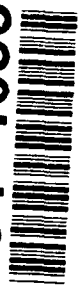
ADDRESS BY
HONORABLE JAMES H. WAKELIN, JR., ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH AND DEVELOPMENT, BEFORE THE 22ND ANNUAL MEETING OF THE AMERICAN POWER CONFERENCE IN CHICAGO, ILLINOIS, ON 29 MARCH 1960.

THE DEVELOPMENT OF NUCLEAR PROPULSION IN THE NAVY

In February of this year, the nuclear submarine SARGO became the third U.S. Navy submarine to cruise under the polar ice cap. Furthermore, the SARGO was the first submarine to break through the ice and surface at the North Pole during the Arctic winter. It has now been dramatically demonstrated that the nuclear submarine can make the crossing from the Pacific to the Atlantic at any time of the year and can operate freely and safely under the Arctic ice pack.

The outstanding success of the naval nuclear reactor program, starting with the launching of the world's first nuclear propelled ship, the NAUTILUS, early in 1954, has justified many times over the large expenditures, the Herculean efforts and the long years of research and development that have gone into the program. The full story of this development has never been publicly reported. This is a story of more than a decade of efforts in the Navy to develop nuclear propulsion, of the men who played key roles in generating and nurturing the idea in the early years and have since been forgotten, and of the frustrating problems which are basic to our democratic form of government that had to be solved before the idea could move forward to realization.

Today I would like to relate this story as an illustration of how technological progress in government depends on a series of critical decisions, each one of which is based on a calculated risk



Navy Department,
THE DEVELOPMENT OF NUCLEAR PROPULSION IN THE NAVY,
ADDRESS BY HONORABLE JAMES H.Wakelin, Jr., ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH AND DEVELOPMENT, BEFORE THE 22nd ANNUAL MEETING OF THE AMERICAN POWER CONFERENCE IN CHICAGO, ILLINOIS, ON MARCH 29, 1960. 16 p., March 1960.

Copy # (Rec'd) Date Copy # (Dest) Date
UNCLASSIFIED

~~1~~ -------3-31-60 E
2 5-19-60 DO NOT circulate this copy to ANYone but MEJansson
DO NOT DESTROY.

Do not destroy ① + ②. ② has memo attached signed by C.O. Holmquist

This reports is of great historical interest please add to regular accession ADA Collection (not 900'000 size)

Thank you
Ken Howes
NRL

1

of huge amounts of the taxpayers' dollars. It is a grave responsibility to make the decision to commit millions of dollars to a radically new development which might end up as a colossal failure.

And so the Navy, fully appreciating the potentialities of nuclear propulsion, made haste cautiously and deliberately. Obviously, I must omit many details in the brief time I have, but I would like to relate some of the more important events which led to the final decision to build the first nuclear powered submarine.

The story begins in March 1939. Following the discovery of uranium fission by Otto Hahn and Lise Meitner the previous fall, the Navy was contacted by various civilian scientists who felt that the military should be made aware of the vast possibilities of the nuclear fission process for military use. The first thought of these scientists was that there was a bare possibility -- and that is all it was at that time -- that uranium might be used as an explosive which would liberate a million times as much energy per pound as conventional explosives. Dr. Enrico Fermi came to Washington and, in a meeting attended by Navy officers and scientists, suggested the possibility of achieving either a controlled chain reaction or a chain reaction of an explosive character. However, he explained that a successful uranium chain reaction had not been demonstrated and encouraged a "wait-and-see" attitude. As Fermi explained several years later, "...in March 1939, there was little likelihood of an atomic bomb -- little proof that we were not pursuing a chimera."

Nevertheless, one man at this meeting was ready to grasp at this chimera. He was Dr. Ross Gunn, the head physicist at the Naval Research Laboratory. He was not particularly interested in the development of an atomic bomb, but he was pointedly aware of the distinct advantages of controlled nuclear power to the Navy. Aside from unlimited range for Navy surface ships, the exceptional advantages of a nuclear power plant in a submarine particularly appealed to Gunn and his associates. The submarine could become a true submersible with unlimited endurance -- one of the deadliest military weapons ever devised.

Within a few days after this historic meeting, Dr. Gunn had requested and received $2,000 for preliminary exploratory work on the possibility of developing nuclear power for ship propulsion. The man who approved this project on his own cognizance was Rear Admiral Harold G. Bowen, then Chief of the old Bureau of Engineering, now the Bureau of Ships. Admiral Bowen was equally enthusiastic about the potentialities of nuclear propulsion. This turned out to be a significant factor in the Navy's development of nuclear power, since shortly afterwards Admiral Bowen became Director of the Naval Research Laboratory. Later, in 1945, he became the first chief of the Navy's new Office of Research and Inventions and continued on as the Chief of Naval Research when the Office of Naval Research was created a year later.

Dr. Gunn decided that the first problem was to find a practical method of obtaining fissionable material in quantity. The Naval Research Laboratory began work on a separation procedure known as the liquid thermal diffusion process. This process was the brain child of Dr. Philip H. Abelson of the Carnegie Institution of

Washington, who later joined the NRL staff to work on his process. Using liquid uranium hexaflouride, the laboratory made rapid strides with this separation process. In fact, Rear Admiral Lewis L. Strauss later reported that it was at the Naval Research Laboratory that "...the separation of the uranium isotope U-235...was first successfully performed on any appreciable scale and many months before any other project had been inaugurated."

One major drawback of this process was the great amount of steam required for the thermal diffusion. ~~For this reason~~, it was ~~not~~ used by the Manhattan District as one of the separation methods at Oak Ridge. Also, ~~However~~, enriched uranium produced by NRL was used in the Oak Ridge electromagnetic separation process, which increased the production rate of fissionable material significantly. This was a factor in having atomic bombs ready to be dropped in August 1945.

When the war ended, NRL scientists were anxious to get on with their basic objective, the development of nuclear power for ship propulsion. However, they faced a formidable obstacle. Because of severe security restrictions on all atomic work during the war, Navy scientists had been unable to obtain any information on the research of the laboratories of the Manhattan District. Without such information, they were unable to make a practical analysis of the possibilities of nuclear power.

Lacking this important information, the Navy could not make certain key decisions. First of all, the Navy could not decide whether it was yet technically feasible or possible to launch a major development program on nuclear propulsion. It could not decide whether such a program warranted a high priority status and

would take precedence over other urgent programs. Since the Navy did not even know whether controlled fission was strictly a research problem or had advanced to the engineering stage, there was little basis on which to even select the developing agency within the Navy. Finally, the Navy did not even know the national policy in regard to the control of atomic energy or whether this policy might nullify any program that the Navy might initiate on nuclear propulsion for naval use.

As it happened, the Navy had the opportunity to state its case early in the game. In August of 1944, General Leslie R. Groves who was the head of the Manhattan District appointed a committee to make recommendations for a post war policy on the development of atomic energy. The chairman of this committee was Dr. R. C. Tolman, vice chairman of the National Defense Research Committee, and the military representative on the committee was Rear Admiral Earle W. Mills, Assistant Chief of the Bureau of Ships.

In November of 1944 the Tolman Committee visited the Naval Research Laboratory and interviewed Rear Admiral A. H. Van Keuren, then Director, and Dr. Gunn and Dr. Abelson. The three men vigorously presented reasons as to why a nuclear powered submarine was needed. They pointed out that a surfaced or partially submerged submarine could easily be detected with the present radars and that the need for extended submerged operations was imperative.

The Tolman Committee was impressed with these discussions and, in its final report in December 1944, urged the government "to initiate and push, as an urgent project, research and development studies to provide power from nuclear sources for the propulsion of naval vessels." The report included a special appendix which

outlined in detail the potential advantages of nuclear propulsion for certain types of ships.

Shortly after the end of the war, Admiral Mills arranged for a conference between General Groves and Navy officials on the possibility of the application of nuclear power to ship propulsion. General Groves stated that the chief handicap was the limited availability of fissionable material. He told the Navy of a proposed project to construct an experimental power pile designed by Dr. Farrington Daniels. Several months later the Navy was formally invited to participate in the Daniels power pile project at Oak Ridge. This project was sponsored by the Monsanto Chemical Corporation.

Meanwhile, in early December 1945, the Naval Research Laboratory formulated the first broad program aimed at the development of a nuclear powered submarine. In a lengthy memorandum forwarded to the Bureau of Ships, NRL stressed that the Navy was the world's largest user of power and pointed out the potential military value of the nuclear submarine with its almost unlimited cruising range. It was estimated that two years would be required to gain the necessary experience in the construction and operation of nuclear reacting piles before the program could turn to actual submarine design and construction. The NRL program was endorsed by the Bureau of Ships and forwarded to the Chief of Naval Operations.

It should be emphasized at this point that the NRL program was based on an educated guess since all of the technical information on the possible development of nuclear power was locked up in the files of the Manhattan District. General Groves had cleared a few people, including Gunn and Abelson, to visit the Manhattan laboratories, but he was extremely reluctant to release

atomic energy information to Navy personnel in general. His policy was that he would welcome the assignment of Navy people full time to the Manhattan District, but he would not grant clearances to Navy personnel who were not in the Manhattan District. General Groves believed that the clearance of individuals not under his jurisdiction would violate the Presidential directive of August 1945 which restricted the release of information related to the atomic bomb. Only the "general nature" of the bomb could be disclosed to project activities. Furthermore, General Groves felt that release of atomic information outside of the Manhattan project might commit the future Atomic Energy Commission to a policy which it would not be willing to approve.

In order to gain access to the required atomic information and obtain approval for the initiation of a nuclear power program in the Navy, Admiral Bowen, now Chief of the Office of Research and Inventions, and Admiral W. S. Parsons, of the office of the Chief of Naval Operations, developed a letter for the signature of the Secretary of the Navy to be sent to Secretary of War Patterson. This letter, which was signed by Secretary Forrestal on 14 March 1946, stated that the Navy desired to undertake the engineering development of atomic power for ship propulsion to the maximum extent permitted by current security and other limitations and wanted to assume responsibility for the program.

In his reply to this letter, Secretary Patterson stated that he believed that the Navy should participate in developmental programs leading to nuclear power for ships, and that General Groves and other scientists of the Manhattan District agreed that the most probable initial application of atomic energy for power purposes

would be in the field of ship propulsion. Secretary Patterson also said that the first step to be taken was the construction of new types of experimental piles and that the Manhattan District was then carrying on this work. He felt that the best and most rapid method for initiating a strong Navy program on atomic power was to assign Navy personnel to this project who could later supervise the Navy's specific program when the development had progressed to the point where a nuclear reactor could be designed for shipboard use.

Secretary Patterson was referring to the Daniels power pile project. The Navy was less than enthusiastic about this program since the goal of the Daniels project was to develop a stationary power plant to produce electric power rather than a pile for ship propulsion.

As it turned out, the Daniels project was a complete failure and was quietly dropped in the fall of 1947. In one respect, however, Secretary Patterson made an accurate prediction. The small Navy team that was sent to Oak Ridge to work on the power pile project later formed the nucleus of the group that supervised the development and construction of the first nuclear powered submarine. This Navy group was headed by Captain Hyman Rickover, now Vice Admiral.

In April of 1946, the Naval Research Laboratory forwarded a report to the Bureau of Ships entitled, "The Atomic Energy Submarine." This report showed that NRL, in addition to working on improved methods for isotope separation, was making a survey of problems involved in the design of an atomic powered submarine. Gunn and Abelson had contributed to this report from the informatic

they had obtained during visits to the Manhattan laboratories and the Clinton Laboratories at Oak Ridge.

The NRL report proposed that a research and development program be initiated immediately to perfect a suitable power pile and to investigate the heat exchange and handling characteristics of suitable coolants, including a liquid alloy of potassium and sodium. The major conclusion of the report was that it was considered feasible to construct atomic power plants of a size and output suitable for ship propulsion. This report also marks the first interest in liquid metal coolants for reactors.

In May of 1946, General Electric, who had taken over operation of the plutonium plant at Hanford, Washington, and had established its own Knolls Atomic Power Laboratory at Schenectady, presented a report to the Bureau of Ships. The report proposed the development f a nuclear propulsion plant suitable for a destroyer. Impressed by this proposal, the Bureau requested the Manhattan District to authorize GE to make a design study and submit a design proposal. This was approved in August, with work during fiscal year 1947 to be supported by the Manhattan District.

Thus, by the middle of 1946, the Bureau of Ships was directly involved in two specific projects concerned with the development of atomic power -- the Daniels pile and work at GE. However, the point had not yet been reached where work could begin on an experimental power pile for ship propulsion. The Daniels experimental pile would certainly provide information, but the objective of this project was not the solution of naval propulsion problems. The GE project was still a paper study with no experimental pile yet in sight.

Because of the state-of-the-art in nuclear reactors and the pending enactment of national atomic energy legislation, the Bureau of Ships felt that the proper role of the Navy at this time was primarily to acquire knowledge in the field through education of naval personnel. The Bureau policy was to follow and participate in the research and development carried out by the Manhattan District, and to take appropriate action when and if a situation developed which was not in the Navy's best interest.

Meanwhile, the Navy was following closely the progress of the McMahon Bill, which eventually became the Atomic Energy Act. Admiral Bowen, Chief of the Office of Research and Inventions, was concerned that section three of this bill might be construed in such a way as to question the legal authority of the Navy to perform research and development in the field of atomic power for ship propulsion, particularly by means of contracts with non-governmental agencies. With the support of acting Secretary of the Navy John Kenney, Admiral Bowen succeeded in getting a sentence inserted in the bill which affirmed the authority of the military departments to contract with non-governmental activities on atomic power matters. The Atomic Energy Commission retained indirect control, however, since all use of fissionable materials and all experimental devices using such material were to be licensed by the commission.

Moving forward in the area of liquid metal coolants, the Bureau of Ships let a contract with the Mine Safety Appliance Company in June of 1946 for work on the chemical and physical properties of alloys of sodium and potassium. This was called project MINNIE. Another contract, called project BABY, was made with the Babcock and Wilcox Company on the use of sodium potassium alloys as a heat

transfer medium in gas turbine regenerators, with possible nuclear power applications as an eventual goal.

The Navy team that was sent to Oak Ridge to work on the Monsanto Daniels power pile early in the summer of 1946 kept the Bureau of Ships closely informed of their progress. At the request of the Chief of Naval Operations, Captain Rickover, assisted by Lieutenant Commander Louis H. Roddis, submitted a memorandum which stated that five to eight years would be required to develop and install a nuclear power plant in a naval vessel, assuming that the present level of effort was maintained. On the other hand, as little as three years might be required if adequate funding and technical talent were available.

At this time Navy submariners began to express extreme interest in nuclear propelled submarines. After hearing a presentation by Captain Rickover, a group of submarine officers in Washington, headed by Rear Admiral Charles W. Styer, strongly urged an immediate program for the development of atomic power plants for submarines. As a result of this recommendation, a submarine desk was established in the office of the Assistant Chief of Naval Operations for Atomic Defense. The first officer assigned to this desk was Lieutenant Commander Edward L. Beach, who later became Naval Aide to President Eisenhower.

In January 1947, the Chief of Naval Operations, Fleet Admiral Chester W. Nimitz, approved a program for the design and development of nuclear power plants for submarines. In effect, this was the first authoritative statement of a Navy operational requirement for nuclear propulsion in submarines.

In May of 1947, General Electric issued its first report entitled, "Survey of Atomic Power Plants for Naval Ship Propulsion."

This report, which was issued to both the Bureau of Ships and the newly-formed Atomic Energy Commission, concluded that it appeared feasible to build a developmental atomic power plant for the propulsion of a destroyer escort class ship. GE also recommended that a suitable reactor be developed to parallel the development of the liquid metal heat transfer system proposed by GE.

The Bureau of Ships was very interested in this proposal. However, the Atomic Energy Commission was anxious at this time to proceed with the development of a land plant that could be used both as a central power station and an experimental breeder reactor for a source of new nuclear fuel. Since the Atomic Energy Commission would not approve the full-scale parallel development of a naval reactor, the Bureau of Ships decided to go ahead with just the heat transfer components of the reactor. Early in June, BuShips established project GENIE and contracted with General Electric for the development of a liquid metal heat transfer system suitable for a shipboard reactor.

In this same month, the Navy requested that the AEC authorize the continuation of the General Electric study of the naval nuclear reactor power plant during fiscal year 1948, to be financed by the AEC. Because of the low priority of the project at that time, funds for the study were cut in half. The newly created Atomic Energy Commission apparently needed time to set up its organization and formulate working policies, and it is understandable that the AEC was not ready at this time to plunge ahead with full-scale support for the Navy's nuclear power program.

In May of 1947, the AEC and Monsanto jointly announced that Monsanto had decided to give up its operation of the Clinton

Laboratories at Oak Ridge. The following September, the Daniel power pile project was quietly abandoned without public announcement.

By this time, the Navy team had been at Oak Ridge for more than a year. In a lengthy report submitted a few months previously to the Bureau of Ships on the status of nuclear power developments, Captain Rickover explained that the AEC, since it was primarily concerned with national security, was concentrating on the production of fissionable material for bombs and considered other aspects of nuclear power as secondary. He pointed out that since there was no incentive for the electric power industry to invest in the development of atomic power, the drive to achieve an atomic power plant for naval vessels must come from the Navy itself. He particularly urged the application of atomic power to submarines and emphasized that most of the scientific problems had been solved. The way was now clear for the Navy to move ahead with an engineering program.

As soon as the Navy team returned to Washington, Admiral Mills, then chief of the Bureau of Ships, appointed Captain Rickover as Special Assistant to the Chief. Captain Rickover's first major assignment was to obtain high-level Navy and Defense Department authorization for the construction and installation of an atomic propulsion plant in a submarine. With the help of Captain E. W. Grenfell of CNO, a memorandum was prepared which was finally signed by Secretary Sullivan and forwarded to the Research and Development Board of the Department of Defense. This memorandum stressed the strategic and tactical importance of a nuclear powered submarine and requested that the R&D Board initiate action with the Atomic Energy Commission for the early development, design and construction of a suitable reactor for shipboard use.

On 20 January 1948, Admiral Mills forwarded to the Atomic Energy Commission the BuShips detailed proposal for designing and constructing a nuclear power plant. The plan asked for the training of additional personnel and provided for considerable expansion of studies then underway, including extensive work on shielding, materials and heat transfer systems.

On 29 March, the Research and Development Board, chaired by Dr. Vannevar Bush, reported to the Secretary of Defense that it endorsed the Navy's request. The Board stated that there was strategic urgency for constructing a nuclear powered submarine and that it was technically feasible. The Board also recommended that the Atomic Energy Commission give formal recognition to this project and assign priority to the work.

At this point, I should mention that a new type of reactor had entered the picture. In 1946, Dr. Alvin M. Weinberg had made a detailed technical study of a water cooled high temperature reactor at the Clinton Laboratories. The Navy team at Oak Ridge became quite interested in this type of reactor. This led to a report by Mr. S. Untermyer issued in October 1947 which presented a design for a water cooled submarine nuclear power plant following the suggestions of Dr. Weinberg. After the Daniels pile had been abandoned, the Power Pile Project at Oak Ridge began a study of the water cooled reactor and continued it when the group moved to the AEC's new Argonne National Laboratory in Chicago. The Westinghouse Electric Corporation through its employees at Oak Ridge also became interested in the water cooled reactor.

On 27 April 1948, the Atomic Energy Commission gave formal project status and high priority to the development of a water cooled

reactor for submarine propulsion. There was now a general awareness not only in the Department of Defense but in the AEC of the importance and urgency of the Navy's nuclear power program. On 28 June, the Bureau of Ships executed a contract with Westinghouse, called Project WIZARD, for the design and development of a power conversion system for a naval vessel, using high pressure water as the heat transfer medium.

Perhaps I should explain that the reason the General Electric reactor program moved forward more slowly than the Westinghouse project was that the AEC did not feel that it could justify a second full-scale project for ship propulsion. The AEC felt that there was more to be gained by keeping General Electric concentrated on the development of an intermediate power breeder reactor. A few years later this project was converted to the Submarine Intermediate Reactor program which designed and constructed the propulsion system for the second nuclear powered submarine SEAWOLF.

On 10 December 1948, the Atomic Energy Commission entered into a contract with Westinghouse for the design and development of the Mark I reactor, a land based reactor which would meet Navy specifications for installation in a submarine. The contract also called for the design and construction of subsequent models leading to a successful nuclear power plant for the propulsion of a submarine. This was to be the NAUTILUS.

In August of 1949, the Chief of Naval Operations issued a formal operational requirement for the development of a nuclear powered submarine to be ready for operational evaluation by 1955. To emphasize this goal, the Chief of the Bureau of Ships issued a memorandum in November of 1949 specifying that the submarine should

be ready to leave the shipyard complete with nuclear power plant on 1 January 1955.

This requirement was almost met to the exact day. On 17 January 1955, the NAUTILUS left the shipyard of the Electric Boat Company at Groton, Connecticut. Shortly afterwards, the Commanding Officer of the submarine, Commander E. P. Wilkinson, signalled the historic message, "Underway on nuclear power." Since that date, the Navy has never looked back but has steamed full ahead on nuclear power.

In the history I have just recounted, I have tried to be frank and factual about the various problems, delays and frustrations in the Navy's attempt to develop nuclear propulsion. From our present clear-eyed hindsight viewpoint, it is easy to see where a different decision here and there might have speeded things along. It must also be remembered that when the Navy first conceived the idea of a nuclear powered submarine in 1939, the principle of a controlled chain reaction had not even been proved. At the end of World War II we still had no idea of how to create useful power from nuclear fission. In the over-all analysis, I believe that there were no serious delays. All in all it was a magnificent cooperative achievement by many people in many places. It was a masterful display of the ability of this nation to advance its technology, and a triumph in which we can all take great pride.