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Leo Szilard

Memo

Recently I went through my files relating to my work in the early development of atomic energy and picked out a number of documents. The attached material consists of the following:

1) A letter to the Editor of the Physical Review (Szilard and Zinn, Phys. Rev. 55, p. 799, 1939) that describes the discovery of the neutron emission in the fission of uranium and states that about two neutrons are emitted per fission. (1) The same discovery was made about the same time, but by a different method, independently by Malban, Joliot, and Kowarski, as well as by Anderson and Fermi.

2) An article in the Physical Review (Anderson, Fermi, and Szilard, Phys. Rev. 56, p. 284, 1939) in which the possibility of maintaining a chain-reaction in a uranium-water system is explored. (2)

3) Three letters written by me to Fermi in July, 1939, dated July 3rd, 5th and 8th, proposing the use of the uranium-carbon system. (3)

4) Fermi's answer, dated July 8, which crossed my July 8th letter to him and also my answer to Fermi's letter. (4)

5) During the second week of July, I saw that by using a lattice of uranium spheres embedded in graphite, one would have a great advantage over using alternate layers of uranium and carbon. I also saw

that if we have a lattice of uranium spheres in graphite a further advantage can be gained by using uranium metal instead of using uranium-oxide. It was these facts which led me to believe from then on that there is a good chance of maintaining a chain-reaction in a uranium-graphite system.

Early in July, I told Wigner of my pre-occupation with the uranium-graphite system. The two of us paid a call on Einstein and Wigner left then for the West Coast. You came to New York to spend the summer there, and I kept you informed throughout July on my thoughts concerning the uranium sphere - lattice system. My appraisal for the chances of a chain-reaction in such a system was communicated to Einstein when you and I called on him later in July.

Einstein's letter to President Roosevelt and my memorandum which was attached to it are enclosed. (5)

When Fermi returned to New York in the fall of 1939, I showed him my computations on the uranium sphere lattice in graphite and he showed me his of a homogeneous mixture of uranium and carbon. In accordance with this the memorandum which I submitted to Dr. Briggs in October, 1939 contains the following passage:

"The properties of a system composed of uranium and graphite have been calculated independently, for a homogeneous mixture, by Fermi, and, for a lattice of spheres of uranium oxide, or uranium metal, embedded in graphite, by myself. The results of these two independent calculations are in reasonable agreement and show the two arrangements have different properties. For instance, in the case of using a lattice of spheres a great advantage could be obtained by using uranium metal instead of uranium oxide, whereas in the case of the homogeneous mixture the use of uranium metal would be of no great advantage."

So that you do not gain the wrong impression from this passage, I should stress that Fermi knew that it is better to keep the uranium

and carbon in separate layers rather than to use a homogenous mixture. This is shown by the passage in his letter of July 9, 1939, which reads as follows:

"Since however the amount of uranium that can be used, especially in a homogeneous mixture is exceedingly small, even a very small absorption by carbon either at thermal energy or even before might be sufficient for preventing the chain-reaction; perhaps the use of thick layers of carbon separated by layers of uranium might allow to use a somewhat larger percentage of uranium."

In the case of the uranium-water system, Fermi had computed as early as June, 1939 that some advantage can be gained by keeping the uranium and water in separate layers. I have no knowledge, however, that Fermi has recognized the advantage of having a lattice of uranium spheres or rods of small diameter embedded in graphite, or the advantage of using the metal in place of the oxide in such a lattice - until I presented my results to him.

The full text of the memorandum which I submitted to Dr. Briggs in October, 1939 is enclosed. (5)

6) Report A-55 of the Uranium Committee which is a copy of a paper that I submitted to the Physical Review in February, 1940. (6) This paper was accepted for publication, but publication was deferred at my request because of the nature of the paper. On the basis of measurements which Joliot and his co-workers have performed on a uranium-water system, it is concluded in this paper that one should be able to maintain a chain-reaction in a uranium-graphite system if a lattice of uranium metal spheres is embedded in graphite. The paper gives a rough theory of such a system. It explains that the chain-reaction can be controlled by shifting an absorber between positions differing in neutron density and it states that the delayed neutron

mission of uranium permits it to move such absorbers quite slowly.

7) A page from Chemical Engineering News showing that the "first nuclear reactor patent (No. 2,708,656) was issued to Leo Szilard and the late Enrico Fermi on May 17, 1955 by the United States Patent Office."

Yours,

Leo Szilard

MEMORANDUM

This Memorandum concerns the following problem:

ELECTRIC POWER produced from ATOMIC ENERGY can not compete in the United States with ELECTRIC POWER produced from COAL.

There is, on the other hand, a strong desire to develop atomic reactors suitable for civilian power production. The policy followed at present consists -- if I understand it correctly -- in developing different designs for such atomic reactors in the following manner:

The Government will buy the reactor and make it available to a consumer who can use the power with the consumer paying only for fuel cost and cost of maintenance but not paying interest on the initial investment or amortization. Thus the reactors are built at government expense and the decision which reactor to build, remains a bureaucratic decision. The present procedure would probably be the only practical one were it not for the fact that in a number of areas abroad atomic power reactors could compete with coal. This should make it possible to adopt a different - additional <sup>rather than</sup> ~~or~~ substitute - procedure for solving our problem.

What I propose is as follows: suppose an American company can obtain in a friendly country a contract to erect and operate a power plant selling electric power at the bus bar to whoever operates the distribution; suppose the contract provides that the American company shall erect and operate the plant for 25 years, and suppose the contract provides that the American company shall receive a fixed number of mils per kilowatt-hour with a guaranteed minimum of kilowatt-hours; and suppose further that the government of the friendly country guarantees the payments due to the American company under the contract, then I believe our problem could be solved by the U. S. Government guaranteeing to the American company the payments due under the contract in dollars and extending to the American company a 25 year loan to cover the initial capital investment at 3 1/2% interest.

A standard contract between the American Government and the friendly country could provide that if the annual payments under the contract with the private American company can not be converted into dollars, these payments will be made to an account of the U. S. Government and will be invested according to the direction of the U. S. Government. If there is a free market in the currency of the friendly country, the free market determines the exchange rate that is to be assumed. If there is no free market in the currency of the country, the price of coal at the site of the power plant will determine the amount to be paid to the U. S. Government, according to formula which establishes how many lbs. of coal shall be regarded as equivalent to One kilowatt-hour.

In order further to enhance the development of atomic energy for the purpose of power production it would seem advisable for the U. S. Government to make available the cost of a pilot plant to any company who has a contract for erecting and operating a 100,000 Kw atomic electric power plant. This would make it possible for American investors to compete effectively abroad because they need charge only the actual cost of the power plant. If they have to charge the full development cost for the first power plant, they deliver, it would be impossible for this kind of business to get going.

The U. S. Government might wish to exercise some discretion on the basis of the judgment of the risk which it takes due to the fact that some American companies are less likely than others to erect and operate a power plant without some serious set-back. Naturally, if the company fails to deliver the power it is liable and will have to pay the damages suffered by the U. S. Government which has financed the plant. Naturally, the foreign country can not be expected to pay unless power is delivered.

In order to give the U. S. Government discretion in this respect, the Government should be free to set the 25 year loan at a value that is less than the capital investment. However, in no

case should this loan amount to less than half of the capital investment since it must be assumed that American companies who put up a large sum of money know what they are doing, and they would not want to incur the risk of losing half the capital needed for the plant.

An attempt to build up business along these lines will be somewhat hampered by the following fact: it is very often not possible to say with certainty what the maintenance cost of the plant will be and how fast the plant will have to be amortized. If a company is forced to give a guaranty in this respect it will either have to engage in very costly experimentation of a development of a kind, or else - in order to be on the safe side - they will have to set the price per kilowatt too high. It will, therefore, be highly desirable to pursue a policy that will permit the American company, the foreign purchaser of power and the U. S. Government to share the risks and benefits. It might thus be advisable to set a rather high maximum price for the kilowatt hour and then provide that the saving due to a lesser cost will be divided three ways among the above mentioned parties.

Under the system here proposed the U. S. Government does not give any grants à fond perdu. A long term loan will be re-paid by the American company out of the income derived from its sale of power over the 25 year period or, if there is difficulty of transferring currency, the U. S. Government will acquire a counterpart fund.

In return for the cost of the pilot plant the U. S. Government acquires the right to make the results of the pilot plant operation available to other American companies unless the company obtaining the foreign country prefers to pay for the cost of the pilot plant itself and retain the know-how for its own use.

New York, June 14th, 1956.

August 30, 1956

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Memorandum by Leo Szilard

At present I am a member (Professor of Biophysics) at the Enrico Fermi Institute for Nuclear Studies at the University of Chicago. This position, while it may be regarded as very desirable in many respects, does not represent the proper setting for the pursuit of my biological interests.

I take the liberty to submit herewith a memorandum in which I propose to work under a research grant either for five or for ten years.

I understand that under the terms of such a position I would be free to pursue my scientific interests anywhere in affiliation with universities or research institutes. Initially, however, I would be affiliated with the California Institute of Technology, Pasadena, California; the Rockefeller Institute for Medical Research in New York; the Department of Pharmacology of the Medical College of New York University in New York; the Department of Biophysics, Medical School, University of Colorado, in Denver; and the Enrico Fermi Institute for Nuclear Studies at the University of Chicago, Chicago.

In general my research will be in the field of quantitative biology. More particularly, I expect to be concerned with the formation of adaptive enzymes in microorganisms, and the formation of antibodies in spleen cells in vitro, problems connected with the growth of microorganisms and tissue cells in vitro, and the transformation as well as the transduction of genetic characters in microorganisms.

I would expect initially to cooperate in the Rockefeller Institute with R. Hotchkiss, M. Fox, N. Zinder and Paul Weiss; at New York University with Bernard Davis and Werner Maas; at the University of Colorado with Leonard Lerman and T. T. Puck; at the California Institute of Technology with Max Delbrück and R. Dulbecco; and at the University of Chicago with A. Novick and H. Anker.

In the following I wish to present two points of view that might be relevant in judging the usefulness of my working under a research grant.

(a) At present certain branches of biology in which I am interested are in rapid progress. The problems of protein synthesis, the role of RNA and DNA, and the general problems of self-reproduction, differentiation and aging are rapidly becoming open to attack by means of new techniques. In part, this is due to progress in the field of microbiology and, in part, it is due to progress in the techniques of animal cell cultures, as well as other fields. This appears to be a situation where it would be of great advantage for anyone interested in general biological laws to be able to shift from one biological material to another, as the problem demands, and to be free from the limitations of using just the few techniques which any one person can



master. This ideal is not fully attainable for anyone short of being made head of a research laboratory of some size created de novo, and thus being enabled to assemble, so to speak, from scratch a sufficiently large and varied team, and at the same time being given an administrative setup which leaves the head of the laboratory free of administrative duties in order to enable him to effectively work with such a team. However, working under a research grant, it might be possible for me to approximate somewhat this ideal situation (which is probably not fully attainable in the United States). Under such a research grant, it should be possible for me to establish collaboration with a sufficiently large and varied group of scientists scattered across the country in different laboratories, and at the same time I would remain free of administrative duties.

(b) Under such a research grant, it should be possible for me to acquire intimate knowledge of experiments conducted with a great variety of biological material and diverse techniques, and thereby to be in a position to try to function as a "theoretical biologist." This statement requires a qualification:

Biology has not quite reached the stage which was attained by physics half a century ago when enough facts were established to permit a theoretical physicist to come up with significant insights on the basis of the established facts. Yet in biology we might be very well on the verge of a similar situation, and a few scientists who are so inclined may attempt to act, for a period of time at least, as theoretical biologists. This means that it might be well at present for a few scientists to put less emphasis on their own experiments and spend more time trying to keep in close touch with the experiments of others in the hope of being able to recognize new patterns and to gain insight into some general biological laws that have so far not clearly emerged. It may be that the main difference between theoretical physicists of the past and the would-be theoretical biologist of the present is quantitative rather than qualitative. The would-be theoretical biologist would probably not be able to keep on studying the results of others and thinking about them for a very long stretch of time. Much sooner than a theoretical physicist, he will feel impelled to do further experiments (or to induce someone else to do them) because he will feel the need to cut down the number of possible avenues along which his further thinking may be tempted to wander.

With respect to the issue of whether support should be given for five or for ten years, I wish to present the following point of view:

If the support is given for ten years, it would take me to the age of 68 years, which is the present retirement age at most universities. On the other hand, if the support is given for five years, I would have to contemplate returning to the University of Chicago when the

support lapses. While I understand that the University of Chicago would be agreeable to my returning to it at any time I desire to do so, prior to reaching retirement age, yet should I return to Chicago after a lapse of five years there would arise the question of how to spend the remaining time in a productive manner.

November 13, 1956.

MEMORANDUM RELATING TO  
CHEESE AND PUBLIC HEALTH.

It is almost certain that by adding to the diet sufficient quantity of unsaturated vegetable fats and including in the diet an adequate amount of proteins, minerals and vitamins to bring the total calories to a point where body weight is maintained, the incidents of coronary attacks in the population could be greatly reduced. It is estimated that within a year there will be nutrition experiments made on at least 10,000 persons in the U.S. who will be put on such a diet.

Thinking of the problem in its larger context we are, however, faced with the issue of how to add an adequate quantity of unsaturated fats to the diet without forcing people to change their dietary habits and without reducing the pleasure which they derive from eating.

I believe that it is possible to prepare almost any type of cheese at present commercially marketed with such unsaturated fats as soybean oil, cotton seed oil, corn oil or peanut oil substituted for the milk fats.

It may be assumed that within ten years almost everybody over 40 will want to include in his diet about 1/4 lb. of such cheese a day. If a sufficient quantity of this kind of cheese is added to the daily diet a large fraction of the protein requirement is met. Also if such a large amount of unsaturated oil has been added to the diet that the people are protected against effects of whatever additional animal fats they may consume. Therefore those who include 1/4 lb. of such "substituted" cheese

in their diet would be free to eat what else they please as long as they maintain their body weight below a certain - individually varying - limit.

It is proposed to set up the manufacture of such cheeses and to market them through a mail order house specializing in "substituted" cheese (which would have to be set up for the purpose). It should be possible to obtain an initial contract for the supply of such cheeses with the organizations which are <sup>now</sup> ~~not~~ being set up for the purpose of making dietary experiments on several thousand people with high vegetable fat diets.

If coronary attacks are made a reportable disease it should be possible to reach every person who has suffered a coronary attack and to offer him a supply of such therapeutic cheeses.

The initial manufacture of such cheeses might be undertaken by a non-profit corporation which would develop the method of producing such cheeses and which would market such cheeses in an experimental way at first and in a commercial way perhaps later. As long as the proceeds are used for research and development in the field of nutrition or other fields related to the public interest, the profit from the sale of such therapeutic cheeses may remain tax exempt.

An alternate possibility would be to take over some small dairy operation engaged in the manufacture of cheeses and to start an experimental manufacturing of therapeutic cheeses and distribute them through mail order. Advertisements might initially be placed in Scientific American, The New Yorker, Saturday Review and other such magazines whose readers may be assumed to be health conscious.