My Research at the Knolls Atomic Power Laboratory (1946 - 1963)

Fred G. LaViolette

The Preliminary Pile Assembly

The power breeder reactor was a program that General Electric had proposed to the AEC (Atomic Energy Commission) to research and develop a power reactor that would produce more fuel than it would burn. The idea was to not only produce useful electrical power, but also Plutonium-239 that could be used as fuel in other nuclear power plants of more conventional design. This was the world's first breeder reactor research program. It was started up in 1947 at the GE Research Laboratory in Schenectady, New York; see figure 1. The power breeder project was headed by Kenneth Kingdon who was a very successful researcher working under Guy Suits, who then headed the GE Research Laboratory.

Figure 1. The General Electric Research Laboratory, main works facility, ~1947.

There were many subprograms in the Breeder Reactor Program, one being the Preliminary Pile Assembly (PPA) that I worked on; see Figures 2 and 3. I began working on the PPA from the time of its inception under the breeder reactor program. I began work directing engineering development and research on the PPA one year after I had arrived at GE after leaving my job at Dupont in 1946. This was three years after I had left Hanford, Washington with the completion of the Manhattan Project. The PPA was a mock up of an experimental test reactor whose fuel rods consisted of the various materials that would be present in an actual power reactor. The materials had never been exposed to any high levels of neutron flux and therefore were only weakly radioactive. This allowed the materials to be handled directly without the danger of exposure to any significant levels of radiation. In addition, the Breeder Reactor Program included a fuel rod development program which developed the idea of the pin type fuel rod. We also had a metallurgy program to resolve

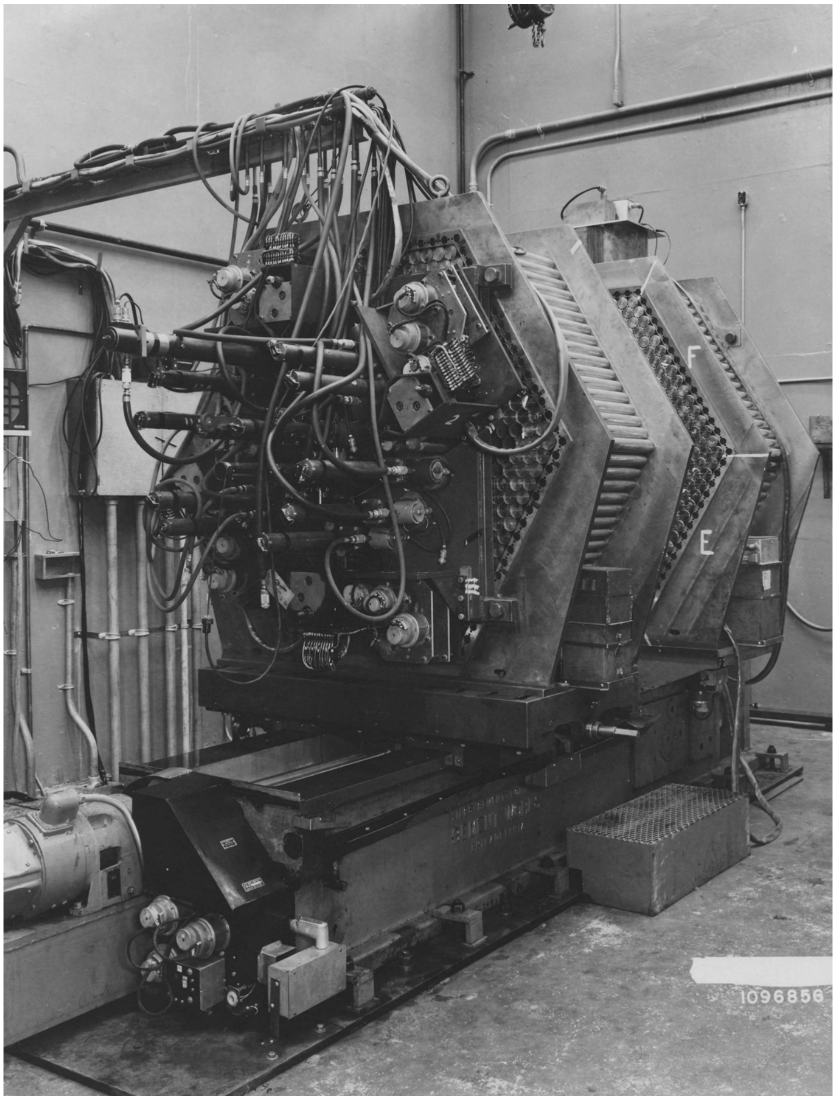


Figure 2. Core of the Preliminary Pile Assembly. Its elements could be rearranged to mock up any combination of materials for designing an experimental breeder reactor for testing. Two such halves are shown. They were slowly brought together by a remotely controlled drive system until they were close enough to allow the pile to go critical.

metallurgy problems that would be encountered and that also was charged with making the fuel rods. We were basicly starting from scratch. We were using zirconium fuel rods. No one had ever used zirconium in a reactor before. We were also using beryllium. We had a big beryllium machining facility. The work we did in fabricating the preliminary pile assembly laid the groundwork for all future nuclear power plants.

The Breeder Reactor Program also had a theoretical physics program which took the results of our experiments with the PPA and fed the information into their computers to check the validity of the computer models their team was developing to simulate the performance of the reactor. Glenn Roe, one of the theoretical physicists, sat at a Freiden calculator all day and hand entered the experimental data. Using our experimental data, his group would continually change the parameters of their theoretical model. The theoretical

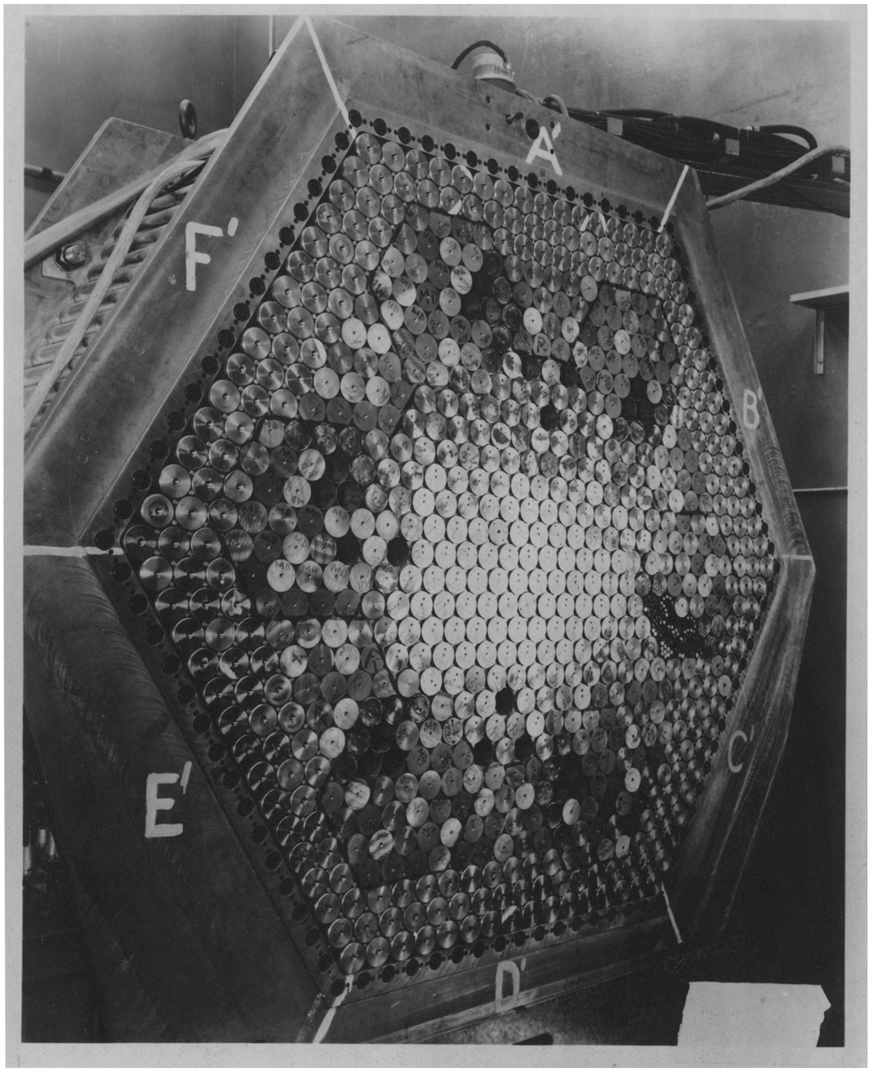


Figure 3. A close up of the face of one of the halves of the pile showing the stack of fuel rods.

program was headed by Henry Hurwitz. He was a genius, a fantastic mind! Also he was expert at dancing the jitterbug.

When we first started operating the PPA, someone gave a talk about how people had gotten killed in a nuclear accident down at Los Alamos. That accident occurred during a classroom demonstration of a nuclear reactor. A collection of uranium-235 cubes were stacked one on top of the other to form a cube pile whose nuclear reaction rate was subcritical. During the demonstration, the speaker was bringing a U-235 cube towards and away from the cube pile showing how the Geiger counter tick rate would soar when the cube was brought in close to the pile causing the reaction to rise slightly above its critical threshold. However, the cube slipped from his forceps and fell into the pile. There was a bright flash and a explosive burst that blew the uranium cubes apart. Most of the people in the room in that brief microsecond received a lethal dose of radiation and died shortly afterward. Before they died, however, someone in the room had the forsight to take a piece of chalk and mark on the floor the places where each person had stood. This allowed researchers later to determine what radiation exposure each person had received so that the exposure levels could be related to the resulting illnesses that each had developed. This provided the first data base on the lethal dose and health effects of nuclear radiation exposure.

Thoma Sneider, who was one of the people in our group, had earlier worked at Los Alamos during the Manhattan Project. After hearing the lecture about this accident, he suggested that we should come up with safety protocols for our own research project so that a similar mishap would not be repeated. Everyone was in agreement and it became my responsibility to develop this safety protocol. I developed the first standard reactor operating procedures that ensured safety against operator errors. I also organized the first nationwide meeting on critical assembly safety.

Rather soon, the PPA experiments showed that the breeder program could not feasibly attain its goal because of some unknown factors that had been discovered, namely that there were losses of fissionable material due to the occurrence of unanticipated side nuclear reactions. Such side reactions would convert fissionable material into products that were neutral and unproductive or that would even poison the reaction. In other words neutrons were absorbed in nonbeneficial nuclear reactions that did not produce more fuel.

After I had worked on the project for two years, Navy admiral Hyman Rickover interrupted the program because he wanted to have it used for the design of a reactor for powering a submarine. He concluded that the Preliminary Pile Assembly would be useless as a power breeder reactor, but would nevertheless have useful application as a power plant for a nuclear submarine. He managed to secure a position in the AEC where he could have control of the budget of GE's nuclear program. After the second year of operation of the power breeder project, Rickover managed to get the appropriation canceled for continuing the power breeder and had it transferred to create a nuclear submarine project.

As his first order of business, Rickover called Kenneth Kingdon in for a meeting regarding the following year's budget for the Knolls Atomic Power Laboratory (KAPL), the GE's newly built research facility situated along the Mohawk river. He said to Kingdon, "Well Kenneth, What are you going to be doing next year?" Kenneth being a naive soul said, "Well we're going to continue working on the power breeder reactor." Rickover responded, "What will you do for funds? I'm in control of the funds of your program now, and I'm not going to approve continued work on the power breeder reactor program. Would you like to work on a power plant for a nuclear submarine?" Kingdon said, "A nuclear submarine is a military project and we prefer to put our time into working on a project for peaceful purposes." Rickover said, "In that case, I suggest you begin looking for another position." Kingdon, though, refused to come on board Rickover's nuclear submarine program. Instead, he switched to a different job in the research laboratory to work on a different research project.

About the time that the program was canceled, I was leaving on a trip to Canada which the Canadians had called. I had just done a preliminary test of a heated fuel rod which I had hoped would help to determine whether there might be a danger of a reactor runaway reaction due to fuel rod heating. This was a special project I was conducting. The meeting lasted for 3 days and when I returned I found that all of the uranium-235 fuel discs used in the breeder reactor had been sent back to Los Alamos. Rickover didn't waste a minute in making his program change. He had all the shipping arranged. Even my special fuel rod had been sent to Los Alamos. Harvey Brooks was the assistant director to Kingdon. He kept notebooks on everything that happened on the Power Breeder Program, every decision, every meeting, everything. Although Kingdon was the head of the program, it was actually Brooks who was making most of the decisions on the program.

The Submarine Intermediate Reactor – SIR

What we had learned in the PPA project laid the groundwork for the Submarine Intermediate Reactor project named SIR. I switched over to the SIR project where I worked as director of research and development on the naval nuclear power plant. Figure 4 shows the badge I was wearing while working at the KAPL facility. Figures 5, 6, and 7 show the test reactor that I was in charge of building. Figures 8 and 9 show a triflute rod my group developed and the triflute rod loaded with uranium discs.

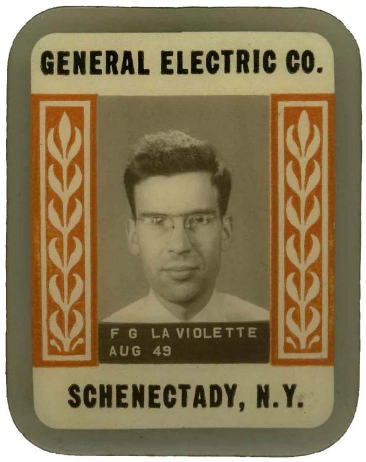


Figure 4. Badge I wore while working at KAPL

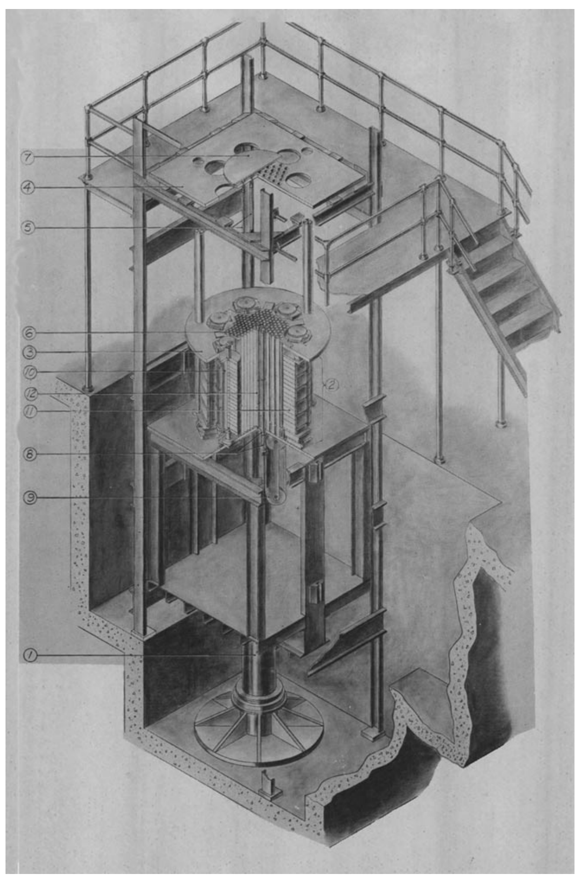


Figure 5. SIR test reactor.

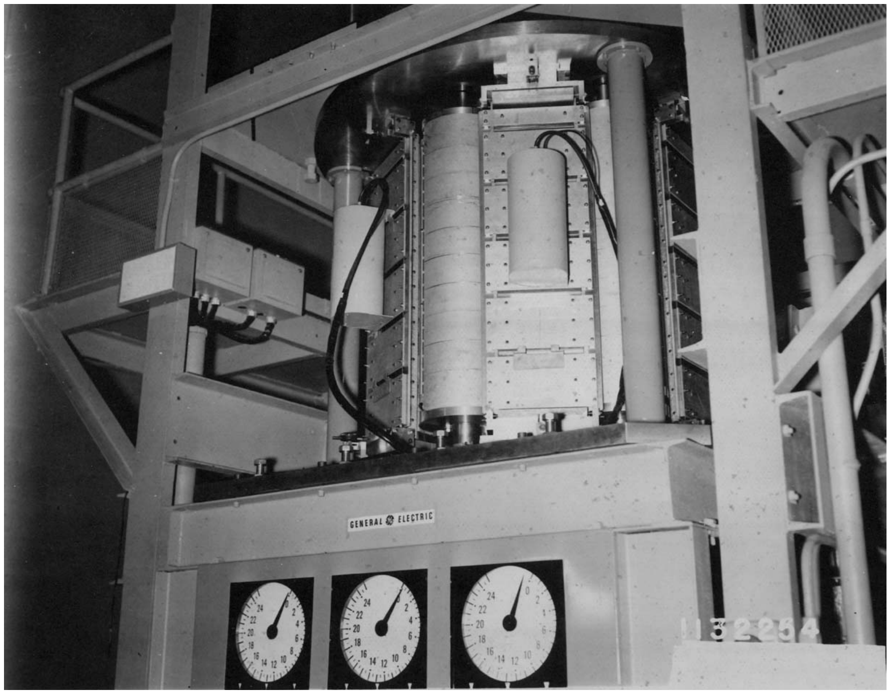


Figure 6. View of the core of the test reactor.

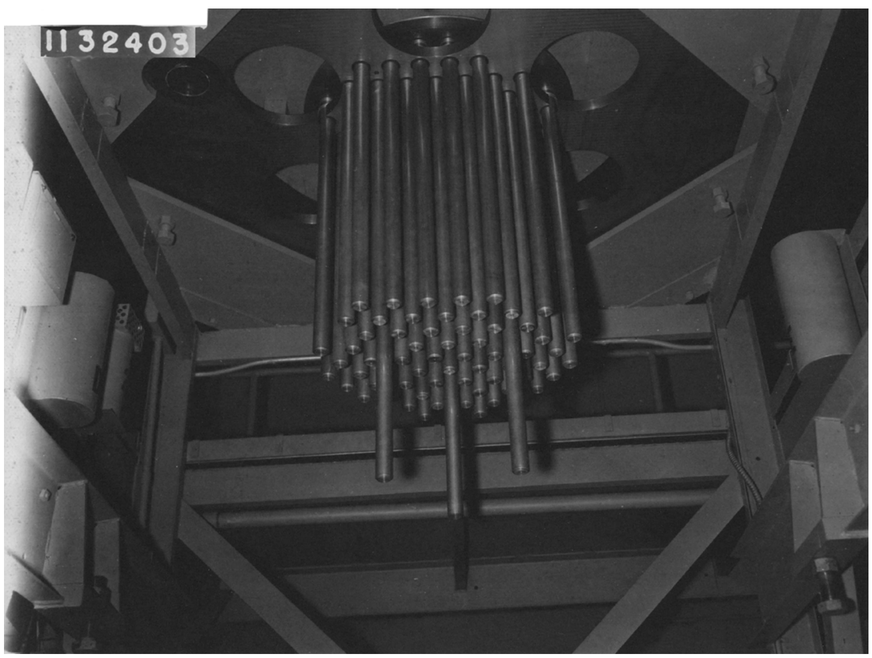


Figure 7. View of the bottom of the core of the test reactor.

While on this project, and earlier on the PPA project I did pioneering work on power reactor core instrumentation, reactor materials testing, reactor measurements techniques, neutron detector design, reactor control instrumentation, and reactor start-up and test methods. In addition, I worked on developing the first annular core test reactor and conducted the first transient stability tests for a nuclear power plant operating at full rated power. I also evaluated the photoneutron source and power coefficients in beryllium

Figure 8. Triflute rod.

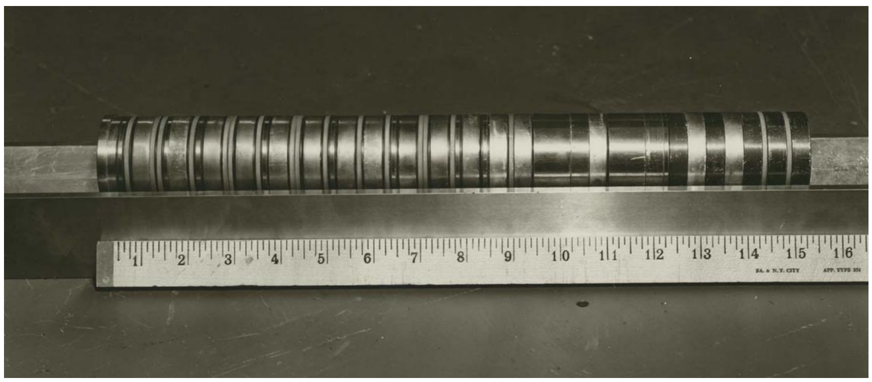


Figure 9. Triflute rod with mounted uranium discs.

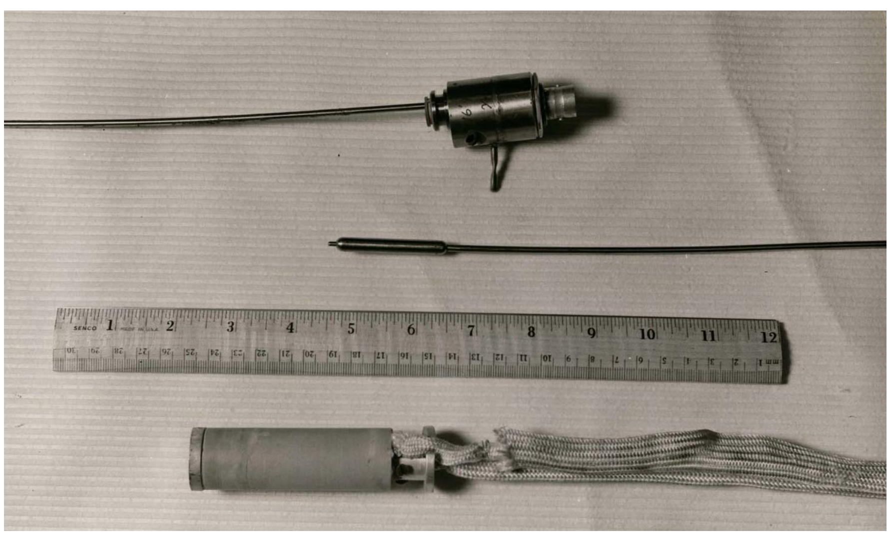


Figure 10. Mini ionization chamber developed to measure neutron flux.

moderated reactors. Figure 10 shows a miniature ionization chamber I developed which could be inserted into the core of the naval nuclear power plant to measure its neutron flux.

After the SIR reactor was built and successfully tested. Work was begun on building the reactor for the U.S.S. Seawolf, the first nuclear submarine to be powered by a sodium-cooled reactor (Figure 11). This was the second nuclear submarine ever built, the Nautilus being the first. The Nautilus, built by Westinghouse instead used a water cooled reactor.

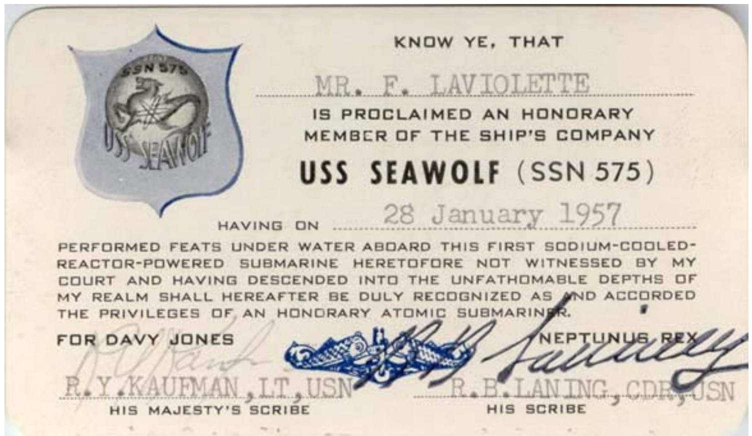
Figure 11. USS Seawolf. The first nuclear submarine powered by a sodium-cooled reactor.

Figure 12. Seawolf arm badge given Fred by one of the crew members

Red Alert Radiation Emergency on Board the Seawolf

The Seawolf ran successfully. During the cold war it was assigned to covert missions in foreign waters. However, one time it did experience a radiation leak mishap. This occurred during a test run conducted while it was docked in the navy yards in Grotten, Connecticut. At that time it had just finished being built and had not yet gone to sea. I was on board at the time. The reactor had been powered up and I was one deck above the reactor talking to a sailor. The sailor saw the pencil-like ionization scope stuck in my jacket pocket. Being curious about it, he asked if he could see it. He took it, put it to his eye, and began pointing it in various directions. Then he pointed it down toward the reactor and asked what it meant when the little needle would go all the way to the right. I told myself that can't be. I took the ion scope and pointed it down toward the reactor bulk head. The needle pinned itself to the right. I immediately realized there was an emergency. Aparently, radioactive liquid sodium had begun to leak past the seal on the shielded reactor bulk head. I ran to a room where I high level meeting was in progress. Iinterupting the meeting, I told the captain that there was a serious radiation leak and that the reactor had to be immediately shut down. Action was taken and a serious danger was averted. The sodium leakage problem was later corrected and did not reappear in any of the Seawolf's many voyages. However, in retrospect I have always wondered what would have happened if that sailor had not been curious about my ionization scope. If we had continued to stand where we were standing, unaware of what was happening, we would soon have gotten a lethal radiation dose. An angel must have been watching over us and the ship at that time.

In 1958 the Navy gave Fred an award for Outstanding Civilian Service. Below is a card he received acknowledging his honorable service aboard the U.S.S. Seawolf on January 28, 1957.


SSN 575
USS SEAWOLF

KNOW YE, THAT

MR. F. LAVIOLETTE

IS PROCLAIMED AN HONORARY MEMBER OF THE SHIP'S COMPANY

USS SEAWOLF (SSN 575)

HAVING ON 28 January 1957

PERFORMED FEATS UNDER WATER ABOARD THIS FIRST SODIUM-COOLED-REACTOR-POWERED SUBMARINE HERETOFORE NOT WITNESSED BY MY COURT AND HAVING DESCENDED INTO THE UNFATHOMABLE DEPTHS OF MY REALM SHALL HEREAFTER BE DULY RECOGNIZED AS AND ACCORDED THE PRIVILEGES OF AN HONORARY ATOMIC SUBMARINER.

FOR DAVY JONES — NEPTUNUS REX

R.Y.KAUFMAN,LT,USN — R.B.LANING,CDR,USN

HIS MAJESTY'S SCRIBE — HIS SCRIBE