UNIVERSITY OF CALIFORNIA

RADIATION LABORATORY
BERKELEY, CALIFORNIA

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Dr. Warren Weaver
Director of Natural Sciences
Rockefeller Foundation
49 West 49th Street
New York 20, N. Y.

Dear Warren:

At long last I have the very real pleasure of writing you and through you the president and trustees something of the vital part played by the Rockefeller Foundation in the development of the atomic bomb. I shall never forget how you and President Fosdick responded so promptly to our need for additional funds to expedite the completion of the giant magnet, and I am so glad that there is now a story to tell that is in a measure a recompense for your extraordinary support.

As you know, the atomic bombs have been made of two materials, uranium 235 and 94^{239} (called plutonium), and the Foundation support has been directly connected with both. I shall speak first of the latter.

Plutonium

In the summer of 1940 McMillan and Abelson, using the 60" cyclotron (and funds largely provided by the Foundation), discovered element 93, neptunium, and later McMillan observed the growth of an alpha particle emitter from a strong sample of neptunium which he concluded was undoubtedly the daughter of neptunium, and which subsequently has come to be known as plutonium. Thus, McMillan and Abelson were the first to identify correctly a transuranic element, and it was this work that set the whole business on the right track and made the subsequent work on plutonium straightforward and inevitable.

McMillan was unable to pursue the work further than the fall of 1940 (because I had persuaded him and Alvarez to go to MIT to participate in the microwave program there) and the work was carried forward by Seaborg, Segre, Kennedy and Wahl, still supported indirectly by our Rockefeller Foundation grant. They went ahead with enthusiasm and competence, and it was not long before they had chemically isolated plutonium and worked out extensively the chemical and physical properties of this extraordinary transuranic element. The importance of Seaborg and company's work was outlined in the following memorandum prepared at the time for the National Academy Committee on Atomic Fission:

> Since the first report of the National Academy of Sciences Committee on Atomic Fission, an extremely important new possibility has been opened for the exploitation of the chain reaction with

unseparated isotopes of uranium. Experiments in the Radiation Laboratory of the University of California have indicated (a) that element 94 is formed as a result of capture of a neutron by uranium 238 followed by two successive beta transformations, and furthermore (b) that this transuranic element undergoes slow neutron fission and therefore presumably behaves like uranium 235.

It appears accordingly that, if a chain reaction with unseparated isotopes is achieved, it may be allowed to proceed violently for a period of time for the express purpose of manufacturing element 94 in substantial amounts. This material could be extracted by ordinary chemistry and would presumably be the equivalent of uranium 235 for chain reaction purposes.

If this is so, the following three outstanding important possibilities are opened:

1. Uranium 238 would be available for energy production, thus increasing about one hundred fold the total atomic energy obtainable from a given quantity of uranium.

2. Using element 94 one may envisage preparation of small chain reaction units for power purposes weighing perhaps a hundred pounds instead of a hundred tons as probably would be necessary for units using natural uranium.

3. If large amounts of element 94 were available it is likely that a chain reaction with fast neutrons could be produced. In such a reaction the energy would be released at an explosive rate which might be described as a "super bomb."

As you can well imagine, this work immediately stimulated much more interest on the part of the government in the uranium program and, as you know, soon thereafter the over-all activity was greatly expanded. It was not long before the plutonium work was transferred to the University of Chicago, under the direction of Arthur Compton, where progress was rapid and remarkable, culminating in the great plutonium plant in Washington state, and the realization of the plutonium atomic bomb.

It seems to me obvious that the generous support from the Rockefeller Foundation made all this possible in time for use in the war.

Uranium 235

As a member of the National Academy Committee on Atomic Fission, which had been assigned the task of reviewing the uranium work then in progress under the OSRD, I realized in the summer of 1941 that there were two great needs to accelerate the program. There was first of all an urgent need for enough separated uranium 235 for more accurate measurements of its nuclear properties; and secondly, there was the yet unsolved technical problem of separating uranium 235 on a large scale (as kilograms were clearly required

for the atomic bomb). It occurred to me at the time that the possibilities of electromagnetic methods for both these needs had not been given adequate consideration, for such methods had earlier been considered and rejected on grounds of space charge limitation of output, while it seemed to me that this limitation might be surmounted by the simple expedient of space charge neutralization.

To make a long story short, we decided here to see what we could do in this direction in a hurry. In November of 1941 the 37" cyclotron was converted into a mass spectrograph, and before the year's end we not only had enough uranium 235 separated to meet immediate needs for research purposes, but also this early work showed that space charge could indeed be neutralized as expected, and thus the possibility of large scale development of the electromagnetic method was opened up. As a result the Government stepped in immediately and the development of the electromagnetic method went forth with great rapidity, culminating in the great electromagnetic plant at Oak Ridge, Tennessee, costing about a half billion dollars. And it was this plant that provided the greater part of the material used in the uranium 235 bomb.

Now I am sure that we would not have gone ahead with much enthusiasm, if at all, with the electromagnetic separation work here if we had not had the 184" magnet in existence, which provided immediately fairly large scale facilities. It was indeed the existence of the great magnet that made it seem possible that we might be able to get somewhere on the problem in time to be of value in this war. And as you can see from the above brief account, that hope was realized. Actually, although the electromagnetic method was the last to be started in development, it was the first to get into large scale production of material for the uranium 235 atomic bomb, and I believe it is true that it was the assurance in 1942 that this method at least would "pan out" that gave Dr. Bush and Dr. Conant final confidence in recommending the necessarily large scale expenditure of funds.

Moreover, it seems clear also that your willingness to appropriate $60,000 in December 1941 to expedite completion of the magnet saved months in the over-all undertaking, thereby shortening the war.

As you can see from the above account, the Rockefeller Foundation indeed played a vital role, and I hope this story can be told as a dramatic example of the far-reaching value of the Foundation's support of pure science to our nation and to the world.

If you wish to show this letter to others than the officers and trustees of the Foundation, or wish to publish any parts, I would be grateful if you would check with General Groves' office.

Again, will you convey to President Fosdick and the trustees my profound thanks.

Very cordially,

Ernest O. Lawrence

EOL:B
CC Major General L. R. Groves

P.S. One of the pleasures in getting your recent telegram was the indication that you are back on the job again. I shall look forward to dropping in on you the next time I am in New York.

Needless to say, all of us are now hoping to get on with the giant cyclotron construction -- for in the light of recent developments it promises to be of far greater importance than we envisaged before the war.

E.O.L.