2nd set
May, 1969

Additional Material for page 121 (third paragraph)

re: "I ENLISTED THE HELP OF H.C. UREY..."

"Third Approach to the Navy, May 1940"	from COMPTON MEMO Nov. 12, 1942
"Memorandum for Professor Urey" by L.S.	May 30, 1940
"Memorandum for Dr. Sachs" by L.S.	May 30, 1940

From Memo to Compton, Nov. 12, 1942 Bk. f. 8A. I (35)

Third Approach to the Navy, May 1940

The second meeting held under the chairmanship of Dr. Briggs on April 27, 1940, represented some progress, insofar as I was now requested to delay the publication of my papers, whereas, up until then, my request to the Physical Review to hold up the publication of my papers was an arbitrary action on my part, and was open to criticism on the part of some of my colleagues. No general recommendation to hold up the publication of dangerous papers was however made by the Uranium Committee. Enclosed is a copy of my letter to Physical Review.

Soon afterwards, Professor Turner in Princeton wrote a paper, which, if it were allowed to publish, would have drawn attention to the importance of element 94. Fortunately Turner showed his manuscript to Wigner, and, on his advice, sent me a copy, asking me whether I saw any objection to its publication. I wrote Turner that I have, in the meantime, approached Urey with the request of bringing about the general policy of withholding publication and asked Turner to delay the publication of his paper.

I suggested to Urey that some committee should be formed under his chairmanship to deal with the requirement of secrecy, and that this committee should include G. Breit, in order to secure the adherence of the Physical Review to the policy of secrecy which may be worked out.

In order to have government sanction for Urey's committee, I introduced Urey to Dr. Sachs, and asked Dr. Sachs to introduce Urey to Admiral Bowen, who, in the meantime, ~~took~~ took over the Naval Research Laboratory. Urey and Sachs visited Admiral Bowen, and Urey's appointment as the chairman of a committee followed.

The committee met under Urey's chairmanship in Washington on June 13, 1940. A general policy of withholding publication was formulated at this meeting in which G. Breit participated. Breit arranged with the Physical Review a practical method for establishing a sort of censorship in execution of the policy formulated at the meeting. After June 13, 1940 papers dealing with uranium were subject to "censorship".

I enclose copies of my letters to Turner and Breit, and a copy of Urey's letter to me, in which he reports on the result of his contact with Admiral Bowen. Urey's letter is a form letter sent with identical texts to some seven men, the members of one of the project committees.

Bk.f.8 (11)

May 30, 1940

MEMORANDUM for Professor Urey

1. Admiral Bowen suggested at a meeting held under the chairmanship of Dr. Briggs at the Bureau of Standards on April 27, 1940, that the scientists working on uranium should form sort of voluntary association and impose upon themselves such limitations concerning the publication of results as appears to be necessary.

While at the time, this suggestion was made it seemed to be difficult to get the cooperation of the majority of scientists the invasion of Holland and Belgium has brought about a change of attitude so that now we may hope to succeed if we act on the suggestion of Admiral Bowen.

It is proposed that a committee"for the"coordination of nuclear research" be formed under your chairmanship and that this committee formulate from time to time the policy which is to be adopted with regard to publication. If this committee were composed of yourself, Pegram, Wigner, Beams, Tuve, Teller, Fermi, and myself, it would be easy to meet once a month and to deal with all problems which may arise. For this reason no names have been included from the Middle-west or the West coast. Since, however, the Physical Sciences Division of the National Research Council has appointed a committee for the purpose of looking into the question of uranium and which consists of Beams, Breit, and Pegram, you might feel that you want to ask Breit to join the committee so that all members of the group representing the National Research Council should be included in your committee.

Your committee could have a sub-committee for unseparated uranium and a sub-committee for the separation of uranium isotopes. Fermi and I would be glad to act as secretaries to the sub-committee for unseparated uranium and I suppose you and Beams might be willing to act as secretaries for the sub-committee for the separation of uranium isotopes.

The scope of the committee could be enlarged immediately after its formation by including the non-governmental members of the Special Advisory

Committee which has been meeting under the chairmanship of Dr. Briggs. Those non-governmental members are Professor Pegram, Dr. Alexander Sachs, and Professor Albert Einstein. They, together with yourself, could then form the link between your committee and the goverment and could act as a nucleus for a board of trustees. Such a board of trustees will be required if funds are to be obtained or solicited from either governmental or private sources.

In order to be able to maintain the necessary secrecy and at the same time to preserve the possibility of free discussion among those scientists who wish to cooperate with each other, it is proposed that your committee after its formation, should draw up a list of names and that there should be free discussion among those who are included in this register. At the same time, an uncontrolled diffusion of information would be prevented by pledging all those [illegible] to be included in this register to refrain from discussing the subject of uranium with anyone else. New names could be added to the list from time to time in order to include all those who are trustworthy and who may wish actively to collaborate. Separate lists of names may be drawn up for the various branches of uranium research in accordance with the fact that the need for secrecy is greater for some branches than for others.

Requirement For Funds:

Fermi and I would desire to carry out a large scale experiment which would involve the use of about 100 tons of graphite and 10 to 20 tons of metallic uranium. Before actually placing orders for such an experiment which will involve considerable expenditure we propose to go through a preparatory stage involving an expenditure of $50,000. The successful completion of this preparatory stage would make it possible to carry out the large scale experiment in a comparatively short time

and with an increased assurance of success.

We are looking forward to obtaining from the Government the sum of $50,000. which is required for this preparatory stage. We feel, however, that a few weeks or months may pass before we will be actually in the position of making financial commitments on the basis of the expected action by the Government. Unless we are able to make such commitments within the next two weeks up to the amount of $15,000. we shall not be able to efficiently prepare the work which otherwise could be speedily carried out during the summer and during the next academic term. This means that we may lose four to six months of valuable time. If this amount could be obtained without delay from a private source, for instance, from the Carnegie Institute through Dr. Bush, it would represent a very great help at this juncture. It could be either refunded if and when Government facilities become available or it could be handed over to your committee earmarked for work on unseparated uranium and used for such expenditure as will not be provided for by the Government.

Of the required $15,000. about $12,000. might be taken up for assuring the collaborators whose help we need adequate salaries for a period of a year. We propose to keep the salaries somewhat higher than usual in order to compensate our collaborators for the damage which in their careers will suffer by their being prevented from publishing any papers.

While undoubtedly a fund of $25,000. would be preferable inasmuch as it would include an item of $7000. for buying materials such as uranium oxide and uranium metal in quantities required within the next six months and another item of $3,000. for building apparatus, we feel that if we could be sure right away that we can go ahead and make commitments on the basis of a budget of $15,000. this smaller sum would

be sufficient to bridge the gap provided that we receive a pledge by the Government concerning the budget of $50,000. by the end of September.

Bk.f.8 (30)

May 30, 1940

MEMORANDUM for Dr. Sachs

Please find enclosed memorandum for Dr. Urey of May 30, 1940.
In addition to the items included in the above-mentioned memorandum the following points seem to require attention.

a. It is important that Dr. Urey and the non-governmental members of the Special Advisory Committee be authorized to investigate whether there is a possibility of mining uranium ore in the Belgain Congo and transporting it to this country under the present conditions. If it is considered premature for the Government to buy any uranium ore perhaps some arrangement could be made with Dr. Sengier, the managing director of the Union Miniere who is at present in New York, or through the Belgian Government in exile that uranium ore be brought to the United States with the assistance of the United States Government, the Belgian company retaining the title of this ore but committing itself not to re-export it without special permission. It is impossible to know whether such and other alternative solutions are feasible, unless a preliminary inquiry is made, and it is not advisable to make such an inquiry without proper authorization.

b. It appears necessary that some experimentation be started at once by industrial firms who are willing to supply 10 to 20 tons of uranium metal at about six months notice. It is necessary that the non-governmental members of the Special Advisory Committee and Dr. Urey should be in a position of approaching industrial firms on this subject and should feel authorized to do so.

c. It would be desirable that Dr. Urey and the non-governmental members of the Special Advisory Committee should form the nucleus for a board of trustees and work out the ~~standards~~ statutes for some

for some non-profit organization which would act as a link ~~as far as the physicists in the universities are concerned form the link~~ between the Government and the university laboratories. If such an organization were formed the physicists ought to be encouraged to take out patents for their inventions which would be assigned either to this non-profit organization or direct to the Government. In any case the Government would thus be safeguarded against having to pay royalties for the use of such inventions, which otherwise might be patented by industrial firms whose research employees begin to show increasing interest in this field of development.

In this connection the question has to be raised whether it is possible to keep such patents secret. In order to do so in an adequate way it might be advisable to modify the present law if necessary. Such a modification of the present law ought of course not to be made exclusively with a view to inventions concerning chain reactions but also with a view to all inventions which have important applications in national defense. The physicists and engineers ought not to be deprived of the stimulus arising out of the possibility of patenting their inventions and at the same time collaborating with the Government in the effort to keep certain of these inventions secret.

Additional Material for page 121 (fourth paragraph) (continued)

"Memorandum Report on Proposed Experiments with Uranium" Aug. 14, 1940
[by Pegram] 18 pp. Marked "Copy."

"Excerpt from bottom of p.6 to bottom of p.8" Marked in Szilard's hand: "Pegrams Memo dated Aug. 14. 1940. Exhib. D."
Includes the sentence: "After full discussion, the recommendation of the group to the Uranium Committee was that funds should be sought to support research on the uranium-carbon experiment."
Only a very few documents have been marked by Szilard as "Exhibit." We don't know for what presentation they were prepared, but they show fundamental contributions.

2nd set
May, 1969

Additional Material for page 121 (fourth paragraph)

re: MEETING OF THE URANIUM GROUP IN WASHINGTON ON JUNE 13th, 1940 AND ITS RESULTS:

1)Recommendations for going forward with the uranium-carbon system.
2) The search for uranium supplies.
3) General policy of withholding information.

Letter, Lyman J. Briggs to L.S. June 7, 1940
Invitation to meeting.

Form letter, Urey to L.S. June 7, 1940
Invitation, with detailed organization of Advisory Committee on Nuclear Research.

Letter, Pegram to Admiral H.G. Bowen (5 pp.) June 19, 1940
Recommends: Going forward with isotope separation (Urey's group)
Survey of nuclear constants of uranium & carbon } (Fermi-Szilard group)
Intermediate scale experiment, U-C system }

Letter, L.S. to Fermi (Not Sent) June 19, 1940
Szilard urges the semi-large scale experiment. He then discusses in detail his relations with Fermi and Pegram at Columbia. He evidently decided against putting this much in writing, and in the letter actually sent (July 4, 1940) is more general on this matter.

Letter, Gregory Breit to L.S. June 20, 1940
Recommends intermediate scale experiment.

Letter, L.S. to Fermi. July 4, 1940
See note above on letter to Fermi of June 19th.
Szilard summarizes events following the uranium group meeting.

Letter, L.S. replies to Breit. July 6, 1940

Letter, L.S. to Wigner July 6, 1940
Encloses letter, Polanyi to L.S. June 18, 1940

Letter, Fermi to L.S. July 9, 1940

Letter, L.S. to Gustav LeChien of Radium Chemical Co. July 10, 1940
Szilard wants information on uranium supplies "for submission to colleagues of the Committee and coordinating authorities." He finally succeeds in working through official channels, rather than personally.

(see next page)

Bk.f. 8. (4)

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON

ADDRESS REPLY TO
NATIONAL BUREAU OF STANDARDS

IN YOUR REPLY
REFER TO FILE

LJB:DEK

June 7, 1940

D

Dr. Leo Szilard,
Columbia University,
New York, N. Y.

Dear Dr. Szilard:

I should like very much to have you accept membership on an advisory committee on nuclear physics to guide the Government in supporting necessary work in this field. This Committee is being organized under the leadership of Prof. Urey and the first meeting is being called at the National Bureau of Standards on Thursday morning, June 13th, in the South Building Conference Room at nine o'clock. The members of the Committee are Messrs. Urey, Breit, Pegram, Tuve, Fermi, Szilard, Wigner and Teller.

Please use the enclosed transportation request in securing your railroad and Pullman tickets. A subsistence allowance of $5.00 per diem will be made for the time you are absent from your official station.

I shall greatly appreciate your cooperation in this matter.

Sincerely yours,

Lyman J. Briggs, Director.

Bk. f. 8 (32)

Columbia University
in the City of New York
DEPARTMENT OF CHEMISTRY

June 7, 1940

Dr. Leo Szilard
Pupin Laboratories

Dear Dr. Szilard:

At the suggestion of Admiral Bowen, and with the approval and suggestions of Dr. Briggs, I have been organizing a committee to be called the "Advisory Committee on Nuclear Research." This is to be an advisory committee to the President's Committee on Uranium, which consists of Drs. Briggs, Pegram, Sachs and Einstein. The committee as suggested at present has been chosen from among easterners in order to decrease the expense of meetings and to permit more frequent conferences. It is proposed that the committee shall consist of the following:

H. C. Urey, Chairman
M. A. Tuve
G. Breit
G. B. Pegram
E. Fermi
L. Szilard
E. P. Wigner
E. Teller

In the second place, another advisory committee on the separation of uranium isotopes has been proposed, to consist of the following men:

H. C. Urey, Chairman
J. W. Beams
R. Gunn
E. Fermi
G. B. Kistiakowsky

My colleagues here have been responsible for working me into the position of chairman of both committees. I do not know that I am the best man, but at least I am near to the center of work in this field and have the virtue of

being an American citizen, which is probably advisable in this case.

We should like to have you serve on the first committee, for we believe that your advice on problems dealing with uranium fission would be valuable. It is proposed that the first committee shall have its first meeting next Thursday, the 13th, in Washington, at the Bureau of Standards at 9 A. M., and I hope very much that you will be there and be prepared to discuss these problems.

We should like to keep the existence of these committees a relatively little publicized matter for one of our objectives is to prevent the dissemination of too much discussion of points which might have military value and if the committees are not known to exist there will be less inquiry about them.

Hoping to see you in Washington.

Sincerely yours,

Harold C. Urey

Harold C. Urey

June 19, 1940

Rear Admiral H. G. Bowen
United States Navy
Naval Research Laboratory
Anacostia Station
Washington, D. C.

Dear Admiral Bowen:

In response to your letter of June 13 the following is submitted:

I. ISOTOPE SEPARATION EXPERIMENTS--CENTRIFUGAL METHOD

Professor Urey has been away from New York since we were in Washington last week. On receipt of your letter Saturday I conferred with Professor Karrelitz, and he saw no reason for any change in the figures that I gave you on June 12 as tentative figures for the centrifugal separation experiment to be done here under Professor Urey's direction. The procedure you suggested as to a proposal under which these experiments could be carried out, namely: that it be a proposal from Columbia University or from the Department of Chemistry of Columbia University to the Naval Research Laboratory to carry out certain experiments and report results; that the Naval Research Laboratory would probably prefer to employ the personnel directly on recommendation of Professor Urey; that the Naval Research Laboratory would probably prefer to provide all larger items of equipment that need to be purchased; that only minor items of unavoidable miscellaneous expenses should be put into the sum ~~set~~ to be paid to the Department of Chemistry; and in general that the whole proposal be as detailed as possible.

In the absence of Professor Urey, Professor Karelitz has already written out in considerable detail the proposal as to the mechanical part of the apparatus. Professor Urey will have that on his return to New York tomorrow and can start at once to work out a proposal. The overall figures as they stand at present for these centrifugal experiments are:

Personnel	$17,400
Laboratory space, preparation of	2,000
Equipment	10,300
Total	$19,700

II. THE FERMI-SZILARD EXPERIMENTS AT COLUMBIA

A. Experiments to determine more accurately the fundamental physical constants of uranium and carbon that bear upon the chain reaction.

In our memorandum of May 9, 1940, it was proposed to perform certain experiments that might be completed within twelve months and were estimated to cost $12,000 for salaries of physicists and $18,000 for apparatus plus the cost of purchasing or renting one gram of radium mixed with beryllium.

Since May 9 there has been much more thought and discussion given to the problem. The scientific committee appointed by Dr. Briggs spent five hours in discussion of the subject in Washington last Thursday. Since my return I have spent all the time I could in further discussion with Fermi and Szilard. It appears that it will require very careful and tedious measurement by any experimental means that have as yet been designed to evaluate the physical constants involved with enough accuracy to enable a valid calculation to be made of the amounts of uranium and carbon that will be needed in order to sustain a chain reaction. Indeed by measuring the constants separately, using relatively small amounts of materials, it will be difficult to prove definitely that the chain reaction can be made to go, and still more difficult to prove that it cannot be made to go. Our present estimate on a series of seven experiments now runs the figures up to the following estimate:

6 physicists' salaries	$18,000
Equipment and supplies	12,000
One gram of radium mixed with beryllium	25,000
Uranium oxide, two to four tons	10,000 to $20,000

(The owners of uranium oxide ought to let it be used free of charge for these experiments.)

Rental of two grams of radium in order to expedite work by using strong sources, possibly $3,000
(Again the producers of radium ought to furnish this free of charge or at a nominal rate for these experiments.)
Four tons of graphite . . . . . 2,000 ?

B. An intermediate experiment.

The idea has been developing that an intermediate experiment on a scale larger than experiments under A preceding, but not large enough to give a chain reaction, could probably be used to obtain measurements bearing directly upon the chain reaction and the amount of material to be used to maintain such a reaction, and that this would in a sense be a method of short-circuiting, so to speak, some of the tedious experiments for measuring the constants of uranium. In its conference last Thursday, the scientific committee came to the conclusion that it would recommend that an experiment be done right away using not less than one-fifth of the material that would be estimated as necessary for maintaining a chain reaction.

The materials needed for such an intermediate experiment would be:

50 to 100 tons of graphite . . . . . $25,000 to $50,000
5 to 10 tons of uranium metal at $8.00 a lb. . . . . $80,000 to 160,000

The figures just given are doubtless too high. The carbon has been figured at $500 a ton, the rate paid for the graphite we have at present. It can probably easily be obtained for $400 a ton or less. The figure of $8.00 a lb. for metallic uranium is the lower figure given here last week by Mr. Alexander, who thought that in ton lots it would not be difficult to furnish metallic uranium at $15.00 to $12.00 a lb., or possibly $8.00. Chemical opinion seems to be that it ought to be possible to purchase uranium at $5.00 a lb., but perhaps that is a little too optimistic.

It is believed that this intermediate experiment which would be on the way of the final experiment might well furnish results that would make feasible a fairly accurate calculation of the amount of uranium and carbon necessary to sustain the chain reaction. The same materials could, of course, be used as far as they would go in setting up the final experiment.

If the intermediate experiment is to be done the question will arise as to whether it would be better to do it here or to do it in some place where it can be more carefully guarded.

C. The full scale experiment.

The estimate on the materials required for this is still fairly indefinite. Probably an outside estimate would be to say:

800 tons of graphite	$100,000
25 tons of uranium metal	400,000
Other expenses difficult to estimate but small by comparison with the main items	

These figures, of course, are pretty large, but it must be remembered in the first place that the material will certainly be by no means worthless, even if the experiment failed of its object and that further knowledge may indicate that a considerably smaller amount of material would suffice for the chain reaction.

- - - - - - -

I hope that the above will be sufficient to answer your immediate purposes. We shall work on a more detailed statement and send it to you as soon as we can. It is necessary for me to be at the meeting of the Physical Society in Pittsburgh tomorrow and Friday. Fermi left Monday night to keep a long standing engagement of a month at the University of Chicago, and we shall need to exchange correspondence with him before putting in a definitive proposal.

I am sorry that I did not make it clear that I was referring to uranium metal in saying that it would be procurable at $12.00 to $15.00 a lb. Fortunately the price of uranium oxide is only about $2.50 a lb.

In closing let me say that there has been one very hopeful development about which I shall not attempt to write now but which we shall be glad to explain to you at an early opportunity.

Very sincerely yours,

George B. Pegram

GBP:Z

Bk f. 8AI (7)

Not sent

420 West 116th Street
New York City
June 19, 1940

Dear Fermi:

I saw Professor Pegram yesterday and discussed with him the situation. He had a letter from Admiral Bowen which he wanted to answer right away.

I told Professor Pegram that in my personal opinion the semi large scale experiment for which you have suggested using 5 tons of uranium metal aught to have the right of way before everything else and that we should not hesitate to place an order for this amount of metal; and perhaps as much as 50 tons of graphite. I have no doubt that this material will be needed in any case and will have to be ordered sooner or later. Clearly, it will be impossible for us to say with certainty even if we succeed in measuring all nuclear constants involved rather accurately within a year that a chain reaction with slow neutrons can not be made to work. Consequently, if we defer ordering this material we would only lose time but not save any money.

Since it is conceivable that 10 tons of uranium metal and perhaps 100 tons of graphite might be sufficient to make a chain reaction work, the ordering of such amounts should also be taken under consideration. Finally, 200 tons of graphite and perhaps 25 tons of uranium metal would give us all the scope for a large scale experiment which we might desire to have.

Assuming that an order will be placed for perhaps 5 tons of uranium metal and 50 tons of graphite we would consider the performance of

a semi large scale experiment(which can not be expected to give a divergent chain reaction)as our most important task; but while waiting for the arrival of this material and in our spare time we would gradually organize the measurement of all nuclear constants involved. While it is impossible to say how long such a survey of the nuclear constants would take it is possible to estimate the cost as amounting to about $50,000. The men who would carry out this survey would be also available for the performance of the semi large scale experiment and the preparation of a large scale experiment so that these experiments would not require additional salaries and the expenditure involved would be mainly the cost of material and perhaps some expenditure for manual labor and apparatus. As to the survey of the nuclear constants for which an expenditure of $50,000. has been envisaged, it seems to me that such a survey has to be carried out whether the semi large scale exp riment shows a favorable result or not. Clearly, if the semi large scale experiment has a negative result we must know the value of the nuclear constants in order to be able to determine the optimum conditions for a chain reaction and the knowledge of these optimum conditions is even more important and an urgent necessity if the semi large scale experiment has a positive result.

Enclosed you will find an estimate for the survey of the nuclear constants; the experiments which will actually be carried out may be different from those which we are at present envisaging since in the meantime we might be able, perhaps, to think of imporved methods, but I do not believe that such changes will greatly affect the total expenditure.

While discussing with Professor Pegram, it became evident that it will be necessary to define my own status with respect to the work

on the uranium chain reaction in such a way that all those who are immediately concerned with this work should have the same conception of it. Otherwise, difficulties might arise later. I told Professor Pegram that I explained my conception of this status to you early in March of this year and again a few days ago just before you left for Chicago and that I had the impression that you accepted this conception. However, our conversation referred to the work on making a chain reaction work in general and not any details of the work to be carried out within the Physics Department in particular, concerning which you would, of course, not want to make any commitments. Moreover, I realize that I may have misinterpreted your attitude and that it is preferable that this point should be rediscussed both with Pegram and Urey.

In the conversation which I had with Professor Pegram I defined my conception in general terms saying that you and I would, according to this conception, jointly be responsible for the task of taking all necessary steps to make a chain reaction with slow neutrons work if it can be made to work at all. This means that all experiments would be carried out under joint direction with such division of labor as appears expedient to us. In practice, this may lead to some overlapping of work, insofar as you may prefer one method for measuring some important nuclear value and I might prefer another method. I would not consider such overlapping a disadvantage, in particular since, if we are unable to agree on a single method to use, then, in all probability, none of the proposed methods are entire satisfactory and accordingly, a cross checking is desirable.

In practice, this would mean that, while we may carry out jointly certain experiments there will be other experiments for which you, and again other experiments for which I will have to bear the responsi bility.

Correspondingly, probably some of those who collaborate with us will primarily work with you and others primarily with me, but I do not see any reason for any rigid coordination of collaborators to either of us. The question arose in the conversation with Professor Pegram what to do if we two should be unable to agree on some such thing as the method of carrying out a large scale experiment; i.e. an experiment which is so expensive that we can not afford to have an overlapping. In my opinion, in such a case, we would have to appeal to a small group of scientists composed of men who, in the opinion of both of us, are capable of balanced judgment and we would have to abide by the verdict to which they arrived, after having carefully studied the issue. I hardly think that such a disagreement between us is likely to arise but the question raised by Pegram may serve as an example to illustrate a certain spirit which I would be glad to see uniformly recognised by all those concerned. It seems to me that one may say the following in order to enter into the merits of the case. It is probably a fair statement to make that if we had separated in April last year and worked independently of each other on this problem both of us would have been quite capable, if given the necessary facilities, of making a chain reaction work by now, provided it can be made to work using an element like carbon. For us to work jointly in this matter has both its advantages and disadvantages and we may at this juncture leave the question open whether the advantages outweigh the disadvantages from the point of view of obtaining speedy results. We may leave this question open because I feel that we are not as free to decide this issue as we have been, in April of last year or even in March of this year. I should certainly feel at a loss to know what to do if it proved impossible now

to find a satisfactory arrangement. However, I feel that if I allowed myself to be influenced by this fact into accepting an arrangement which I would inwardly, rightly or wrongly, not consider as fair and just in the circumstances, this would put a strain on our collaboration. I think it would be useful if you defined your attitude in this matter in a letter addressed to Professor Pegram; and if you would be kind enough to send me a copy I would show it to Urey and perhaps to others who have a legitimate interest.

A program of work of the scope which is at present envisaged would, (if all the work is carried out in the Physics Department at Columbia) no doubt, strain the department to some extent and represent a not negligible encroachment upon the available space and other facilities of the department. The strain is perhaps somewhat lessened by the fact that the number of our collaborators would increase only very gradually since both you and I realize that it will be a slow process to find the right collaborators and neither of us has the desire to rush into a large number of new experiments simultaneously. Nevertheless, if it becomes certain that in addition to these limitations there are other limitations within the Physics Department which make it impossible to carry out the proposed survey within a year, then it seems to me it is our duty to see if some of the experiments can not be started in some other laboratory either under the supervision of one of us or under the supervision of somebody else whose judgment can be trusted. This is a point which I think ought to be carefully considered upon your return in connection with a list of experiments which may be set forth in detail.

Yours sincerely,

(Leo Szilard)

Bk f. 8A

THE UNIVERSITY OF WISCONSIN
MADISON

DEPARTMENT OF PHYSICS

June 20, 1940.

Dr. Leo Szilard
Department of Physics
Columbia University
New York City

Dear Szilard:

I should like to thank you for the many discussions we have had in New York and for your hospitality. It seems to me that matters would be helped along very much if the intermediate experiment could be performed and if the set up could be kept flexible. My impression is that in work of this type practical success in a limited time may depend considerably on detailed planning regarding the ease of assembley and flexibility. I still think that more rapid progress will be achieved by arranging an intermediate or full scale experiment rather than by careful measurement.

Sincerely yours,

Gregory Breit

G. Breit

Bk. f, 8A I (2)

420 West 116th Street
New York City
July 4, 1940

Dear Fermi:

I think I ought to write you about the following events which took place after you left:

1. Lawson, after carefully consideration, decided that he would prefer to go to the University of Pennsylvania next fall as previously arranged. Since I told him that I would try to get a salary of $3000. per year for him, his decision was not due to a lack of financial inducement.

2. Wigner told me during the last meeting which we jointly attended in Washington that he intends to withdraw from further cooperation with the Government representatives on the subject of uranium. At my request he refrained from saying anything about this during the meeting but I understand that he wrote a letter to this effect a few days later to Urey and Briggs. I do not think that we ought to worry unduly about this since I am sure that if a proper frame-work is eventually created for carrying out work on uranium it will be possible to get Wigner's cooperation. For the present though his resignation is one of several disturbing elements.

3. Bowen has shifted his grounds insofar as he now prefers to give the university a lump sum rather than pay salaries and everything else as much as possible directly to the recipient. Moreover, according to the present plans, Bowen will support isotopic separation rather than the work we contemplated and our project is supposed to receive support through another Government committee which is headed by Bush. I assume that Professor Pegram will write you about this in greater detail so I need not go into this for the present.

4. I compiled an estimate of cost for a complete survey of the nuclear constants involved which you will find enclosed. Though the experiments eventually carried out may be very different from those which I have listed the changes will hardly affect the conclusion that about $50,000. will have to be spent by the time the survey is carried out. I believe that you share my opinion that such a survey has to be carried out whether or not the intermediate experiment shows a positive result. According to present plans, $90,000. would be requested for buying materials for the intermediate experiment and I believe our policy should be to give the intermediate experiment the right of way before the general survey of nuclear constants. I feel that this will be a somewhat academic statement since we may have to wait for quite a long time before we get materials for the intermediate experiment.

5. Enclosed you will find a copy of a letter which I sent to Gunn which speaks for itself.

6. Sachs and Urey saw the Belgians. From what Sachs tells me we have probably "missed the bus" as far as Belgian ore is concerned. As far as uranium oxide is concerned he has the impression that the Belgians will treat it merely as a business matter andif they are not handled skillfully they will charge an exaggerated price for the amounts which we need for the large scale experiment. In these circumstaces, it appears essential to find out from the Canadians just how much they are able to do for us and Professor Pegram is look ng after this end of the matter.

7. During the last fortnight I was considerable worried by doubts oncerning the possibility of realizing my conception of our collaboration within the frame-work of the Physics Department. Having discussed with you my conception of our proposed collaboration quite extensively in March and also shortly before you left for Chicago I considered this point settled and it was not my intention to raise in this connection any questions of principle. However, it so happened that the question came up more or less accidentally in a conversation with Professor Pegram and was raised by him rather than by me.

Having explained to Professor Pegram what I had previously explained to you I believe he has now a clear picture of the stand which I propose to take with regard to the question of principle which is involved. At first I thought that we might leave the matter open until your return though this did not appear necessary since there are no questions of detail which will require being discussed. On further consideration I feel that it may be better to ask Professor Pegram to take any decision which may be required in this matter as soon as possible, and no doubt he will want to consult you before doing so. You may therefore expect to hear from him in the course of the next few days in this connection.

With kind regards.

Yours,

L. Sz.

(Leo Szilard)

Bk. f 7

420 West 116th Street
New York City
July 6, 1940

Dear Breit,

Many thanks for your letter. Following the conversation we had on our way from Washington to New York. I have given some thought to the issue mentioned in your letter and I am now entirely convinced to your point of view. Consequently, I am taking a strong stand in favor of an experiment on as large a scale as possible. This large scale experiment, or some intermediate experiment, operating with at least five tons of uranium ought to have the right-of-way before the general survey of the neuclei values involved. Nevertheless, this general survey will also have to be carried out.

There is another point about which I became converted to your opinion. I now think that steps should be taken to prevent certain publications in Nature and the Proceedings of the Royal Society of London. With the collapse of France there is an immediate danger that Joliot and his co-workers will start publishing something of their previous work in these periodicals.

On the other hand I feel even more strongly than before that your attempt to prevent publication will break down unless we create a satisfactory substitute in the form of some private publication. If that is not done there will be a growing tendency towards indulgence and finally practically everything will be published as it has been in the past. I wonder whether you have given the matter further thought since your return to Madison.

With kindest regards.

Yours,

(Leo Szilard)

Bk. f 8

420 West 116th Street
New York City
July 6, 1940

Professor E. Wigner
c/o Physics Department
University of Michigan
Ann Arbor, Michigan

Dear Wigner:

I am end osing a letter which I just had from Polanyi and which does not sound very cheerful. I am embarassed about answering his question since I believe that no information should be sent abroad. However, I shall perhaps try to write up something and give it to Urey with the request of passing it on if Urey is willing to take the responsibility.

I now believe that your resignation was exactly the right thing to do and that it will have some beneficial effect. Urey did not understand your letter but Briggs did. I hope that eventually some framework will be set up for the work on uranium and that I shall then be in the position of persuading you to collaborate, but for the time being there is an increasing amount of confusion and a constant change of the personnel of committees concerning uranium and a growing dissatisfaction on my part as well as on the part of Sachs. I almost reahhdd the point of following your example. I had a growing suspicion during the last fortnight that Pegram's conception concerning the role which I am going to play in the work is very far from my own conception. Finally I decided to explain to him the stand which I propose to take in connection with the principle which is involved and ask him to take any decision which may be required in this connection as soon as possible. Naturally he will consult Fermi before doing so. I am writing you on this in order to keep you informed but I do not think that you ought to intervene in any way. Sachs is very much aroused by the way in which matters are treated in Washington on the part of Briggs and for the present I have to restrain him from taking the matter up with the White House. As far as Wheeler is concerned I do not think that Breit or you need to worry about this aspect for the present. I am keeping him constantly in mind and I believe I can convince Pegram very soon that only part of the necessary experiments can be done at Columbia and that a collaboration with other universities is essential. I am enclosing a copy of a letter I wrote to Wheeler some time ago to show you the line which I am taking in the meantime.

I shall be very glad to see Dr. Torda if I hear from her.

Yours,

(Leo Szilard)

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THE UNIVERSITY OF MANCHESTER.
DEPARTMENT OF CHEMISTRY

FROM
PROFESSOR M. POLANYI

TELEPHONE: ARDWICK 2681.

June 18th 1940.

Dear Szilard,

I am interested at the moment in devising a method for the purification of the light isotope of uranium. I know that this is a subject on which a large number of workers are engaged and in order not to waste my time I would like to ask you to help me. I would like to know how far the work has been carried out already in the United States and which is considered there to be the most promising line of attack. I believe that the centrifugal method in the form of a fractionation column, as suggested by Urey, is the most hopeful, but I have no experimental experience of anything of the kind and in consequence do not trust my estimate very much. The method of Clusius seems also capable of development to a practicable degree but again I feel uncertain about this possibility.

This letter written by anyone but myself to anyone but yourself would seem very silly but in view of our old friendship you will understand the sort of advice I need in this matter. My only trouble is your unwillingness to write letters but may I please assure you that this may be really important, both to me and to my collaborators in the Physics Department here.

We are not in high spirits here at the moment but are sufficiently composed to carry on with work even though it may not be of immediate utility for the war but, of course, all other interests are almost completely effaced. I hope that I may yet see you and Wigner again and would be grateful to receive a letter from either of you.

Yours ever,

Michael Polanyi

Dr.Leo Szilard,
Pupin Physics Laboratories,
Columbia University,
NEW YORK.

Bk f. 8A I ④

Chicago July 9 1940

Dear Szilard:

thank you for your letter of July 4.

1: Lawson – I am sorry that he cannot stay with us, but I dont think that we can do anything about it.

2: Wigner – I can perfectly well see the reasons of his withdrawing from the collaboration. And I am sure that if and when we shall need his help he will be willing to help.

3: I am waiting to know more about this point. But perhaps the proposed arrangement might work better.

4: The experiments that you suggest will certainly cost a sum of the order of magnitude that you suggest; my impression is that your estimate is some what too large (not very much); but

it depends of course to a large extent on what program is carried out. I share your view that we shall have plenty of time for this part of the program, no matter whether we whish it or not.

5: I read your letter to Gunn and I agree with it entirely.

6: I had for a long time the impression that we could not expect much cooperation from the Belgians. I hope that the Canadians will appreciate the situation somewhat better.

7: I think that a frank explanation between Pegrane and yourself would be very desirable. This would be helped, however, if you could express in a clear way what you consider as a satisfactory arrangement. This, however might be difficult. I expect to hear

from Pegram about this matter.

I had a very extensive discussion of all the situation with Teller, who stopped in Chicago on his way to the mountains.

Yours sincerely

E. Fermi

Bk. f. 8 (2)

July 10, 1940

Dear Mr. Le Chien:

In furtherance of our telephone conversation, in the wake of the enlightening conference that Senator Grey and I had with you on June 21st, I should like to make more precise the two sets of questions on which we should like an answer for submission to colleagues of the Committee and coordinating authorities:

The first set is concerned with uranium oxide as distinguished from the ore, and the quantities are an initial amount of, say, ten tons, with an option on another forty, to be taken up within the fiscal year. I take it that the present commercial price would apply to the total quantity.

The second set of questions is concerned with the importation of uranium ore from the Belgian Congo, on condition that transportation and storage charges are paid, in exchange for an undertaking not to re-export without permission and the right of the potential buyer to take up to the total amount thus imported. This, presumably, will require your setting forth and reaching an understanding as to the conditions and as to the prices for varying amounts of the thus optioned imports and the terms of renewal of the imported ore that may not be taken up within specified initial periods.

In connection with the available 1,000 tons of 65%-pure ore to be thus imported, questions will be put to us on which further light and information from you would be of great help, namely: (1) the arrangements that we understand you are planning to make for smelting in this country as against the former Belgian arrangement, and (2) potential output and product comparisons with Canada. Finally, while remote, a question may also arise as to what further quantities of ore on a monthly or quarterly basis could be mined in the Congo for inclusion in a supplementary arrangement.

With kind regards,

Yours sincerely,

Mr. Gustav Le Chien,
Radium Chemical Company,
570 Lexington Avenue,
New York City.

Bk. f. 8A I (12)

Pegram's Memo (K.W.)

14 August, 1940

MEMORANDUM REPORT

ON PROPOSED EXPERIMENTS WITH URANIUM

Objective of the Experiment

To get, if possible, energy from uranium through nuclear fission by means of a self-sustaining nuclear reaction without the necessity of separating the uranium isotopes. Such reaction would supply:

(1) Power - through heat developed in the reaction and utilized by means of a heat engine, e.g., a steam turbine;

(2) Neutrons in large amount usable for

(a) Production of artificial radioactive substances;

(b) Biological and therapeutic uses.

Primarily the reaction would involve only the uranium 235 isotope which constitutes about 1/140th part of ordinary uranium, most of the rest being uranium 238. By a secondary reaction uranium 238 will also become involved and there is a good possibility that part, at least, of the uranium 238 can be made to contribute to the fission with very obvious advantages.

Stages of the Research

Immediately upon the discovery, early in 1939, in Europe and in this country of the large amount of energy liberated in the fission of uranium nuclei after capturing neutrons, it became conceivable that if, as seemed plausible, a sufficient number of free neutrons are released in the splitting of a uranium nucleus,

the new supply of neutrons from fissions might be picked up by other uranium nuclei causing new fissions, and so on cumulatively, or in a so-called "chain reaction". The release of energy in such nuclei reactions could be enormous since the energy released per atom of uranium is about 200 million electron volts, while the energy of the strongest chemical union is only about five electron volts per atom of one of the substances combining.

It was soon realized that in ordinary uranium there are two different types of fission, (a) fission upon capture of a neutron with negligible kinetic energy (slow neutron capture) and (b) fission on entrance of a high energy neutron into the uranium nucleus (fast neutron capture). It is with fission of the first type of "slow neutron capture" that these proposed experiments have to do. It was surmised by Bohr and Wheeler and others, and proven early this year by Nier, Booth, Dunning and Grosse that it is the uranium isotope of atomic weight 235 present to the extent of only about one part in one hundred forty in ordinary uranium which gives fissions upon capture of slow neutrons. Nearly all of ordinary uranium is uranium 238, which gives fission only when hit by fast neutrons having energy of the order of one million electron volts.

The general arrangement to obtain slow neutron chain reaction would be to have uranium 235 distributed through a mass of some substance that would slow down the neutrons shaken off in a fission, which neutrons are of pretty high speed when first emitted so that they would stand a good chance of being captured by uranium 235 before traveling too far

away or entirely out of reach of the uranium 235. Ordinarily hydrogen is the best substance with which to slow down neutrons, but if ordinary uranium even in pure metallic form were mixed with a hydrogen compound such as water as a slowing-down agent a chain reaction could not result, for hydrogen has a rather large capture cross-section for slow neutrons and the uranium 238 present has a high cross-section for neutrons of about ten electron volts energy, and would capture a large number of neutrons before they got slowed down to normal slow-neutron velocity, corresponding to about 1/40th of an electron volt. On the other hand the uranium 235 isotope, if it could be separated in sufficient quantity, should, when mixed with water, sustain a chain reaction if the mass used is made large enough.

The factors that are favorable for a chain reaction are (1) an average number of neutrons emitted in one fission considerably greater than one, so that after allowing for the capture of neutrons by the slowing down material and other substances present there would be more than one neutron free to bring about, in turn, the fission of another nucleus; (2) a sufficiently low probability of capture of neutrons by any uranium isotope present in a way that does not produce fission; (3) the slowing down material to bring the neutrons emitted in fission down to normal molecular speed in a short distance - the shorter this distance the smaller the volume of the mixture that would be required for a chain reaction if otherwise possible; (4) a low probability of capture (small capture cross-section) of neutrons, slow or fast, in the slowing-down material; (5) a sufficient mass of uranium

and slowing-down material to make the peripheral escape of neutrons relatively small, and an appropriate geometrical distribution of the uranium in the slowing-down material; (6) a high probability of capture of slow neutrons (large fission cross-section) of the uranium 235; (7) the absence of materials other than the necessary uranium and the slowing-down material, since other materials would capture some neutrons.

Professor E. Fermi[1] and Dr. Leo Szilard[2] at Columbia University

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1. Enrico Fermi, formerly professor in the University of Rome, since 1938 professor of physics in Columbia University.

2. Leo Szilard, a native of Hungary by birth, who had resided in Vienna, in Berlin, and latterly, until the fall of 1938, at Oxford University in England, since early in 1939 a research guest in the Department of Physics, Columbia University.

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in the summer of 1939 came to the conclusion that it might be possible to obtain the desired chain reaction by the use of metallic uranium (ordinary uranium containing both U_{235} and U_{238}) with carbon in dense graphite form as the slowing-down material. At that time knowledge of the nuclear properties of uranium and carbon was quite inadequate to support any sound prediction as to the possibility of obtaining a chain reaction by the use of uranium and carbon. Measurements of the number of neutrons released per fission had been made at Columbia University and in Paris

without close agreement and without much precision in either case. No reliable measurements had been made of the capture cross-section of carbon for slow neutrons. Additional measurements were required. It was realized that better measurements of the factors involved might give a definitely negative answer as to the possibility of a chain reaction, they might give a definitely positive answer, or the results might still have so large a margin of error that they would give no definite answer, in which case they would probably give valuable information on which to design further experiments to test the possibility of the chain reaction. It was believed that the possibility of achieving the release of nuclear energy from uranium was large enough to justify the expenditure of a considerable sum of money on further research, and that because of the possible military significance of uranium energy, the Federal Government would be quite justified in supporting such research.

The first approach to government officials on this subject was made in March, 1939, when, through arrangements made by Prof. George B. Pegram of Columbia University, with the office of Mr. Charles Edison, Assistant Secretary of the Navy, Prof. Fermi conferred with certain officers of the Navy, indicating the possibility of the energy to be derived from uranium becoming a matter of military importance. The naval officers were interested and requested that the Navy be kept informed of any developments. In the fall of 1939, through a letter from Prof. Albert Einstein and through personal representations of Dr. Alexander Socks[1], the desirability of supporting research on the prob-

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1. Dr. Alexander Socks is an economist with the firm of Lehman Bros., New York.

lem of power from uranium was presented to President Roosevelt. The President appointed a committee, composed of Dr. Lyman J. Briggs, director of the National Bureau of Standards, chairman, Col. Adamson, Ordnance Department, U.S.A., and Commander Hoover, U.S.N., to do something about supporting research on this problem. Funds to the extent of $6,000 were provided by the Army and the Navy. Partly by allotments from these funds the Uranium Committee supplied four tons graphite, costing about $2,000, and amounts of sheet cadmium and of paraffin costing a few hundred dollars, and also about $1,200 worth of measuring apparatus to enable experiments to be done at Columbia University in the spring of 1940 by Prof. Fermi, Dr. Szilard, Mr. Anderson and certain other assistants. No government money was expended for salaries or any general laboratory equipment.

From these experiments better measurements than had been previously available were obtained for the capture cross-section of carbon for neutrons, of the resonance absorption of neutrons by uranium 238 and of the slowing down of neutrons in carbon.

It is not easy to measure these quantities with accuracy without the use of very large amounts of material. The net results of these experiments in the spring of 1940 were that the possibility of the chain reaction was not definitely proven, while it was still further from being definitely disproven. On the whole, the indications were more favorable than any conclusions that could have been fairly claimed from previous experiments.

The whole question of an uranium-carbon chain reaction in

the light of the 1940 experiments of Fermi and Szilard was the subject for discussion by a special advisory group assembled by Dr. Briggs to advise the Uranium Committee. This group, composed of Messrs. Briggs, Urey, Tuve, Wigner, Breit, Fermi, Szilard and Pegram, met at the Bureau of Standards on June 13, 1940. After full discussion, the recommendation of the group to the Uranium Committee was that funds should be sought to support research on the uranium-carbon experiment along two lines: (A) further measurements of the nuclear constants involved in the proposed type of reaction; (B) experiments with amounts of uranium and carbon equal to about one-fifth to one-quarter of the amount that could be estimated as the minumum in which a chain reaction could sustain itself. It was estimated that about $40,000 would be necessary for the further measurements of the fundamental constants and that approximately $100,000's worth of metallic uranium and pure graphite would be needed for the "intermediate scale" experiment.

The desirability of the measurements of the nuclear constants is obvious. It should be remarked that the immediate value will be to enable the "intermediate experiment" recommended as "B" above, and, subsequently, a full-scale experiment, to be designed with more knowledge than would be possible without the measurements under recommendation "A" above.

As to recommendation "B", the "intermediate experiment", the argument in its favor is the following. As nearly as can be estimated at present the smallest amount of materials necessary to secure

a chain reaction with uranium and carbon would be 25 tons of uranium metal and 60 tons of graphite. This would represent an expenditure of perhaps $500,000. However, even if this rather large amount of material were in hand it would be advisable to proceed only by stages to set up the mass of material presumed necessary for the chain reaction. Measurements taken on the behavior of neutrons in intermediate amounts of the uranium-carbon mixture will not only be of the greatest value in predicting the total amount of material necessary, but will be absolutely essential, from the standpoint of safety, to the persons who are working on the experiment. Since the amount of material required for the chain reaction is certainly not in hand, and since it would cost a large sum of money, it is obvious that progress should be attempted by stages, and it is believed that the first stage should make use of not more than one-quarter of the amount which, so far as present knowledge goes, would be the minumum required for sustaining a chain reaction. It is not believed that there would be any danger in working with this intermediate amount of material, particularly since even this amount of material would not be put together all at once but would be assembled in stages and measurements taken at the several stages. Some question has been raised as to whether this intermediate experiment should be carried out in a university laboratory or in some more isolated spot. Prof. Fermi thinks there would not be the slightest hazard in carrying out the experiment in any laboratory.

After the formation of the National Defense Research Committee, the Uranium Committee appointed by the President was informed that it

would become a sub-committee of the National Defense Research Committee. The chairman of the Uranium Committee transmitted to the National Defense Research Committee on July , 1940, a recommendation that the proposed experiments on the uranium-carbon reaction should be supported by an allotmentof $140,000.

Proposed Experiments at Columbia University

Obviously the question of how much expenditure on the proposed experiments is justifiable will depend, in part, on the scientific knowledge gained in the researches, but much more upon the value, from the standpoint of power production, to be attached to the accomplishment of release of nuclear energy from uranium. As indicated above, it is likely that an uranium-carbon set-up that will actually produce power through a chain reaction, will cost something of the order of half a million dollars. It would be a very concentrated source of a very large amount of energy, that is, very concentrated as compared with existing power plants and fuel piles. The most obvious application would be for the powering of a ship. It would probably be well worth the investment.

It is proposed that the National Defense Research Committee contract with Columbia University through George B. Pegram, professor of physics and dean of the Graduate Faculties, for researches on the uranium-carbon chain reaction problem to be made in the Department of Physics at Columbia University, and for reports on results, with suitable arrangements for the payment to Columbia University of appropriate amounts for the expenses of the experiments. The following is a brief

outline of the proposed investigations, together with an estimate of cost.

At the present state of development of the technique we cannot hope to obtain a sufficiently accurate knowledge of the interactions of neutrons with uranium and carbon as to permit a mathematical prediction of the success of a chain reaction experiment. However, it seems worth while to continue and improve our study of these properties, not so much in order to make such a prediction possible,, but rather to permit a rational planning of the best arrangement to be used. In order finally to decide whether a mixture of carbon and uranium of a certain size can give a chain reaction it will be necessary to perform an intermediate experiment on a sample of the mixture of about one-quarter or one-fifth of the estimated total amount necessary to sustain a chain reaction. Accordingly, it is proposed to divide our program into two parts.

A. Study of the interaction of neutrons with uranium and carbon; determination of the important nuclear constants.

B. "Intermediate experiment" with the appropriate mixture of uranium and carbon.

PART A

It is proposed to carry out the following measurements:

(1) To determine more accurately the number of new neutrons emitted per thermal neutron captured by uranium, and resulting in a fission. An approximate value was obtained by Anderson, Fermi and Szilard (Phys. Rev., Vol. 56, p. 284, 1939). A method for this

measurement consists in comparing the activity produced by neutrons slowed down in water or carbon with or without masses of uranium of suitable geometrical disposition spread through the slowing-down material. The accuracy of these measurements can be increased by using larger amounts of uranium oxide than were available in the above quoted research, and by using strong sources of neutrons.

(2) To measure the fraction of neutrons absorbed by uranium in the resonance band during the slowing-down process. This fraction is largely dependent upon the geometry used. We plan to vary the geometry so as to get an estimate of this magnitude for different configurations. One possible method requires the knowledge of the self-absorption curve of the uranium resonance neutrons. Such a curve has been determined by Anderson (Phys. Rev. in print). It is not possible, however, to measure this curve for very thick absorbers on account of the scattering. We shall attempt, therefore, to get an estimate of this fraction by measurements of the intensity of neutrons having energies above and below that of the resonance band.

(3) Study of the slowing-down of neutrons in carbon. This research, which is already in progress, has as its purpose to determine the length of diffusion of the neutrons during the slowing-down process. The method consists essentially in the determination of the activity of a detector sensitive to neutrons just above the thermal energies in masses of carbon of a shape suitable for calculation.

(4) Absorption of thermal neutrons in carbon. A measurement of the absorption cross-section of carbon for thermal neutrons was made last spring, using about four tons of graphite. With larger amounts of graphite available the experiment could now be repeated under more favorable conditions. Since a very precise knowledge of this cross-section is very essential in planning the final experiment it might also be desirable to repeat this experiment, using an essentially different geometrical arrangement.

(5) Tests of what would essentially be a single unit of the large-scale experiment, namely a single sphere of uranium metal, approximately 10 cm. in diameter, surrounded by a graphite mass of approximately 60 cm. in diameter. Measurements of the density of neutrons at various distances from the uranium sphere would have to be performed, placing sources of neutrons outside of the graphite mass.

(6) Measurements of scattering absorption and fission cross-sections of uranium with improved accuracy. Measurements of the absorption and fission process already in progress will be performed by comparing these cross-sections with those of manganese and gold. A new measurement of the total cross-section of uranium for thermal neutrons is desirable since the samples used by various investigators in previous measurements have proved to be contaminated by considerable amounts of hydrogen.

(7) Measurements of neutron absorption by other elements which might be present as impurities or which might be introduced for mechanical purposes, as, for example, in order to form a really fusible alloy of uranium.

An estimate of what would be needed for carrying out Part A above is the following: Besides the general laboratory equipment which would be made available by Columbia University, this Part A of the program would require:

(a) Special measuring instruments which have already been constructed under contract with the National Bureau of Standards (Uranium Committee).

(b) All of the experiments require strong sources of neutrons and the stronger the sources the more accurate and more readily attained will be the results of the experiments. A source consisting of one gram of radium mixed with beryllium powder will be sufficient for some of the experiments. It is hoped that a gram of radium already ordered by the Navy Department will be available for this neutron source. For the cost of making up the source and mixing the radium with beryllium and for separating the radium again after the termination of the research an allowance should be made of about $250.

(c) For some of the experiments still stronger neutron source will be needed and can

	probably be rented. Photo-neutron sources, consisting of one to three grams of radium inserted in a beryllium cylinder can be used and can probably be rented for	$2,000.
(d)	Two tons of uranium oxide for experiments 1 and 2 - estimated cost	10,000.
(e)	A sphere of uranium metal, about 10 cm. in diameter for experiment 5 - estimated cost	1,000.
(f)	Four tons of pure graphite, in addition to four tons already in hand - estimated cost	2,000.
(g)	Experimental constructions, such as containers for the various materials - allowance	2,000.
(h)	Miscellaneous expenses for supplies, small apparatus, shop work, etc. - $1,000 a month for twelve months	12,000.
(i)	Salaries of research assistants for one year	10,750.
	Total for Part A	$40,000.

PART B

The research assistants allowed for under Part A can also work on Part B with no additional item for salary proposed within the year.

This intermediate experiment will need 12 tons of pure graphite, more than half of which will be already on hand. The cost

of the remainder should not be more than $3,000. The chief expense will be for five tons of uranium metal in spheres or blocks, whose size will be better determined after results have been obtained from Part A of the program. It is impossible to predict accurately what uranium metal in the proper form will cost. It is proposed that an allotment of $100,000 for this intermediate experiment be made and that as much uranium metal and other materials will be purchased as this amount will provide. An amount up to $5,000 should be at once available for preliminary metallurgical experiments to determine how uranium metal best suited to the purpose can be obtained. It may be pointed out that the materials used in this experiment will form part of those required for the final experiment on a scale sufficiently large to obtain a chain reaction if this full-scale experiment should ultimately be performed. Otherwise these materials - uranium and graphite - will have some salvage value either on the market or for use in other lines of experimentation.

Proposed Personnel

It is proposed that Prof. Pegram represent the University officially in connection with this research and that Prof. Fermi should be directly engaged in the research itself. Profs. Pegram and Fermi will, of course, receive no salary. Dr. Szilard, as one of the originators of the project, should be engaged with Prof. Fermi in the immediate direction of the research. It is proposed that a salary be paid to Dr. Szilard at the rate of $4,000 a year. It is proposed that Mr. Herbert L. Anderson, a recent Ph.D. graduate of Columbia University, who is well known in this field through his work for the past year with Prof. Fermi,

be one of the research assistants at a salary of $2,400 a year.

It is not possible definitely to propose the names of additional assistants at the present time. If the University is assured of this contract it is likely that efforts will be made to induce Dr. Walter Zinn, of the Department of Physics of the College of the City of New York, who has been engaged in research in this field for the past few years at Columbia, to try to secure leave of absence from his City College post in order to work on this problem. In any case, in addition to Dr. Zinn and Dr. Anderson, two more men will be needed. It is, of course, desirable that the personnel for this research should consist of physicists who have already worked in this field.

Suggestions as to Contract with Columbia University

The following suggestions are made as to items of the contract between the National Defense Research Committee and Columbia University:

(1) The contract should be for researches to be made under the direction of appropriate members of the University staff, in general accordance with the experiments proposed in the preceding section, and for the reporting of results to the National Defense Research Committee.

(2) The contract should specify that the University will provide the direction of the experiments, the necessary laboratory space and the general equipment of a physics laboratory such as the University already has available.

(3) The contract should specify that the University should be reimbursed for all the direct expenses of the research, including:

(a) The cost of materials.

(b) The cost of supplies and apparatus necessary for the prosecution of the research.

(c) Salaries paid to research assistants.

(d) Such minor and incidental outlays on the part of the University as the prosecution of the research may necessitate.

(4) The contract should specify that the results of the research should be kept confidential and reported only to the National Defense Research Committee.

(5) The contract should specify that all personnel employed in connection with the research should be subject to the approval of the National Defense Research Committee.

(6) The contract should provide for interim reports on the research at intervals of two or three months and a complete report at the end of one year.

(7) The term of the contract should probably be for one year.

(8) The contract should specify that all important quantities of materials purchased for these researches should become the property of the National Defense Research Committee.

(9) The contract should specify that all apparatus and supplies purchased or constructed for this research should become the property of Columbia University after the termination of the contract. This would constitute a small return to the University for what it supplies in the contract. If it should, for any reason, not be desirable to have the apparatus become the property of the University, provision should be made for payment of a small sum to the University - say, $300 to $1,000 - for the inevitable cost to it of services, such as clerical work, which it would be difficult to itemize.

(10) The contract may provide that in the case of materials or apparatus of which the cost is large, purchase may be made through the University, with subsequent reimbursement, or the materials may be purchased through an appropriate government agency and supplied to the University.

Pegrams Memo dated Aug 14, 1940. Exhib. D.

Excerpt from bottom of p.6 to bottom of p.8

Bk. f. 8A

The whole question of an uranium-carbon chain reaction in the light of the 1940 experiments of Fermi and Szilard was the subject for discussion by a special advisory group assembled by Dr. Briggs to advise the Uranium Committee. This group, composed of Messrs. Briggs, Urey, Tuve, Wigner, Breit, Fermi, Szilard and Pegram, met at the Bureau of Standards on June 13, 1940. After full discussion, the recommendation of the group to the Uranium Committee was that funds should be sought to support research on the uranium-carbon experiment along two lines: (A) further measurements of the nuclear constants involved in the proposed type of reaction; (B) experiments with amounts of uranium and carbon equal to about one-fifth to one-quarter of the amount that could be estimated as the minimum in which a chain reaction could sustain itself. It was estimated that about $40,000 would be necessary for the further measurements of the fundamental constants and that approximately $100,000's worth of metallic uranium and pure graphite would be needed for the "intermediate scale" experiment.

The desirability of the measurements of the nuclear constants is obvious. It should be remarked that the immediate value will be to enable the "intermediate experiment" recommended as "B" above, and, subsequently, a full-scale experiment, to be designed with more knowledge than would be possible without the measurements under recommendation "A" above.

As to recommendation "B", the "intermediate experiment", the argument in its favor is the following. As nearly as can be estimated at present the smallest amount of materials necessary to secure a chain reaction with uranium and carbon would be 25 tons of

uranium metal and 60 tons of graphite. This would represent an expenditure of perhaps $500,000. However, even if this rather large amount of material were in hand it would be advisable to proceed only by stages to set up the mass of material presumed necessary for the chain reaction. Measurements taken on the behavior of neutrons in intermediate amounts of the uranium-carbon mixture will not only be of the greatest value in predicting the total amount of material necessary, but will be absolutely essential, from the standpoint of safety, to the persons who are working on the experiment. Since the amount of material required for the chain reaction is certainly not in hand, and since it would cost a large sum of money, it is obvious that progress should be attempted by stages, and it is believed that the first stage should make use of not more than one-quarter of the amount which, so far as present knowledge goes, would be the minimum required for sustaining a chain reaction. It is not believed that there would be any danger in working with this intermediate amount of material, particularly since even this amount of material would not be put together all at once but would be assembled in stages and measurements taken at the several stages. Some question has been raised as to whether this intermediate experiment should be carried out in a university laboratory or in some more isolated spot. Prof. Fermi thinks there would not be the slightest hazard in carrying out the experiment in any laboratory.

2nd set
May, 1969

Additional Material for pages 117 to 121. (1)

Miscellaneous 1940-41 documents.

re: SZILARD'S CONTINUING SEARCH FOR OUTSIDE HELP.

Letter, L.S. to Strauss. Jan. 30, 1940
"Memorandum" attached.
Both marked "Not sent".

Letter, L.S. to Howard A. Poillon, President, Research Corp.
Feb. 26, 1940

"Memorandum" by L.S. June 24, 1940
(It is not clear for whom this was written)

Not sent

BK. f. 8A. I

(37)

UNDER
KNOTT MANAGEMENT

TELEPHONE
UNIVERSITY 4-2700

King's Crown Hotel

420 WEST 116TH STREET
NEW YORK

OPPOSITE COLUMBIA UNIVERSITY

January 30, 1940

Lewis L. Strauss
52 William Street
New York City

Dear Mr. Strauss:

This is to remind you that about a week ago we thought it might be a good plan for me to talk to Godowski and others. If you wish to arrange something for me I could keep appointments this week at twenty-four hours notice. If your secretary telephones the King's Crown Hotel the clerk will tell him if I am in town or at Princeton, and in the latter case, I can be reached there at the Nassau Tavern.

I have looked more closely into the question of driving naval vessels with an atomic engine and I am enclosing a memorandum on the subject which we might use as a starting point for further deliberations.

Is it possible for you to see me some time during the second half of this week or early next week?

Yours very sincerely,

Leo Szilard

Bk f. 8A. I

(38)

TELEPHONE
UNIVERSITY 4-2700

King's Crown Hotel

420 WEST 116TH STREET
NEW YORK

OPPOSITE COLUMBIA UNIVERSITY

MEMORANDUM

I have found a way to maintain a chain reaction and ways to use it producing a power, for instance, for the purpose of driving naval vessels. The crew of of the vessel can be protected against irradiations emanating from the atomic engine by means of water tanks of rather moderate size. About ten tons of uranium might be used for such an engine.

Whether it is a rather rare isotope or the abundant isotope of uranium which is possible for the reaction is not known. If it is the rare isotope then ten ton of uranium would supply as much power as about fifty thousand tons of coal before the atomic engine gets . If it is the abundant isotope which splits then ten tons of uranium will supply as much power as five million tons of coal and even then would use up only about one fifth of the uranium so that the rest could be reconditioned.

The question could be decided after investigating a small sample of isotopes.

not sent

February 26, 1940

Mr. Howard A. Poillon
President, Research Corporation
405 Lexington Avenue
New York City

Dear Mr. Poillon:

I wonder whether you will remember that I visited you in the spring of 1935. I believe I was introduced to you then by G. B. Pegram while on a visit to New York shortly before my return to Oxford, England. At that time I talked to you about the potential possibilities of producing power by liberating nuclear energy on a large scale and you told me that you did not propose at that time to support any experiments except those in Berkeley and kindly suggested that I get in touch with Ogden in Englad. By now you have perhaps completely forgotten this incident.

As you can see from the enclosed reprints, I have been recently doing some work along the line which I proposed to follow in 1935. More can be said on this subject than would be wise to say in publications which are printed in periodicals and I should very much appreciate having your comments on a number of questions which arise out of the present situation. If you are free this week perhaps you would be kind enough to have your secretary telephone me at UNiversity 4-2700, Extension 302.

Yours very truly,

(Leo Szilard)

BK & 8A

June 24, 1940

MEMORANDUM

In the memorandum which was submitted in the course of a meeting held under the chairmanship of Dr. Briggs on April 27, 1940, I discussed the possibility of using uranium as a source of power for the purpose of driving naval vessels. In the case of a chain reaction maintained in a system composed of carbon and uranium a conservative estimate leads to the prediction that one ton of uranium will be equivalent to about 3,000 tons of oil. Certain recent developments make it appear conceivable that the conditions can be so chosen as to obtain from 1 ton of uranium as much power as from about a few million tons of oil. Professor Louis A. Turner of Princeton sent me a manuscript in which this possibility is discussed. In discussions which Dr. Turner had with Dr. Wigner and myself he expressed his willingness to have the publication of his paper delayed if required. Certain observations made by Macmillan and Abelson which were published in the June 15th issue of the Physical Review opened up the way for investigating the potential possibility discussed by Dr. Turner. By following up the work of Macmillan and Abelson and by carrying out the contemplated general survey of the nuclear constants it will be possible to decide whether 1 ton of uranium "burned" in a system composed of uranium and carbon is capable of supplying as much power as a few million tons of oil or whether it is only capable of supplying as much power as 3,000 tons of oil, the previously given conservative estimate.

L. Szilard

(Leo Szilard)

2nd set
May, 1969

Additional Material for pages 117 to 121. (2)

Miscellaneous 1940-41 documents.

re: SZILARD'S PATENTS, APPLICATIONS, AND DISCLOSURES, IN NUCLEAR PHYSICS

Letter, L.S. to Wigner. April 30, 1941

(re page 1) For further information on Szilard's English patents, see Note 8 on page 102.

(re page 2, first paragraph) For Szilard's letter to Fermi, see: Additional Material for page 102.

(re page 2, second paragraph) The American patent is entitled: "Process of Producing Radio-active Elements." It was filed on March 11, 1935 (Serial No. 10,500) and issued on June 13, 1939 as U.S. Patent No. 2,161,985.

(re page 2, third paragraph) See Communication from U.S. Patent Office, below.

(re page 2, fourth paragraph) Szilard's German cyclotron patent is described in both the text and note, Section 4, Berlin 1920-1933 (page 7 of typed version).

Communication, U.S. Patent Office to L.S. April 29, 1941
Abandonment of patent application for "Apparatus for Nuclear Transmutation," filed in 1939.

Disclosure. "MEMORANDUM" mailed to himself by Szilard.
Dated July 4, 1940
Postmarked Nov. 14, 1940
The memo suggests using beryllium in the uranium system.

Typed memo (2 pp.) entitled "PATENT" Dec. 9, 1940
Paragraphs headed: "Method of Cooling" Uses liquid bismuth.
"Heating up."

Bk 7.9 (3)
Szil. → JW

420 West 116 Street
New York, N. Y.
April 30, 1941

Professor E.P. Wigner
Fine Hall
Princeton University
Princeton, New Jersey

Dear Wigner:

You have asked me to send you a complete list of those patents taken out by me which have some connection with nuclear physics.

I have taken out three such patents; two in England, and one in America. All of these patents are based on English applications which were filed in 1934.

One of the two English patents has as its subject the idea of the nuclear chain reaction in which more than one neutron is emitted per neutron absorbed. This patent was assigned to the British Navy in 1936 and has been sealed secret and remains unpublished.

The other English patent contains essentially two inventions, the generation of radioactive elements by means of neutrons and the chemical separation of radioactive elements from non-radioactive isotopes, a method which was first demonstrated in the case of Iodine, by separating Iodine from Ethyliodine.

The relevant provisional English patent application was filed before Fermi's discovery of the production of radioactive elements by means of neutrons. After Fermi's discovery became known and after the issue of my patent I wrote Fermi and others and suggested that all patents in this field should be pooled and given to some scientific foundation or some other non-profit organization. No solution of this type materialized, however. Later I gave an exclusive license agreement for the chemical separation part of the patent which I considered as my own contribution to the art, but reserved the right of letting the rest of the patent be used by third parties free of royalty should this appear to be justified.

The American patent filed in the United States in March, 1935, is essentially along the lines as the above-mentioned British patent and falls under the same license agreement.

None of the other patent applications which I have filed at one time or another have been kept alive and they have all become abandoned. Consequently, there is at present no patent application on file which may lead at a later date to the issue of a patent.

One of these abandoned applications was filed in 1928 in Germany and described the invention of the cyclotrone.

I hope this statement covers everything that might be of interest to you. With best wishes,

Yours,

L S

Leo Szilard

Bk. f. 9. (2)

Div. 56 Room 4725 260 JRS/ecc Paper No. 8

Address only
"The Commissioner of Patents,
Washington, D. C.,"
and not any official by name

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON

MAILED All communications respecting this application should give the serial number, date of filing, and name of the applicant

APR 29 1941

Copy sent attorney.

Please find below a communication from the EXAMINER in charge of this application.

Conway P. Coe
Commissioner of Patents.

... 11—8023

Leo Szilard,
420 W. 116th St.,
New York, N. Y.

Applicant: Leo Szilard.

Ser. No. 263,017.
Filed Mar. 20, 1939.
For Apparatus For Nuclear Transmutation.

A letter of abandonment signed by applicant has been received in this application on April 26, 1941 and is hereby acknowledged. The application is accordingly herewith forwarded to the abandoned files.

EXAMINER.

Bk. f. 84 (56)

STATION J

NEW YORK. N.Y. NOV 14 4 30 PM 1940

UNITED STATES POSTAGE 2 CENTS 2

L. Szilard

420 W 116 Str.

N.Y.C.

If this small scale experiment gives an encouraging result then we ought to attempt to obtain plates of beryllium metal, for instance plates of sizes 5 x 15 x 15 cm and other plates 5 x 5 x 10 cm. Such plates used in conjunction with a cube of uranium metal can be so arranged as to have a cubic layer of beryllium 5 cm thick surrounding the uranium cube. Each uranium cube would require four of the smaller and two of the larger type beryllium plates. The use of beryllium might be of marked advantage even if the cross-section for the knock out process were as low as $10^{-25} cm^2$ for uranium fission neutrons.

(Leo Szilard)

July 4, 1940

MEMORANDUM

If we used in the chain reaction experiment uranium spheres of 5 cm. diameter surrounded by $2\frac{1}{2}$ cm. layer of beryllium metal we would have about six times as much volume of beryllium as uranium and taking into consideration the ratios of the densities about $\frac{1}{2}$ as much beryllium as uranium. Assuming that beryllium metal may be bought at a price of $10.00 per lb. and uranium metal at a price of $5.00 per lb., 10 tons of uranium metal will be about $100,000. and 5 tons of beryllium would be $100,000. making a total of $200,000.

PATENT December 9, 1940

Method of Cooling.

1. No cooling liquid inside the graphite-uranium system.

2. Cooling by liquid bismuth, the bismuth surrounding the uranium spheres; the bismuth flowing in graphite channels and not in iron pipes.

3. Cooling by some cooling liquid, for instance a bismuth-lead compound containing 60% of bismuth, melting at 126°, flowing inside a uranium tube inside a uranium cylinder. This method can be used only if cylindrical bodies of uranium are embedded in graphite. In this arrangement liquid mercury could be used instead of liquid bismuth or bismuth alloys; also perhaps water. Note: melting point of bismuth 322°; melting point of lead 326°. A Pb-Sn alloy containing 70% Sn melts at 185°. There may be suitable Sn-Pb-Bi alloys. Boiling point of bismuth is at 1470°. Boiling point of lead is at 1613°.

Heating up.

If the cooling medium is used which becomes solid at room temperature it may be necessary to heat up the carbon-uranium system in order to start the machine. ~~xxxxxxxx~~ Another reason for heating up may lie in the fact that the graphite used contains impurities which have an appreciable thermal absorption. In the case of an appreciable thermal absorption in the graphite, whether due to impurities of a certain kind or to the carbon itself, the efficiency of the arrangement for the chain reaction increases with ~~x~~ increasing temperatures within the range between room temperature and the highest temperature which is practicable in such machines. This in itself may be a reason for heating up the carbon-uranium system in order to start the chain reaction, and the temperature will then be maintained at a high level, perhaps at 800° during the operation of the machine by the heat which

is liberated in the chain reaction.

In order to heat up the graphite-uranium system heating elements may be pushed into cavities in the graphite and these elements must then be withdrawn in order to start the chain reaction, otherwise their thermal neutron absorption may interfere with the chain reaction.

2nd set
May, 1969

Additional Material for pages 121-122

Miscellaneous documents from Szilard's folder marked "1940", but not directly mentioned in the REMINISCENCES.

Letter, Placzek to L.S. May 9, 1940

Memorandum, Placzek to L.S. "On the Diffusion of Neutrons in Air"
The title page of this Memorandum reads "Confidential. Memorandum sent by G. Placzek to Dr. L. Szilard. April 1940." This title page was probably added later by Szilard. (It is on plain Macadam Bond, whereas the Memorandum itself is on paper with the Cornell University watermark.) The Memorandum may well have been sent in May, after the May 9th letter.

Letter, Placzek to L.S. July 25, 1940

Letters, L.S. to Wigner Sept. 29, 1940
and Nov. 3, 1940

CORNELL UNIVERSITY
ITHACA, NEW YORK

DEPARTMENT OF PHYSICS
ROCKEFELLER HALL

9. Mai 1940.

Lieber Szilard,

Besten Dank für das Manuskript. Sie kriegen den Zusatz prodemkt, sobald er getippt ist. Das Resultat ist sehr einfach: Die Anzahl der von einem schwarzen Detektor pro sec. & und Flächeneinheit absorbierten Neutronen*) ist:

$$I = \frac{1}{8\pi} \frac{Q\, l_f}{\rho^3} \left\{1 - \varphi\left(\frac{\rho}{L}\right)\right\}$$

L_f

Die Funktion $\varphi\left(\frac{\rho}{L}\right)$ für die Sie eine kurze Bezeichnung, ist Null für $\frac{\rho}{L} = 0$ und z. B. 0,6 für $\rho = L$, und φ geht dann schnell gegen 1. L ist etwa 1 km, l_f bekanntlich ca 140 m. Für Ihre Genauigkeit verlangen Sie aber einfach für mässige Abstände ρ

mit $I \sim \frac{1}{8\pi} \frac{Q\, l_f}{\rho^3}$

*) erzeugt von Quelle über fressendem Boden.

Das ist Ihnen hoffentlich einfach genug.
Viel scheint es ja nicht zu sein. Ich weiss
nicht wie Ihre Mordpläne sind, aber
Sie sehen dass dies um einen Faktor $\frac{e_0}{\rho}$ kleiner
wenigen ist als der Effekt einer Quelle im
Vakuum ohne jede Diskussion.

Beste Grüsse

Ihr

C. Planck

(original in 36.s.6) Bk.f. 8A (46)

Confidential

Memorandum

sent by Dr. G. Placzek to Dr. L. Szilard

April 1940.

(Original in 3b/3.6) Bk. f. 8A (47)

On the Diffusion of Neutrons in Air

The diffusion of neutrons in air has been recently discussed by Bethe, Korff and Placzek[1], the average energy distribution has been derived by Placzek[2], and the ~~local~~ spatial distribution of neutrons in air over a water surface has been derived by Bethe[3] for the case of production of neutrons in air homogeneous in a horizontal plane.

§ 1. Diffusion of neutrons in free air. We first discuss the diffusion in free air. The results will hold if the distance of the neutron source from the ground is larger than the diffusion path (see below) of the neutrons produced by the source.

The average energy distribution is approximately given by[1,2]

$$N(v)\,dv = M Q \ell_s(v) \frac{dv}{v^2} e^{-M \int_v^{v_1} \frac{\ell_s(v')}{\ell(v')} \frac{dv'}{v'}} \qquad (1)$$

Here $N(v)dv$ is the number of neutrons of velocities between v and v + dv for initial velocity v_1, M = 14.4 the mean atomic weight of air, Q the number of neutrons produced per second (with velocity v_1) and $\ell_s(v)$ and $\ell_c(v)$ the mean free path of neutrons in air for scattering and capture respectively, as functions of the velocity.

---

[1] Bethe, Korff and Placzek, Phys. Rev. 57, 573, 1940

[2] See " " , ref. 30

[3] See " " , ref. 31

From a discussion of (1), together with the available experimental material about scattering and capture cross sections in nitrogen and oxygen it can be concluded (cf. ref. 1), that capture effects will probably not change the neutron density by orders of magnitude for all energies down to 1 ev. In the following, we shall neglect these effects, they can be roughly accounted for by multiplying all neutron densities with the reduction factor $\exp\left\{-M \int_{v}^{v_1} \frac{\ell_s(v')}{\ell_c(v')} \frac{dv'}{v'}\right\}$ as soon as the respective cross sections have been measured.

At energies considerably below 1 ev the capture due to the n-p reaction in nitrogen will come into play and remove most of the neutrons before thermal energies are reached. In the following table, we give approximate numerical values for some of the characteristic lengths, important for the study of the diffusion process in air.

These are: The mean free path for scattering ℓ_s for fast and slow neutrons, the mean free path ℓ_{ct} for capture of thermal neutrons, the diffusion path for thermal neutrons λ defined by:

$$\lambda = \left(\frac{\ell_s \ell_{ct}}{3}\right)^{1/2} \qquad (2)$$

and the root mean square distance of diffusion $\sqrt{(r^2)_{Av}}$, for neutrons produced at energies E_1 and captured at energy E_c.

$$\left(r^2\right)_{Av}^{(E_c)} = M_{eff} \int_{E_c}^{E_1} \ell_s^{\,2}(E)\,\frac{dE}{E} \qquad 3$$

$$M_{eff} = 15,6 \qquad (3)$$

E_c lies slightly above thermal energies.

		cm water equivalent	meters air at normal pressure
ℓ_s	for fast neutrons	18	140
	" slow "	2.6	20
ℓ_{tr}		24	190
$\bar{\lambda}$		4.6	35
$\sqrt{(r^2)_{Av}}$	for 2Mev neutrons	150	1200

The most inaccurate of these figures is $(r^2)_{Av}$, because of insufficient data about the energy variation of the mean free path. (see ref. 1) The spatial distribution of the neutrons can be found approximately by assuming that the time spent in the slowing down process from the original energy E_1 to any energy E_2 is the same for all neutrons, so that the energy is a function of the "age" of the neutron. Then the problem can be treated by the standard methods of diffusion theory. Actually, the assumption is not quite correct, since to every energy belongs an age distribution of neutrons, but it can be shown that the use of this idealization is a good approximation as long as capture is unimportant.

If we define a symbolic time ϑ by

$$\vartheta(v) = \frac{1}{6}\left(r^2\right)_{Av}^{(v)} = 5,2 \int_{v}^{v_1} \ell^2(v')\,\frac{dv'}{v'} \qquad (4)$$

the diffusion equation reads

$$\frac{\partial F}{\partial \vartheta} = \nabla^2 F \tag{5}$$

where F is the neutron density. If Q neutrons of velocity v_1 are produced per second at r = 0, the solution of (5) is

$$F(v, r)dv = M Q \, l_s(v) \frac{dv}{v^2} \frac{e^{-\frac{r^2}{4\vartheta(v)}}}{(4\pi\vartheta(v))^{3/2}} \tag{6}$$

with (11) This is correct. ✓

Or, if we introduce the diffusion path L(v) by

$$L(v) = 2\sqrt{\vartheta} = \sqrt{\frac{2}{3}(r^2)_{Av}} \tag{7}:$$

$$F(v, r) = M Q \, l_s(v) \frac{dv}{v^2} \frac{e^{-\left(\frac{r}{L(v)}\right)^2}}{\pi^{3/2} L^3(v)} \tag{6a}$$

If we have a source of thermal neutrons, their density F_t is determined by the equation

$$\nabla^2 F_t - \frac{F_t}{\lambda^2} = \frac{Q_t \tau \delta(r)}{4\pi r^2} \tag{8}$$

where τ is the lifetime of thermal neutrons in air (about 1/100 sec), f and λ is given by (2). (7) is solved by

$$F_t = Q_t \tau \frac{e^{-r/\lambda}}{4\pi\lambda^2 r} \tag{9}$$

f Q_t the number of thermal neutrons produced per sec.

the number of thermal neutrons produced per sec.

§ 2. Diffusion of neutrons above ground. We now consider the following problem: The space of air is limited by a plane infinite boundary z = 0 (ground). At an altitude z_0 we have a point source of neutrons of velocity v_1. We ask for the neutron density in air as a function of velocity and coordinates. Obviously, the neutron density will depend on the capture and scattering properties, and hence on the chemical composition of the material forming the ground. However, we will get lower limit for the neutron density by assuming that every neutron reaching the ground is captured. This leads to the boundary condition F = 0 for $z = -\frac{\ell_s(v)}{\sqrt{3}}$.

The solution of the diffusion equation with this boundary condition is;

$$F(z,\rho,v)\,dv = MQ\ell_s \frac{dv}{v^2} \cdot 2\pi^{-\frac{3}{2}} L^{-3} e^{-\rho^2/L^2 + \left(z+\frac{\ell_s}{\sqrt{3}}\right)^2/L^2 + \left(z_0+\frac{\ell_s}{\sqrt{3}}\right)^2/L^2} \sinh \frac{2\left(z+\frac{\ell_s}{\sqrt{3}}\right)\left(z_0+\frac{\ell_s}{\sqrt{3}}\right)}{L^2} \qquad (10)$$

z is the altitude and ρ the distance of the projections of source point and field point on the plane z = 0. If the source is at $z_0 = 0$ and we are interested in the spatial dependence of the neutron density on the ground (i.e. z = 0), (10) becomes approximately, for $L(v) \gg \ell_{(v)}$:

$$F(0,\rho,v) = MQ\ell \frac{dv}{v^2} \frac{e^{-(\rho/L)^2}}{\pi^{3/2} L^3} \frac{4}{3}\left(\frac{\ell_{(v)}}{L_{(v)}}\right)^2 \qquad (10a)$$

Comparing (10a) with (6a), we see that the neutron density at the ground is reduced by the factor $\frac{4}{3}\left(\frac{\ell}{L}\right)^2$ with respect

$\frac{1}{3}v$

to the case of free air. This reduction factor does not depend on the distance ρ .

If the ground is formed by a substance the neutron constants of which are sufficiently well known, as for instance water, the above treatment can be refined by calculating the probability $\varphi(v, v_o)$ that a neutron hitting the surface with velocity v_o, re-emerges from it with velocity v, and then using the product of the current of the density (6a) as function of v_o times the function $\varphi(v, v_o)$ as a new source in the diffusion equation (5). This procedure can be applied again to the new result, and in this way a well converging series of positive terms is obtained. The physical meaning of this procedure is that one considers successively the neutrons which have entered and emerged from the boundary once, twice, three times, and so on. The most important difference of this solution compared to the first approximation (6a) in the case of water is the presence in air of a certain amount of thermal neutrons, which have been slowed down in the water and emerged from it. The further diffusion of these thermal neutrons can then be treated in a single step by solving a differential equation of the type (8), with a simple boundary condition which is obtained from albedo considerations.

§ 3. Total effect on small black detector.

We now calculate the total number of neutrons above velocity v absorbed by a black detector of dimensions small compared to the mean free path.

The number of neutrons above velocity v absorbed per second and unit surface of the detector can be shown to be (for a convex detector)

$$I(v) = \frac{1}{4} \int_{v}^{v_0} v\, F(v)\, dv \qquad (11)$$

For constant mean free path, the integration gives in the case of the free atmosphere (6a):

$$I(v) = \frac{3}{16\pi} \frac{Q}{r\ell} \left\{ 1 - \Phi\left(\frac{r}{L}\right) \right\} \qquad (12)$$

and in the case of source near capturing ground (10a):

$$I(v) = \frac{1}{8\pi} \frac{Q\ell}{\rho^3} \left\{ 1 - \varphi\left(\frac{\rho}{L}\right) \right\} \qquad (13)$$

where Φ is the error function and φ is related to the incomplete Γ-function of order 3/2 by

$$\varphi(x) = \frac{2}{\sqrt{\pi}} \Gamma_{3/2}(x^2) \,.$$

If the distance from the source is small compared to L, Φ and φ can be neglected. Fig. 1 gives the dependence of $1 - \Phi$ and $1 - \varphi$ on r and ρ.

Actually, in air, the mean free path is not constant,

but varies from about 140m for fast neutrons to about 20m for slow neutrons. The transition probably takes place in the region between 150.000 and 10.000 ev.(cf. ref. 1). We may roughly describe this behavior by putting

$$l = l_f = 120\,m \quad \text{for} \quad E > E_1,$$
$$l = l_s = 20\,m \quad \text{for} \quad E < E_1, \tag{14}$$

where E_1 lies between 150.000 and 10.000 ev. With (14) we get instead of (12) and (13)

$$I(\nu) = \frac{3}{16\pi}\frac{a}{r l_f}\left\{1 - \Phi\left(\frac{r}{L_f}\right) + \frac{l_f}{l_s}\left(\Phi\left(\frac{r}{L_f}\right) - \Phi\left(\frac{r}{L}\right)\right)\right\} \tag{12a}$$

$$I(\nu) = \frac{1}{8\pi}\frac{a l_f}{\rho^3}\left\{1 - \varphi\left(\frac{\rho}{L_f}\right) + \frac{l_s}{l_f}\left(\varphi\left(\frac{\rho}{L_f}\right) - \varphi\left(\frac{\rho}{L}\right)\right)\right\} \tag{13a}$$

where L_f is the diffusion path from the initial energy to energy E_1. With the values (14) for l, L_f has, for an initial energy of 2 Mev, a value between about 0.75 km and 1km depending on the value of E_1. Because of the small mean free path for slow neutrons, the total diffusion path L is not very different from L_f. For energies in the neighborhood of E_c (at which capture becomes important), $\frac{L - L_f}{L_f}$ is of the order of 5 per cent.

In spite of this, the slow neutron contribution to I is still important in the case of the free atmosphere and can be derived from fig. 1 (for $r = L_f$ it is of the same order of magnitude as the fast neutron contribution). For capturing ground, however, it is in general negligible because of the

small factor $\sqrt{\ell_s/\ell_f}$ (12) (13a), so that (13a) may be replaced by (13) with $\ell = \ell_f$.

CORNELL UNIVERSITY
ITHACA, NEW YORK

DEPARTMENT OF PHYSICS
ROCKEFELLER HALL

July 15, 1940.

Dear Sti-Card,

Enclosed with my thanks your undamaged MS. I do not need it at present, but it may be practical if I could refer to it at several passages of one of my future papers. You know how bad my memory is. Therefore I would be grateful if I could dispose of your paper again when I come to the writing up of the passages in question. In order to avoid extralegal procedure, we may consider it as this time not as paper any longer, but as „aide-memoire".

Please let me know about Teller.

Best regards Yours G.P.

Bk. f. 84 (41)

420 West 116th Street
New York City

September 29, 1940

Professor E. P. Wigner
Fine Hall
Princeton University
Princeton, N.J.

Dear Wigner:

You have asked me if I had any innome, the source of which is in Germany.

Prior to March 1933 I had an income from the German General Electric Co. (A. E. G.), Berlin, consisting in royalties and consultant's fee amounting to about ℳ 3000.- per annum. The agreement from which this income was derived was terminated before March 1933, and I received no payments from the A. E. G. after that date.

After March 1933 the only source of income which could perhaps be considered as from German origin was an agreement concluded with the Berlin office of Phillips, a well-known Dutch industrial corporation, before March 1933. This agreement provided for the payment of royalties to me in the amount of about ℳ 250.- per annum. The agreement was terminated in or before 1938, and no income from this source was forthcoming after 1938.

Yours sincerely,

signed
Leo Szilard

3k f.8A (40)

TELEPHONE
UNIVERSITY 4-2700

KING'S CROWN HOTEL

OPPOSITE
COLUMBIA UNIVERSITY

UNDER KNOTT MANAGEMENT

420 WEST 116TH STREET, NEW YORK N.Y.

November 3, 1940

Professor E.P. Wigner
Fine Hall
Princeton, N.J.

Dear Wigner:

You have asked me whether I have any income from German sources.

Previous to 1933 I had an annual income from the Allgemeine Elektricitaets Gesellschaft-AEG (German General Electric Company) amounting to about three thousand dollars. The agreement out of which this income was derived gave the company the rights to use certain joint inventions of Professor Einstein and myself, but this agreement was terminated by the AEG before I left Germany in March 1933. I have at present no income whatsoever from Europe.

Yours sincerely,

Leo Szilard

Leo Szilard

2nd set
May, 1969

Additional Material for page 122 (section 6)

re: "AFTER REORGANIZATION IN WASHINGTON..."

With this brief phrase Szilard lightly covers the efforts of himself and of Sachs.

In his letter to Wigner of July 6, 1940 (included with the page 121 material) Szilard writes, "...there is an increasing amount of confusion and a constant change of the personnel of committees concerning uranium and a growing dissatisfaction on my part as well as on the part of Sachs."

Later came:

Letter, L.S. to Sachs Aug. 28, 1940
enclosing
Draft, by Szilard for Sachs's use. Untitled. Aug. 27, 1940
9-page memo, somewhat inclined towards the Navy; it summarizes the history of uranium chain reaction research, and gives in detail Szilard's recommendation: formation of a non-profit organization with scientists included in the executive, in direct touch with government representatives.

Another version of above draft, probably by Sachs, undated.
Marked in L.S. hand: "sent Octr". (It is unclear to whom it was sent - KW)
This version covers substantially the same material, but in altered form. The recommendations are similar but vary slightly.

August 28, 1940.

Dr. Alexander Sachs

Dear Dr. Sachs:

Enclosed you will find a rough draft which I am certain you will want to change in many places.

I am sending it to you in advance of my visit which is scheduled for 5 p.m. , so that you may be able to redictate it if you wish to do so before we discuss it orally.

Yours very sincerely,

(Leo Szilard)

Szilard's draft (KW)

Bk. f. 8 (16)

August 27, 1940

In September last year I was approached by a group of scientists with the request of helping them to enlist the support of the Government for a line of work which might be of great importance for the U.S. Navy. After having studied the matter the attention of the Administration was drawn to this line of research and its potential possibilities by a letter written by Professor Albert Einstein, which was addressed to the President and which I transmitted to him in a personal interview.

According to the scientists who work in this field it will be possible to liberate energy in uranium by means of a cchain reaction, and it appears likely that it will be possible to utilize the energy liberated in the chain reaction for power production. It has yet to be demonstrated though that a chain reaction can in fact be maintained in a mass of about 30 tons of ordinary uranium of such purity as can be obtained by applying methods of ordinary chemical engineering. A conservative estimate shows that we may expect one ton of uranium to supply as much power as about 3000 tons of oil, but pending the outcome of certain newer experiments there is a 50:50 chance that one ton of uranium may supply as much power as would correspond to 1 million tons of oil.

If one ton of uranium supplies as much power as 3000 tons of oil then a power plant of this type could be installed on warships of the larger type and serve as a reserve driving power to be used in war time, which would seem to be of part-

icular significance for the United States in case of a war with Japan. This can be seen from the following consideration;

The naval base at Hawaii is at a distance of 3400 miles from Japan. A capital warship which carries a maximum load of about 4000 tons of oil will use about ½ ton of oil per mile if cruising at a satisfactory speed. It has therefore to be refueled after traveling 8000 miles. In the circumstances such a ship, if it is refueled at Hawaii, could cruise only for a very short time in the vicinity of Japan proper. Assuming that it may be possible for the Navy to obtain 300 tons of uranium per year it might be possible to equip six boats every year with a plant comprising 50 tons of uranium and representing an oil reserve of 150.000 tons. This would enable these boats to have in war time a cruising range which is no longer limited by the necessity of refueling. Moreover, a considerable increase in speed may be achieved by reducing the oil load from 4000 tons to perhaps 1000 tons, resulting in a reduction of weight which is only partially compensated by the weight of the additional equipment of the uranium power plant. Assuming that one ton of uranium corresponds to only 3000 tons of oil, it would not seem likely that uranium can replace oil as a driving power for capital ships, but we may expect it rather to play the role of a reserve driving power to be used only in war time and at manoeuvres. Should further experiments, however, show that one ton of uranium can supply as much power as 1 million tons of oil, then capital ships could be equipped with this new source of power exclusively and do away with oil altogether.

In that case the present capital ships may have to be considered as obsolete.

2. Present Status.

The above-mentioned line of development is pursued by Dr. Fermi and Dr. Szilard in the laboratories of Columbia University. Another line of research, which is followed up by Dr. Urey at Columbia University and also at several other placed in the United States, represents an entirely different approach and aims at extracting from ordinary uranium a substance called uranium 235. There is no doubt that, if this substance can be extracted on a sufficiently large scale at a reasonable price, it could be used as a source of energy for purposes such as described above. I understand that this second line of research is at present adequately supported both by the Army and Navy, whereas the first line of research, which promises practical results in a much nearer future, is at present not adequately organized. The state of affairs with respect of this first line is at present as follows:

Dr. Fermi and Dr. Szilard are proposing to carry out certain experiments at Columbia University. It is assumed that Dr. Bush's committee will meet the expenses of these experiments. A Special Advisory Committee headed by Dr. Briggs, which comprises representatives of the Army and Navy as well as Professor Pegram, Professor Einstein and myself, has concerned itself with various aspects of the work of Dr. Fermi and Dr. Szilard, including the necessity of its support. A committee of scientists headed by Dr. Urey is supposed to advise the Special Advisory Committee. The relationship of all these committees to

each other and to Dr. Briggs' committee is rather unclear.

3. Shortcomings of the present status concerning the organization of the line of work represented by Dr. Fermi and Dr. Szilard.

The production of a chain reaction in uranium in circumstances which are suitable to be utilized in an engine capable of driving a naval vessel is a task of considerable complexity. This task cannot be carried out by a loose cooperation of various committees and universities. It requires planning, the preparation of experiments six months and occasionally one year ahead, the gathering of a group of physicists prepared to collaborate for a number of years, whose loyalty has to be with this work rather than with the individual teaching institutions with which they happen to be associated. At present we may assume that the work carried out at Columbia University will be supported by Dr. Bush's committee, but it remains to be seen how much of this complex task can be carried out at a single university where the available space and the necessity of maintaining the routine work carried out by the department will naturally limit the speed at which the work should be carried out. A loose cooperation between various universities can be anticipated and may to some extent remedy the situation, but surely this is no way of obtaining quickly the desired results. The existing committees both by virtue of their composition and by virtue of their structure can hardly be expected to fulfill the function which is required. This is fully borne out by the experience gathered during the past year. For this reason the history of the past year is summarized in the following:

Bk f. 8 (20)

4. History.

In order to test the possibility of maintaining a chain reaction in ordinary uranium Dr. Szilard proposed last year to carry out an experiment using 100 to 200 tons of graphite and 20 to 30 tons of uranium metal. A successful conclusion of such an experiment may ultimately involve expenses up to half a million dollars, and in October last year I made an appeal to the Government for its moral and material aid in carrying out this project. In response to a letter received from Professor Einstein the President appointed a committee, with Dr. Briggs as chairman, and I submitted the matter to this committee jointly with Dr. Szilard, Dr. Wigner of Princeton University and Dr. E. Teller of George Washington University, Washington, D. C. We emphasized the urgency of deciding the question whether a chain reaction could be made to work with ordinary unspparated uranium, so that in case of a favorable result, steps might be taken to secure an adquate supply of rich uranium ore from the Belgian Congo. It was also pointed out that the matter had been discussed extensively with Professor E. Fermi and Dean G. B. Pegram of Columbia University, that their collaboration could be counted upon, and that certain preliminary experiments were being prepared at Columbia.

The Government representatives expressed their interest and their desire to help at this meeting, and various Government departments represented on the committee promised material aid towards the preliminary experiments (which have since been carried out to their completion at Columbia with a definitely encouraging result). A favorable report was sent by Dr. Briggs' committee to the President in October.

Bk. f. 8 (21)

A number of meetings, with constantly varying membership, have taken place between October of last year and ~~m~~ July this year, at which the Government representatives showed a steadily increasing desire that the proposed project be carried out with Government funds rather than private funds. The representatives of Columbia University - Dr. Fermi, Dean Pegram and Professor J. C. Urey - played an increasingly prominent part in these conferences, as well as Admiral Bowen of the Naval Research Laboratory.

In spite of the increasing favourable reaction of the Government representatives little ~~help~~ was made during the past ten months, either towards organising and financing the nessecary experiments or towards securing an adaquate supply of uranium ore for the future from the Belgian Kongo, which is the most important source of highgrade uranium ore.

At present it may be assumed that the experiments which will be carried out at Columbia University will find financial support trough Dr. Bush's committee, but if each nessecary step requires ten months of deliberation than abviously it will not be possible to carry out this development efficiently. Since April of this year it has been known that work on uranium is proceeding in Germany in great secrecy and on a very large scale in two of the Kaiser Wilhelm Institutes under the auspices of the German Government. This is precisely what was predicted bei Prof. Einstein in his above mentioned letter of Spptember last year.

5. Suggestions:

In order to insure that the task before us is carried out with the efficiency of a going enterprise it is proposed that it be entrusted to a non-profit orpanisation which is formed for the purpose. The scientists responsible for devising this project and who are familiar with the various aspects of this complex material ought to be included in the executive and ought to be in direct touch with Dr. Bush and such other government representatives as are interested in the details of the project. Large scale experiments ought to be carried out as a joint enterprise of this organisation and Columbia University and such other universities as may be willing to collaborate and to put up required space and other facilities. It would be the responsibilty of this organisation:

1.) to see to it that all necessary experiments be carried out at one place or another and

2.) to see to it that all necessary materials be available for such experiemtns in the required quantity and quality.

3.) to find out in what form if any collaboration with industrial organisations such as for instance Westinghouse, General Electric and Dupont is desirable and possible, and if desirable to establish such collaboration.

4.) To maintain contact with the Canadian and U.S. producers of uranium and to stimulate if necessary an expansion of the production.

5.) To advise the government in general and the Secretary of the Navy in particular of the developments and to prepare the ground for gradually transfering the experience acquired to the Navy at the appropriate time.

It may be mentioned that this form of organisation has been repeatedly discussed at previous meetings and an opinion strongly in favour of it has been expressed by Prof. Einstein in a letter addressed to Dr. Briggs, a copy of which is enclosed.

It is proposed that the seat of the organisation be in New York City , that the board of trustees include the names of Prof. Pegram, Prof, Urey, Prof. Laurence, Prof. Du Bridge, Dr. Sachs and if government employees be included the names of Dr. Briggs and Admiral Bowen. It is proposed that Prof. Pegram be chairman of the board and Dr. Sachs act as treasurer.

It is proposed that the executive be composed of Dr. Pegram, Dr. Urey, Dr. Fermi, Dr. Szilard and Dr. Sachs , all of New York City and that a committee of scientists be responsible for supervising all the work which committee includes the names of

H.C. Urey

M.A. Tuve

G. Breit

G.B. Pegram

E. Fermi

L. Szilard

E.P. Wigner

E. Teller

It is proposed that a fund of $ 20.000 be put at the disposal of the trustees of such an organisation .

Sachs' version
[1940] (KW)

Bk f. 8 (7)

Oct Szilard

In September of last year I was advised by Professor E. P. Wigner and Professor Albert Einstein of Princeton that Dr. Szilard had devised a method for maintaining a chain reaction in a system composed of uranium and carbon, and that the energy liberated in such a system could be effectively used for producing power. A conservative estimate shows that one can expect one ton of uranium to supply as much power as 3,000 tons of oil and, in the circumstances, uranium might be used as a fuel reserve in warships of the larger types. I understand that there is at present a 50-50 chance that this chain reaction could also be maintained under conditions in which one ton of uranium might supply as much power as would correspond to the burning of one million tons of oil. If this favorable alternative can be realized, then the larger naval units built according to the present naval program would have to be considered obsolete in the near future.

In order to test the method proposed by Dr. Szilard, an experiment using 100-200 tons of graphite and 10-30 tons of uranium metal would have to be carried out. Such an experiment may involve expenses which ultimately may aggregate half a million dollars, and in October of last year I made an appeal to the Government for its moral or material aid in carrying out this project. In response to a letter received from Professor Einstein the President appointed a committee, with Dr. Briggs as chairman, and I submitted the matter to this committee jointly with Dr. Szilard, ~~Professor E. P.~~ Dr. Wigner of Princeton University and Dr. E. Teller of George Washington University, Washington, D. C. We emphasized the urgency of deciding the question whether a chain reaction could be made to work with ordinary unseparated uranium, so that in case of a

favorable result, steps might be taken to secure an adequate supply of rich uranium ore from the Belgian Congo. It was also pointed out that Dr. Szilard had discussed the matter extensively with Professor E. Fermi and Dean G. B. Pegram of Columbia University, that their collaboration could be counted upon, and that certain preliminary experiments were being prepared at Columbia.

The Government representatives expressed their interest and their desire to help at this meeting, and various Government departments represented on the committee promised material aid towards the preliminary experiments (which have since been carried out to their completion at Columbia with a definitely encouraging result. A favorable report was sent to the President in October.

A number of meetings, with constantly varying membership, have taken place between October of last year and July this year, at which the Government representatives showed a steadily increasing desire that the proposed project be carried out with Government funds rather than private funds. The representatives of Columbia University - Dr. Fermi, Dean Pegram and Professor H. C. Urey - played an increasingly prominent part in these conferences, as well as Admiral Bowen of the Naval Research Laboratory. The opinions of scientists from other universities, such as Dr. Breit of the University of Wisconsin and Dr. Wigner, were heard and were favorable. A consensus of opinion developed to the effect that a fund of $140,000, if it could be spent freely with no strings or red tape attached, might be sufficient to bring the project to a stage at which the ultimate success of the whole enterprise could be considered as established as beyond doubt.

In spite of the favorable opinion and manifest desire to help

of all those concerned, the project has failed to make any headway since its introduction last October. It has become known during this period that work on uranium is proceeding in Germany in great secrecy and on a very large scale in two of the Kaiser Wilhelm Institutes under the auspices of the German Government. The increasing degree of interest shown by the Government representatives in this country has so far only resulted in dissuading Dr. Fermi and Dr. Szilard from seeking assistance from private sources and in establishing a constantly changing system of committees, none of which seems to possess any clearly defined authority.

The present state of affairs in this respect is as follows: Drs. Fermi, Szilard, Wigner and Teller are now supposed to act as unofficial advisors to six other scientists who form an official scientific advisory committee to the special advisory committee headed by Dr. Briggs. This latter committee is supposed to be a sub-committee of Dr. Bush's advisory committee. I understand that Dr. Bush's committee has now decided to appropriate $40,000 for the proposed project, if and when it will have funds at its disposal, and is also recommending that $100,000 worth of material be purchased through some purchasing agency of the Government for the requirements of the project. I understand that Dr. Bush's committee has no funds at present at its disposal. It decision to provide the material required through a Government purchasing agency was made without having heard either Dr. Fermi or Dr. Szilard, and does not solve the problem, since the bulk of the material required cannot be bought but has to be procured by methods other than straight purchase.

The task of establishing a chain reaction in unseparated uranium under conditions in which the energy liberated can be efficiently used for power production is of considerable complexity. It cannot successfully be carried out unless those who are familiar with all its aspects and who are supposed to carry out the work are given the authority necessary to effectuate the task. It is therefore proposed that (1) a fund of $140,000 should be entrusted without restriction to a board of trustees comprising Dr. Briggs, Dean Pegram, Professor Urey and Mr. Sachs; (2) that the seat of the board be in New York City; (3) that Drs. Pegram, Sachs, Fermi and Szilard should act as executives; (4) that a board of scientists, - namely Drs. Pegram, Urey, Wigner, Tuve, Teller, Breit, Fermi and Szilard - supervise the work and coordinate the work conducted at universities outside of New York. An estimate of the cost for the measurement of nuclear values which will have to be carried out is enclosed. This will leave $90,000 of the total of $140,000 to be used for buying materials required for an experiment with large quantities of material for the purpose of deciding the issue. The largest item, as far as materials are concerned, is an amount of 5-10 tons of uranium metal. It is not possible at present to buy uranium metal in the required quality and quantity. It is therefore proposed to approach two or three firms with a fixed offer to buy one ton of uranium metal of a specified quality at a price of about $5 per pound, and thereby to induce these firms to carry out such experiments as they find necessary in order to be able to accept such an order or to be able to make a bid of their own. If the firms find that they have to charge a higher price, we would then be free to place an order for a quantity of 5-10 tons with the firm which makes the lowest bid.