman to deliberately split uranium atoms by bombarding them with neutrons. While Fermi focused on the potential of nuclear energy as an explosive, the possibility of using it as a power source was discussed. Fermi left the meeting feeling it had yielded little, being told by a Navy spokesman that the service was interested and would contact him. However, the meeting was the stimulus for Gunn to initiate research into using nuclear energy for submarine propulsion.[2]

Theoretical knowledge of nuclear fission was generally known among physicists as early as 1937. Prior to the Fermi meeting, Gunn's division had discussed creating a tentative research program to examine the application of nuclear energy to naval propulsion. However, it was decided not to present such a theoretical program to the "highly practical" Navy bureau chiefs "until more substantial evidence was in hand." The Fermi meeting provided the evidence that Gunn's division needed. On March 20, 1939, Gunn and NRL Director Captain Hollis M. Cooley went to see Admiral Harold G. Bowen, Chief of the Bureau of Engineering, to request $2,000 to initiate research into uranium power. Gunn's goal was to find a propulsion source since he saw it as a more practical application, and also would provide the groundwork for weapons research. The NRL would not be alone in exploring this field of research. The Army's Manhattan Project was started in October 1939, and would eventually take over all nuclear energy research in the United States, putting a halt to the efforts undertaken by the Navy.[3]

The NRL's efforts to develop a nuclear powered submarine were blocked by the Manhattan Project's monopoly on nuclear research, and by President Franklin D. Roosevelt's order to exclude the Navy from major research. NRL physicist Dr. Phillip Abelson, in a 1946 report on the potential of a nuclear submarine, stated that the NRL's work had been deferred first to conduct the preliminary work on isotope separation, and then to assist in completing the atomic bomb. Gunn felt that the separation between the work of the Army and Navy "had its roots in partisan Presidential politics." After World War II, Gunn told Bowen "Roosevelt had no business appointing an independent political group to be responsible for atomic energy when there was already established, under forward-looking Navy management, a team and program designed not only to produce a bomb, but who were dedicated to its long range utilization as a military tool and implement of public welfare." It would seem that Gunn felt the rug had been pulled out from under him, as he was the one who initiated the first research into atomic energy. Gunn summed it up by saying, "I think we had the hose turned on us."[4]

The NRL's initiation of isotope separation research was a critical first step in nuclear energy research. With uranium 235 established as an ideal source for a nuclear chain reaction, scientists needed to find a method to separate that isotope from the more common uranium 238 isotope. As it was important to determine the best method by the earliest date, the NRL simultaneously began studies with the University of Virginia, Columbia University, and the Carnegie Institution of Washington. However, before isotope separation research could begin, a supply of the basic uranium chemical, uranium hexafluoride (hex) was needed.[5]

To provide material for these studies the NRL developed two means for the production of hex. Scientists from NRL's Chemistry Division and the University of Maryland first devised a method that used a powdered uranium-nickel alloy, which resulted in only about a hundred grams of pure hex in an expensive and laborious process. This allowed NRL to supply hex to the university laboratories, but not in quantities to meet research and production requirements. Abelson, then working at the Carnegie Institution, required more than a kilogram of hex for his experiments and so set out on his own to produce hex without using the metal. Abelson was able to devise a "fairly simple method" using a common salt of uranium that could produce more cheaply nearly a kilogram of hex per day. Using Abelson's method, NRL became the primary supplier of hex until October 1941 when the Harshaw Chemical Company was contracted to begin commercial production.[6]

As the university laboratories experimented with the different methods of isotope separation, the NRL became increasingly interested in the Carnegie Institution's liquid thermal diffusion research under the direction of Abelson. The basis for this method was that lighter isotopes had the tendency to diffuse to a hotter area, whereas heavier isotopes diffused towards cooler areas. The theory behind how the apparatus would work was very straightforward. A column would be constructed that contained a hot pipe on the inside, a cold pipe on the outside, and liquid hex flowing between the two pipe walls. As diffusion took place, the uranium 235 enriched fluid would flow to the top of the column where it could be collected. The rate at which diffusion took place would depend on the difference in temperature and the spacing between the two pipes. Work began by building and testing "some simple columns." Positive results encouraged further research on the method, with work moving from facilities at the Institution to the Bureau of Standards and finally to the NRL. By the fall of 1942, the NRL was pleased with the separation method to the point where they were ready to build a pilot plant to produce uranium 235. In a letter to Dr. Lyman J. Briggs, director of the Bureau of Standards, Bowen commented that despite its high steam consumption this was a "practicable method" with many production advantages "under war conditions."[7]

The Manhattan Project made its first effort to either take over or curtail the Navy's work in late 1942. On December 10, Manhattan Project director General Leslie R. Groves paid an official visit to the NRL facility, at which time he was given an extensive tour and briefing. Gunn recalled that "a rather complete review was given of the Naval Research Laboratory's research interest in this project in its earliest days, and our part in the preparation of uranium hexafluoride for the original work was emphasized." While discussing the work at the NRL, the Navy was informed that the Army had been placed in charge of "all production work" by order of the President. Gunn was not happy with the Navy's lack of representation in the Manhattan Project.[8]

The Army's review led to a curtailing of the Navy's work. Groves was not impressed with the Navy's research since he felt it lacked urgency. The Navy already had a strike against it when President Roosevelt excluded the service on the basis that inter-service rivalry would hinder the program. Groves felt that liquid thermal diffusion was unsuitable as an independent process due to its large requirement of steam. The Army viewed the research as being "extremely limited," despite Abelson conducting it "in a most competent manner." From this point forward, the information flowed one way—from the Navy to the Army. Gunn later commented that he "had no idea what the Army was doing." Except for guessing, he only knew that the Army was operating a "pretty big project" because of his inability to get additional scientific personnel for the NRL's work. The Army even hindered the Navy's access to supplies of hex and equipment.[9]

By fall 1943, the NRL proposed the construction of a larger liquid thermal diffusion pilot plant, "with the object of providing insurance against the complete failure of the Manhattan Project." The proposal was authorized with the stipulation that it not "draw on technical personnel" that might be needed by the Manhattan Project. To provide the needed space and adequate steam supply, the Naval Turbine and Boiler Laboratory (NTBL) at the Philadelphia Navy Yard was chosen as the site for the plant. Construction began on January 1, 1944, with the NTBL responsible for the equipment needed to supply steam and cooling water, and NRL responsible for the columns and the secondary equipment needed for their operation.[10]

The Manhattan Project's renewed interest in the Navy process put the final breaks on the progression of the NRL's propulsion program. The Army had chosen two methods for isotope separation (electromagnetic separation and gaseous diffusion), constructing facilities in Oak Ridge, TN. As the Philadelphia plant neared completion in June 1944 only the electromagnetic plant was in operation, causing the Army to look for a means of increasing production. Dr. J. Robert Oppenheimer, head scientists for the Manhattan Project, reviewed the progress of the NRL research and theorized that liquid thermal diffusion could be used as a means of partial separation before feeding the uranium to the electromagnetic diffusion plant. Upon bringing this to Groves' attention a review committee was sent to Philadelphia, which led to the decision to construct an identical plant at Oak Ridge. The Army obtained the blueprints for the Philadelphia plant, and broke ground on July 6 for the plant, labeled S-50, with the first columns ready by September 15.[11]

The NRL Philadelphia plant now became a training and supply center for the Manhattan Project. In order to have trained personnel to operate S-50, Groves had ten enlisted men recruited within the Army and sent to the NRL's Philadelphia plant. These men were involved with the plants only accident. On September 2, 1944, at 1:20 m. a cylinder of hex feed stock in the transfer room exploded, fracturing nearby steam pipes, and creating hydrogen fluoride, a very caustic acid. Three men were inside the room at the time: Army soldier Arnold Kramish and civilians Peter N. Bragg, Jr., and Douglas Meigs. All three inhaled large quantities of uranium compounds and suffered acid burns over their entire bodies resulting in Bragg's and Meigs' death. The accident also injured four civilians and four soldiers. Abelson wrote Meig's widow that his "memories of the tragic accident" were "the saddest and the bitterest that I know and will remain so the rest of my life."[12]

One result of the accident was that it helped establish new safety precautions for the operation of nuclear separation plants. The Philadelphia plant continued in use after repairs were made, and was operated even after the S-50 plant was shut down at the end of the war. During its operational time, the Philadelphia plant shipped more then 5,000 lbs. of partially enriched uranium to Oak Ridge. Work at the Philadelphia plant finished by January 1946, and it was closed in September. The personnel and work were transferred back to the Washington, D.C. facility, with surplus material being dumped off the New Jersey coast.[13]

The tension between Navy researchers and the Army-dominated project, which had simmered for years, began to emerge more clearly immediately after Hiroshima and Nagasaki. At the end of World War II, NRL scientists were eager to continue their research into nuclear propulsion. Gunn felt an obligation to inform the Navy of the "promise and dangers" of nuclear energy. Despite the continued security blackout on nuclear information, Gunn was able to organize a symposium in November 1945 for submarine leaders to discuss the facts of nuclear propulsion. The general public also learned about the potential of nuclear energy in 1945 when Dr. Henry DeWolf Smyth published *Atomic Energy for Military Purposes.* Although requested by the United States Government to produce this book, the detail of information it provided was greater then what Groves had anticipated. Bowen felt that if the Navy was going to pursue the creation of nuclear propulsion it needed to control all of the related activities. As a result, the Navy would need to create its own capabilities in both basic nuclear science and propulsion. Abelson's 1946 report stated that a nuclear submarine could be built in two years only if the NRL received "sufficient priority" from the Navy, the President, and the Manhattan Project; not to mention expanded cooperation from the Manhattan Project to allow the construction of an uranium pile suitable for the Navy's needs.[14]

Secretary of War Robert Patterson was in a difficult position, mediating between Navy aspirations and the Army's dog-in-the-manger attitude about its nuclear reactors. To help foster a postwar program, Bowen and Admiral Deak Parsons drafted a letter to Patterson for Secretary of the Navy James Forrestal to sign. Dated March 14, 1946, the letter stated that the Navy wanted to begin its own program for nuclear propulsion. Forrestal felt that "one of the first justifiable and practicable uses of atomic energy for power will be in the propulsion of naval vessels." In that end, he hoped that Patterson would help establish an "interim arrangement" to allow the Navy to proceed with their work until the Atomic Energy Act was passed. Patterson's reply to Forrestal seems to have been influenced by Groves, as it allowed the Navy to continue nuclear energy research only by sending representatives to work under the jurisdiction of the Manhattan Project. Forrestal accepted Patterson's invitation, even though it did not give the Navy its own program.[15]

The Navy was unable to get its own nuclear program until 1948 when the Bureau of Ships formed the Nuclear Power Branch under Rickover. Rickover had first been involved with the development of a nuclear propulsion program when he was selected in 1946 as one of the naval officers assigned to Oak Ridge. Rickover's prominence in the nuclear program further overshadowed the work conducted by Abelson and Gunn. Bowen, in an effort to gain recognition for the NRL's work, contacted Admiral H. Smith at the Bureau of Personnel, and was told by Smith that any recognition would not be coming as the "unfavorable publicity" the Navy had received over the "alleged discrimination against Admiral Rickover" made recognition of others unlikely. While Smith does not indicate how the Navy discriminated against Rickover, it may have been over Rickover's Jewish heritage.[16]

Despite the Army's lack of recognition, the Navy's contribution to the development of nuclear energy is clear. While Manhattan made use of the Navy's method to create hex, and method for liquid thermal diffusion to refine the material prior to final enrichment, Groves only credited the Navy with speeding things along by a couple of days. However, even those associated with the Manhattan Project disagreed. In a 1956 letter to Bowen, Briggs wrote that Bowen's initial authorization of funds for Gunn's research was critical in the development of the atomic bomb. Briggs stated, "If it [had] not been for your generous cooperation and foresight in making funds available at a critical time, the work on the atomic bomb would have been set back at least six months."[17]

Overall, the Naval Research Laboratory's initial research on nuclear energy played a crucial role in both the work of the Manhattan Project and the nuclear propulsion program. Many of the scientists first contracted by the Navy were later employed by the Army. Unfortunately, the work of Gunn, Abelson, and their colleagues has largely and undeservedly been lost in the history of nuclear development.

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