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(c. 1955)

United States Atomic Energy Commission
Patent Compensation Board ~~Application~~

Application by Leo Szilard for just compensation and/or an award.

Leo Szilard, hereinafter referred to as the applicant, hereby applies to the Atomic Energy Commission for just compensation and/or an award, under Section 157 of the Atomic Energy Act of 1954, approved August 30th, 1954, on the basis of the following facts:

Discovery of the neutron emission in fission.

(1) He was the first to make the theoretical discovery that uranium must emits neutrons in the fission process, and that a chain reaction might be possible on this basis in a system containing uranium. The same theoretical discovery was made independently and somewhat later by Enrico Fermi. This theoretical discovery was communicated by ~~xxxxx~~letter, ~~xxxxxxx~~ dated _____, to Frederic Joliot (Exhibit 1), but applicant believes that Joliot made his theoretical discovery himself independently. Applicant made this theoretical discovery in the first days of January 1939 upon being informed by E. P. Wigner in Princeton of the discovery of Hahn and Strassmann that uranium undergoes fission when bombarded by neutrons. He discovered upon theoretical grounds that uranium will emit neutrons in the fission process and that a nuclear chain reaction might, therefore, be possible in a system containing uranium. As proof of this contention he submits Exhibit (2). This exhibit is an excerpt from a memorandum written by E. P. Wigner on April 16th, 1941, a copy of which was sent to the applicant by E. P. Wigner in 1941. The applicant was able to recognize the possibilities of a chain reaction in a system containing uranium immediately upon discovering that uranium will emit fishion, because in 1934 he had thought of the possibility of a nuclear chain reaction carried by neutrons -- de-

rived the concept of the critical size for a chain reacting system -- and recognized the possible military applications of the nuclear chain reaction. As proof of this contention, the applicant encloses Exhibit ( ) consisting of an excerpt from a memorandum written by E. P. Wigner on April 16th, 1941 and communicated to the applicant by E. P. Wigner in 1941. As further proof of this contention, the applicant encloses Exhibit ( ). This exhibit is a copy of a patent filed by the applicant in 1934 in England. Because of the possible military use of the chain reaction, applicant assigned this patent to the British Admiralty, free of charge, in order to enable the British Admiralty to seal the patent secret and prevent its publication. After the war the patent was returned by the British Admiralty to the applicant and was published.

Upon making the theoretical discovery that uranium will emit neutrons in fission, the applicant took immediate steps to prove experimentally that neutrons are, in fact, emitted in fission. Applicant, having reached the conclusion that the neutrons emitted in the fission of uranium are fast and that their existence can, therefore, be best shown by bombarding uranium with slow neutrons from a radium photo-neutron beryllium source, the emission of neutrons from beryllium was discovered by the applicant jointly with Chalmers in 1934, ("Detecting Neutrons Liberated from Beryllium by Gamma-Rays", Szilard and Chalmers; Nature, p. 494, 134 (1934)). Applicant borrowed $2,000. from a friend, rented a gram of radium, and using a block of beryllium which he had bought with his own money, on March 3rd, 1934, he discovered experimentally, jointly with Walter Zinn, that about two neutrons are emitted in the fission of uranium. Applicant did not wish to publish this discovery because of its military implications, but was finally overruled,

and the discovery was published in the Physical Review ("Instantaneous Emission of Fast Neutrons in the Interaction of Slow Neutrons with Uranium"; Szilard and Zinn, Physical Review, p. 799, 55 (1939); Exhibit ( ).

About the same time Enrico Fermi, working with H. L. Anderson and H. B. Hanstein, attempted to find out whether uranium emitted neutrons in fission. They used a different method. As a neutron source they also used at first a fast neutron source which made it difficult for them to distinguish between the neutrons emitted in fission (if there were any) and the neutrons from the source. The applicant, therefore, ~~made available to them~~ suggested to them that they use the beryllium photo-neutron source which he had procured for his own experiments, ~~and using this slow neutron source~~ made available to them they were enabled to show that uranium emitted neutrons in fission.

Halban, Joliot, and Kovalski also reported that uranium emitted neutrons in fission, and published this fact in Nature in March, 1939. Their report post-dates ~~my~~ Joliot's letter to Joliot (Exhibit 1). I have reason to believe that Joliot thought independently of the possibility of such a neutron emission and the chain reaction based on it. Thus, this thought seems to have occurred independently to Frederic Joliot, to Enrico Fermi, and to myself during the month of January, 19___.

Subtitle

Applicant communicated both his theoretical discovery that neutrons must be emitted in fission and the experimental discovery, jointly made with Walter Zinn, to Edward Teller and E. P. Wigner, together with his concern for the consequences of this discovery. E. P. Wigner came to New York and met with G. B. Pegram, Enrico Fermi and the applicant, and proposed that the Government be informed of this discovery prior to its publication. This proposal was unanimously accepted, and Dr. Pegram telephoned Charles Edison, at that time Under Secretary of the Navy, and arranged with him that Fermi, who was about to go to Washington on some other business, should meet with a group designated by Charles Edison and describe the discovery and explain its consequences for national defense. The meeting took place, and among those present was, I believe, Rothgunn who was at that time connected with the Naval Research Laboratory. There is no indication that the Goernment was persuaded to take any interest whatsoever in the matter.

The Possibility of a Chain Reaction in a System Containing Natural Uranium.

Even though it had been established that uranium is about two neutrons efficient, the question of whether natural uranium could sustain a chain reaction remained undecided. Natural uranium can sustain such a chain reaction only in a system in which the neutrons are slowed down to thermal velocities if more neutrons are emitted than absorbed by uranium in the thermal region. Applicant discovered that this is, indeed, the case by performing an experiment jointly with Enrico Fermi

and H. L. Anderson. In this experiment a lattice of uranium-oxide rods immersed in water was used. Such a system cannot maintain a self-sustaining chain reaction because of the high absorption of water, but measurements performed on this system permitted answering the question stated above. In this way it was discovered that the absorption of slow neutrons in natural uranium does not preclude the possibility of maintaining a self-sustaining chain reaction in uranium. Because such a self-sustaining chain reaction, if it can be set up, has far-reaching implications, the applicant approached the Government through Rothgunn, who at that time was connected with the Naval Research Laboratory, and asked Mr. Rothgunn whether the Government might not take an interest in this matter and help with the financing of an experimental program which he proposed to undertake at Columbia University, jointly with Enrico Fermi. Exhibit ( ) which is attached is a photo-copy of a letter written by Rothgunn, embodying the negative response of the Government.

Chain Reaction in a Graphite-Uranium System

In the first ten days of June, (?) 1939, the applicant came to the conclusion that one would have a very good chance to maintain a self-sustaining chain reaction in a system composed of uranium and heavy water, or uranium and graphite. Applicant wrote to Enrico Fermi, who spent the summer away from New York, three letters (Exhibit), in which he stated his belief that a self-sustaining chain reaction may be set up in a system composed of graphite and uranium, and at the same time started inquiries relating to the procurement of graphite. About July 10th, as shown by these letters,

Between July 2nd and July 11th, I discovered that one would have a fair chance of maintaining a self-sustaining chain reaction in a system composed of uranium and graphite or of uranium and heavy water, and on or about July 10th, 1939, I discovered that while a lattice of uranium oxide rods embedded in water, such as was used in the experiments which applicant jointly performed with Anderson and Fermi (Exhibit) was not capable of maintaining a self-sustaining chain reaction. A lattice of uranium spheres or rods, and particularly a lattice of uranium metal spheres or rods would be more likely than not to maintain a self-sustaining chain reaction. In support of this contention, I submit the following facts:

(a) On July 3rd I wrote a letter to Enrico Fermi (Exhibit), in which I showed that by using carbon in place of water one may expect to set up a self-sustaining chain reaction;

(b) described an experiment that would permit measuring the absorption of carbon in neutrons on the assumption that carbon absorption will turn out to be less than the then known upper experimental limit (which would have made carbon about as bad as water);

(c) Stated that I have taken steps to find out if it is physically possible to obtain a few tons of heavy water to be used in case the absorption of carbon does not prove to be low enough.

On July 5th I wrote the second letter to Fermi explaining in greater detail how the neutron absorption of carbon may be measured, and pointing out the especial advantage of carbon over heavy water, as follows: Carbon would also have an advantage over hydrogen insofar as there is no change in the scattering cross-section, in the transition from the resonance region to the thermal region. Consequently if layers of uranium oxide of finite thickness are used, the diffusion of the thermal neutrons produced in the carbon to the

uranium layer is not adversely affected as in the case of hydrogen by such a change. I once more stressed the importance of heavy water as a second line of defense and wrote: "I shall let you know as soon as I can how many tons can be obtained within a reasonable time." Fermi, in his reply to my first letter of July 3rd (Exhibit) stated: "I have discarded heavy water as too expensive." He also said that he had been considering the possibility of using carbon for slowing down neutrons but gave a pessimistic estimate based on the concept of/a homogeneous mixture of carbon and uranium. He wrote: "Since, however, etc."

(d) He raised some objection to the experiment which I proposed for measuring carbon absorption which he withdrew in one of his later letters.

By July 8th, 1939 I had reached the conclusion that the chances of maintaining a self-sustaining chain reaction in a system of graphite and uranium were so great that it would justify the building of a pile, and that this was the right course of action under the circumstances. I later stated that I had told Professor Pegram how I felt about the situation, and that he seemed to be willing to take the necessary action.