

April 18th, 1939

Dear Richards:-

It has now been decided to let the papers come out in the next issue of Physical Review, and I wanted you to be informed of this fact.

With kind regards,

yours,

(Leo Szilard)



(160 2311212)

LOUIS:

With kind regards  
informed of this fact  
I have written you to be  
before some one in the next issue of  
It has now been decided to let  
Dear Sir:-

*Public Opinion*  
*Magazine*

1933



July 9th, 1939

Dear Richards:

I tried to reach you at your home over the telephone, but you seemed to be away, and so I am sending this letter in the hope that it might be forwarded to you. You can best see the present state of affairs concerning our problems from a letter which I wrote to Mr. Strauss on July 3rd, a copy of which I am enclosing for your information and the information of your friends. Not until three days ago did I reach the conclusion that a large scale experiment ought to be started immediately and would have a good chance of success if we used about \$ 35,000 worth of material, about half of this sum representing uranium and the rest other ingredients. All of this material would remain unharmed and would be returned if the experiment failed. The possibility that the experiment will fail cannot be entirely excluded, but the experiment will decide once for all if a chain reaction can be made to work with the ingredients used in the proposed experiment.

I told Pegram about the situation and have also written to Fermi who is teaching at the summer course at Ann Arbor. He will have my letter on Monday 10th, and I hope to hear from him and that he will share my opinion.



I am rather anxious to push this experiment as fast as possible. At present I do not know just how quickly the Physics Department can move in this matter, and whether outside funds will be needed or not. Such outside funds, if required, could perhaps be used with a minimum of formality by making the experiment as a joint venture of the Physics Department and the Association for Scientific Collaboration, which is a taxfree non-profit association created for such purposes, and which has so far paid the rent for the radium we used etc. I would, of course, like to know whether there is a chance of getting outside funds if this is necessary to speed up the experiment, and if you have any opinion on the subject, please let me know.

If you think that a discussion of the matter would be of interest I shall of course be very pleased to take part in it. You could probably reach me at the King's Crown Hotel, with the exception of Wednesday, July 12th. Please let me know in any case where I can get hold of you over the telephone and your postal address.

Yours,

(Leo Szilard)



October 26th, 1939

Memorandum.

Part I.

Meeting of October 21st, 1939. Washington D.C.

by Leo Szilard.



## SUMMARY

Recent experimental work and calculations based on its results make it appear possible that in the immediate future a nuclear chain reaction might be set up under certain well specified conditions in a system composed of uranium and graphite. In view of this and other possibilities it seems desirable

1. that it should be made the responsibility of some person or persons to watch on behalf of the government the further development of this branch of research, so that the government should be at any time in the position of taking such action as it deems appropriate;

2. that some person or persons, who have the confidence of the government, should take upon themselves the task of furthering this branch of research, of insuring that it should not suffer from lack of facilities, and of preparing the grounds for experiments on a large scale, which might become necessary.

### Observation to the above.

The fairly large quantities of material, which might be required for performing large-scale experiments, might perhaps be secured, without drawing on existing funds, by enlisting the assistance of certain industrial firms in the U.S.A. and of the Union Minière du Haut Katanga. Most of the materials required are produced by large corporations who own uranium mines and would therefore directly benefit if the present development created a market for uranium. Some of these firms could be approached now with a view of obtaining the promise of their assistance.



THE POSSIBILITY OF A LARGE-SCALE EXPERIMENT  
IN THE IMMEDIATE FUTURE.

At present it appears quite possible that a nuclear chain reaction could be set up in a system composed of uranium oxide (or uranium metal) and graphite. The graphite would have to be piled up in a space of perhaps 4 x 4 x 4 metres and might weigh about 100 metric tons. Perhaps 10 ~~to~~ 20 tons of uranium oxide would have to be used, embedded in some such pile of graphite.

The probable success or failure of such large-scale experiment cannot be forecast at present with any degree of assurance. The properties of a system composed of uranium and graphite have been calculated independently, for a homogeneous mixture by Fermi, 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 that 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. In spite of these calculations, we cannot foretell with certainty whether or not a nuclear chain reaction can be maintained in such a system, because the absorption cross-section of carbon for slow neutrons is not sufficiently known.

In order to remove this uncertainty Fermi and I have devised two different experiments by means of which the absorption cross-section of carbon, which is very small, could be measured. It is assumed that one of these experiments, or both of them, will be



started at Columbia University as soon as the facilities required can be obtained.

If the absorption of carbon should turn out to be comparatively large we could conclude that the large-scale experiment is bound to fail, and in this case it need not be started. If the absorption of carbon should prove to be exceedingly small the large-scale experiment would appear to be very promising, and it can be assumed that everybody will then be in favor of starting it without delay.

Unfortunately, we must also be prepared to find an intermediate value for the carbon absorption. In this case a large-scale experiment will have to be performed in order to find out whether or not a nuclear chain reaction can be achieved with a combination of uranium and graphite. So we may have to make the experiment and risk its possible failure.

It should be borne in mind that a negative result of the large-scale experiment could also be of value by showing with certainty that a chain reaction cannot be achieved with simple means in the near future. Otherwise there remains an ever present potential threat arising out of experiments on uranium, which are carried out in certain other countries. Therefore, in my personal opinion, a large-scale experiment ought to be performed unless the possibility of its success can be excluded with reasonable assurance on the basis of experiments which are designed to determine the absorption of carbon, or other similar experiments which can be carried out on a moderately small scale.



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RECOMMENDATIONS CONCERNING LARGE-SCALE EXPERIMENTS.

No expenses need be incurred in connection with large-scale experiments until the absorption of carbon has been measured. On the other hand, steps ought to be taken now in order to prepare the ground for a large-scale experiment, so that this can be started with <sup>out</sup> delay at the proper time. For instance, the possibility of converting uranium oxide into uranium metal ought to be explored. An attempt ought to be made to obtain a promise on the part of certain industrial corporations to supply at the proper time the quantities of the materials which are required. If possible, these materials ought to be loaned without any financial consideration. Barring an accident in the case of a successful large-scale experiment, most of the materials used would remain unaffected and could be returned after the experiment is completed.

100 metric tons of graphite represent a value of about \$ 33,000 at the rate of \$ .15 per lb. If a purer brand of graphite has to be used, which rates at \$ .24 per lb., the value involved would be \$ 53,000.-

20 metric tons of uranium oxide represent a value of \$ 100,000 at the rate of \$ 2.50 per lb. If it need not be converted into uranium metal but can be used in the form of oxide in the large-scale experiment this material could be kept pure and could be returned undamaged. It would be desirable to have up to 50 tons of uranium oxide readily available for experiments in the United States.



STATEMENT CONCERNING THE POTENTIAL ASSISTANCE OF  
THE UNION MINIERE DU HAUT KATANGA.

It would be of particular value to enlist the assistance of this Belgian corporation which is to some extent controlled by the Belgian government. It appears to be the only corporation which could supply at short notice 20 metric tons of uranium oxide, and probably even 50 tons. I understand that the Managing Director, Mr. E. Sengier, is on a short visit in America.

From conversations which Professor G.B. Pegram of Columbia University had with a representative of the Eldorado Gold Mines, Ltd., it appears that this Canadian corporation might be able to supply uranium oxide for our purposes at the rate of 1 ton per week. If the uranium oxide were to be bought rather than obtained as a gift or a loan, it might be secured from Canada probably just as easily as from Belgium. On the other hand, the Canadian corporation is rather small and can hardly be asked to give away large quantities of material without financial compensation.

So far, radium up to 2.5 grams was used in our experiments, and we had to pay high rent to a subsidiary of the Union Minière, the only corporation from which large quantities of radium can be readily rented in this country. An attempt ought to be made to obtain radium for the purposes of experiments - like the proposed measurement of the carbon absorption - and other similar small-scale experiments - rent-free from the Union Minière in the future.

Carnotites containing uranium are mined in the U.S.A. among others by the U.S. Vanadium Corporation which is owned by the Union Carbon and Carbide Corporation. A conversation, which I recently had



with William F. Barrett, Vice-President of the corporation, did not encourage the hope of obtaining large quantities of uranium oxide from this firm, but the issue could perhaps be reopened.

STATEMENT ABOUT URANIUM ORE.

As far as I was able to find out, pitchblend, which is an ore rich in uranium, is mined in Czechoslovakia, Canada and Belgian Congo. The total content of uranium in the deposit in Czechoslovakia is estimated to be between 1000 and 1500 tons. The Canadian deposit visibly contains a total of 3000 tons. The amount of pitchblend in the Belgian Congo is not known, but it is believed to be very much larger. In the United States uranium occurs chiefly in the form of carnotites, which is an ore poor in uranium, and is mined for the sake of its vanadium content. The total deposit is estimated to contain 3000 tons of uranium oxide. (Perhaps there are in the United States larger quantities of ore containing a very small amount of uranium, which are not included in the above estimate.)

RECOMMENDATION CONCERNING URANIUM ORE.

Steps to secure a stock of uranium ores for the government can hardly be recommended at the present time if such steps would involve financial commitments on the part of the government. It might, however, be advisable to begin to study the question in what manner the government could secure such a stock at a later date, if required.

For instance, the question has been raised whether it might not be possible to obtain for the government a large quantity of pitchblend from Belgium as a token reparation payment. Such a transaction would not cause alarm abroad if it were arranged before the



world learns of the results of some successful large-scale experiment. The transaction could be justified without reference to the uranium content of the ore. Pitchblend is also the ore of radium, and action could be taken on the ground of securing the ore for the sake of its radium content, with a view of extracting the radium at some future date for medical purposes. Action taken on this ground alone might in fact be entirely justified.



out of B-17

November 2nd, 1939

Dear Richards:

Enclosed I am sending you a memorandum to be used for your personal information only, and a reprint. In the reprint I have marked the passage which concerns the question of a possible time delay in the emission of neutrons.

It seems advisable that we should talk about these things in greater detail before you take up the matter with a third person. You can reach me by telephone almost every day at about 9 a.m. If you call later and I am out, you can leave a message.

Yours,

(Leo Szilard)