

Material on Teller's last paper to consider for the Edward Teller Centennial:
Celebrating the Man and His Vision

My association with Edward Teller—Ralph Moir

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My association with Teller began in 1962 when I had the wonderful opportunity of taking a class from him at UC Berkeley, "Peaceful uses of nuclear explosives NE290E." Of the six students, I was the only undergraduate. Teller's teaching assistant was Wilson Talley. This class was eye opening and inspired much of the rest of my life. It was mind blowing to consider underground nuclear explosions for energy production. Being in his presence was inspiring. During the summers of '62 and '64 at Livermore I again attended lectures Teller gave every summer, classified this time. After completing graduate work at MIT and a year post doc in France I came to work at the lab in 1968 as a physicist in the magnetic fusion program. Over the years Teller would summon me as he did with many at the laboratory for discussions in his office.

During one of these summonses in about 1979, he asked if I would contribute a chapter to a book he was preparing to write on fusion energy. My chapter was to be the fusion-fission hybrid. During the next two years, I had many sessions in his office where he gave extensive suggestions and editing of my chapter 15, "The Fusion-Fission Fuel Factory," in the book, Fusion, edited by Edward Teller, Academic Press, New York (1981). From this time on when Edward summoned me, I knew it was probably to discuss some aspect of nuclear reactors.

Edward was keen on reactors built deep underground, analogous to nuclear explosive tests that were much more than 100 m underground with no planned in-place repair. The reactors would be operated automatically by computers or self controlled to avoid human error; and, most importantly, the wastes were to be left in place. I objected to the deep undergrounding because it added well over 20% to the cost. The lack of access to make the simplest repairs of even pinhole leaks would put the reactor at great financial risk. Finally, I argued that leaving the reactor wastes in place required the site to qualify as a deep geologic repository, a daunting set of requirements. Over a ten-year period at least, these discussion went on while his work with others on the deep underground reactor proceeded.

Finally, in 2003 he called me into his office and stated he wanted to do something about nuclear reactors, and he bluntly asked if we could meet two or three times a week for the next twelve weeks. For these meetings in his office in Livermore, he would be driven by limousine from his home in Palo Alto on the Stanford campus to the lab in Livermore and back. I quickly agreed to his proposal and this set off an exhilarating, tiring adventure that lasted much longer than twelve weeks. He would ask at the end of a session of an hour or two if we could meet

again in two days. I quickly found out what that meant. The next meeting would be at his home. I would arrive in Palo Alto at 11 am and leave about 3:30 to 4 pm. He would often begin the sessions by asking me how today's fission reactors work. I would review each type of reactor and tell him (remind him) how they work. He asked lots of questions that sent me off searching for answers. How much does it cost to build a reactor underground? What are the advantages of liquid metal fast reactors and so on? I would be exhausted by the intensity of the sessions and then by the extensive preparations between meeting days but always exhilarated. Together we compared each reactor type, slow neutron and fast neutron, each with a number of coolants options. I always discussed all the options I knew of but kept coming back to my favorite, the molten salt reactor with the uranium and thorium fuel dissolved in the circulating molten salt that flowed through a graphite core. I reviewed the successful experience the people at Oak Ridge National Laboratory had with this reactor. I had become quite familiar with this reactor and the people who had worked on it as a result of my studies of the fusion-fission hybrid reactor, where my favorite choice of fuel and coolant was molten salt.

Finally, one day he said, "You have convinced me the molten salt reactor is the best choice. Let's write a paper." This set off an intense effort. I would write a draft and read it to Edward. He often interrupted and said, "Try this....." I would furiously make calculations and write. At the next meeting I would read the clean draft to him. He was completely blind. After each meeting I would write and make calculations. Finally, he said, "I am satisfied. Let's send it off to the journal. *Science* rejected it and *Nature* rejected it. He died and I finally sent it off to the American Nuclear Society Journal, *Nuclear Technology* on August 2004 and they accepted it. It was published in September 2005. We never found out the reasons for rejection and could only speculate.

The paper is his last:

Ralph Moir and Edward Teller, "Thorium fueled underground power plant based on molten salt technology," *Nuclear Technology* **151** (2005) 334-340.