

F-53
X
c/o Clarendon Laboratory
Parks Road
O X F O R D

8th August 1936

Dear Giannini,

I ought to have answered your letter (April 20th 1936) before and have to apologize for not having done so. I am writing this only to inform you that after your departure I have made no attempt to do anything further towards the creation of some sort of organisation. Patents like those which I have taken out should not be considered as my private property and I am reluctant to dispose of them as if they were mine. It is probably best to wait until some other physicists take an interest in such matters and are willing to share the responsibility for the steps which have to be taken.

I shall be very interested to hear how your plans have developed since I last saw you. Do not follow my bad example and keep me informed as far as possible. I am convinced that we shall be able to co-operate in some form if practical applications of real importance materialize.

With kind regards

Yours very sincerely,

(Leo Szilard)

P.S.

I shall be working in Oxford over the holidays and if you should pass through England do come and see me.

c/o Clarendon Laboratory,
Parks Road,
Oxford.

27th May, 1936.

Dear Dr. Oliphant,

You may still remember that I visited you about two years ago shortly after Fermi's first discoveries, and told you about certain patents connected with the Fermi effect, for which I have applied. The question now arises what to do with these patents which obviously cannot be considered as my property. I should very much like to have on these matters and also on some unpublished experiments the opinion of some of you. I may be in Cambridge over the weekend, and may enquire on Saturday or Monday, whether you are about and happen to be free.

With best wishes,

Yours sincerely,

R-1 (extra)
Sent to Tabin 10/24/67

Sir,

I wish to draw attention to the theoretically possible transmutation processes of a special type and indicate simple experiments which could lead to their detection. The energy liberated in a process of this type may very well be large as compared to the energy input required for the maintenance of the process, and if it is used for the generation of power we may have an active power balance. By radiating a metastable element with neutrons it may prove to be possible to maintain a process in which collisions of neutrons with nuclei of the metastable element lead to a transmutation of the latter which does not stop the neutron from further remaining active in the process but increases the average energy of number of the neutrons.

We have reason to believe that there exist metastable elements apart from those elements which betray their metastable character by their radio-activity, ^{seems to be} The mass of Beryllium ^{is} ~~is~~ ^{is} sufficient to allow its spontaneous disintegration into two alpha particles and a neutron, which is apparently inhibited under ordinary conditions. Such inhibition may, however, be lifted in a nuclear collision with a neutron; a neutron hitting a Beryllium nucleus would then liberate energy without getting captured and could go on hitting efficiently further Beryllium nuclei, the total number of its efficient collisions, and the total amount of the liberated energy being determined by the geometrical conditions only.

$Be + n = "Be" + n + Energy.$
"Be" would be an isomer of Be, which would or would not break up into parts.

Additional neutrons could be liberated along some such chains, which will then be called multiplicative chains in this note.

A metastable element must necessarily be involved in a chain in which only one kind of ^{non-positive} ~~positive~~ nucleus, for instance only neutrons form the links of the chain.

It is theoretically possible to maintain chains in mixtures of stable elements and also in certain pure stable elements if two different kinds of non-positive nuclei form the links of the chain, but there is no conclusive evidence as yet showing that negative protons or neutrons of the mass number two which could, together with the neutron, serve as links in such chains have been actually generated in the laboratory.

If we surround a neutron source with a closed layer of a material in which a chain reaction is maintained by the source we can theoretically liberate an unlimited amount of energy and in the case of a divergent chain also an unlimited number of neutrons. In order to get some idea of the geometrical conditions in which a stationary ^{and} process can be maintained for a divergent chain/ of the orders of magnitudes involved we wish to consider a closed spherical layer in which such a chain is maintained by a neutron source placed in the centre of the hollow sphere. In a stationary process ^{within the layer} the density of the neutrons is sufficiently well described for our purpose as a function of the radius r by the equation

$$d(r)/dr + 3f/r = 0$$

where λ is the mean free path of the neutrons for nuclear collisions in the layer and f is the fraction of the nuclear collisions that yield an additional neutron. This equation holds in the case of spherical symmetry under assumptions which may be sufficiently closely realized if λ/r and f are both sufficiently small ^{within} the layer.

If r is the outer radius of the spherical layer and r_0 its inner radius, stationary solutions are possible if the thickness of the layer $r - r_0$ does not exceed a certain

critical value. If the neutrons can freely escape from the outer surface $r = R$ the value l of the critical thickness is for large R close to

$$l = \dots$$

For $R = 10$ cm and $f = 1/100$ we get for instance l of the order of magnitude 100 cm.

The number of neutrons radiated into space from the outer surface tends to be some infinite if the thickness of the layer approaches the critical thickness. If we exceed the critical thickness no stationary solution is possible and we would get an explosion. At about $2/3$ of the critical thickness the number of the neutrons radiated by the source is only doubled by the chain reaction.

Suggested Experiment.

It would be possible to detect for any given material whether it is able to increase the energy or number of the neutrons by experiments in which the neutrons are scattered in the test material. The elastic scattering in the material causes some difficulty as it may hide the "inelastic" effect in which we are interested. If, however, we surround a neutron source the emission of which has spherical symmetry, by a spherical layer of the test material the elastic scattering in the layer will not upset the spherical symmetry and will, therefore, not affect the total number of neutrons going through any point outside the layer. Yet the elastic scattering greatly affects the angular distribution, going through any point which is close to the scattering layer, and can therefore falsify our measurements. It may for instance be very convenient to use for such ~~measurements~~ ^{make our purpose of} the Fermi effect and draw conclusions on the number and energy of the neutrons from the activity induced by the neutrons in bodies built of suitable elements placed close to the scattering layer. If such bodies have for instance the shape of a sheet and are placed close to the scattering

By measuring the total number of neutrons going through such a given point and comparing the value in the presence of the test material and in its absence we could theoretically at least obtain useful information. Yet the elastic scattering greatly affects the angular distribution, going through any point which is close to the scattering layer, and can therefore in practice falsify our measurements. It may for instance be very convenient to make use for our purpose of the Fermi effect, and measure the activity induced by the neutrons in bodies built of suitable elements placed ~~around~~ ~~in~~ ~~the~~ ~~neutronizing~~ layer and draw conclusions on the number and energy of the neutrons going through these bodies. Yet if such bodies have the shape of a sheet and are placed close to the scattering layer (in fact and it may be necessary to place them close to the layer in order to induce an activity that will yield a large number of impulses in an electron counter, sufficiently large to detect changes of 1% in the energy or number of the neutrons), the elastic scattering by affecting the mentioned angular distribution will greatly affect the observed induced activity. This difficulty can be removed by using a large number of small spheres of the material which is to be activated and replacing by them the above mentioned sheet.

There is very strong theoretical evidence in favour of the assumption that ^{for} some of the heavy elements which have a Fermi effect of a certain type the activity induced by slow neutrons will strongly increase with increasing neutron energy. This would make it possible to detect a change in the neutron energy by measuring the ratio of the activity induced in several elements.

A systematic investigation of the ^{non-}elastic scattering of the elements would not be expensive. If material for a suitable chain reaction were to be found thereby the ratio of the immediate economic value of the proposed investigation to its expense would exceed 10.

F-53 X

G. M. GIANNINI & CO., INC.

30 ROCKEFELLER PLAZA

NEW YORK

Circle 7.5895-96
Cable AMITARAD

April 20, 1936

Dr. Leo Szilard
Clavendon Laboratory
Oxford, England

Dear Dr. Szilard:

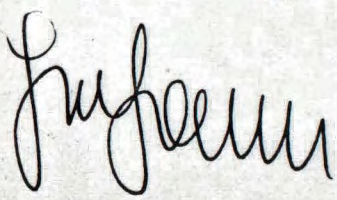
I have been waiting to hear from you on the subject of our conversations, but I have received as yet no news.

I would appreciate very much if you will be kind enough to let me know about your pending plans, so that I may eventually draw up an agreement along the lines suggested and send it to you for your examination and approval.

I am still very much interested in a corporation with you and it may interest you that at the present time I am working on plans for the formation of an independent laboratory on radioactivity, which may eventually develop into an industrial unit. The plan is very similar to the one you had for England, although a different scope.

Waiting to hear from you, I am,

Yours very sincerely,



GMG:MG

R-1

c/o Clarendon Laboratory,
Parks Road,
O x f o r d .

1st April, 1936.

Dear Segrè,

Many thanks for your letter of March 21st. Please let me know when you reach a decision in Rome about the question of "patents". Could you please convey to the others some of the following points of view and suggestions which I am tentatively putting forward. Perhaps you could bear them in mind when you are discussing this thing in Rome at Easter.

Point 1. Let us first envisage the possibility that practical applications in the field of nuclear physics will become so important that an attempt to exercise some measure of control over them through disinterested scientists will appear to be justified. In order to achieve this, some sort of association could then be brought into existence to which we could all hand over our patents, so that most of us should be able to remain more or less aloof.

Such an association need not follow the example of the Research Corporation (New York) by mixing manufacturing activities and the promotion of science. It could confine its activities to bringing about a co-operation between industry and scientific research along the following lines:

The association could grant non-exclusive rights for the use of its patents to manufacturers under the condition that they contribute to a fund which is used for promoting further research and on the further condition that the manufacturer does not block the way for others by patents of his own. The funds which are available could be used for carrying out systematic investigations in University laboratories which fit in well with the work already carried on in such laboratories. The results of such investigations ought to be

automatically available to all industrialists who contribute their share to the research fund of the association. Perhaps it is possible to avert in this way competitive research into nuclear physics in industrial laboratories.

2. It may very well be that no important applications of nuclear physics may arise and in this case none of us will be willing to take much trouble about these patents. Unless, however, we are willing to take the trouble involved in their proper administration and in the proper administration of the funds which would be forthcoming, I for my part would rather withdraw the patents which I have taken out, than let them float about in an irresponsible way.

At present we do not know whether or not the practical applications will be sufficiently important for us to go out of our way and exercise some sort of control over the patents. The question therefore arises what should be done until we can decide about the proper course of action.

It seems to me that in the meantime we could ask some men like Chadwick, Cockroft or Fermi, or at least two of them, to accept the responsibility for whatever action is in the meantime required and jointly to decide each issue which arises.

If we think that it is justified to raise funds for further research we may attempt to do so and I have been in touch with some private persons who may or may not be willing to contribute towards such a fund. In my personal opinion we might feel justified in suggesting that a fund of £5,000 should be created and that this fund should be spent on research in the course of the next three years. It should be used to carry out investigations which fit in well with our present work, but which have a more direct bearing on possible practical applications. There are three main ways in which such a fund could be used for the present:

- a) For hiring radium and providing certain laboratories which are badly off in this respect with steady

sources of neutrons (radium properly mixed with beryllium).

- b) For salaries of young physicists who could carry out certain systematic measurements in one of the laboratories in which such work is already in progress.
- c) For enabling any of us to move from one laboratory to another if this is justified from the point of view of apparatus which is present in one laboratory, lacking in the other and needed for the particular experiments which now appear to be of interest.

when you see him in Rome

Please ask Fermi/to let me know if he would care to share the responsibility for the decisions which may now be required until we either withdraw the patents or find some definite form for their administration.

The question of the patents for which you are no longer free is hardly of primary importance. We ought, however, to bear in mind that it must be awkward for any scientist to have a personal income from such patents, while other scientists, who also could have taken out such patents, refrain from doing so. It is not customary to take out patents on scientific discoveries and it is hardly desirable to act against such an unwritten law unless one has reason to think that a departure is justified by unique circumstances.

Naturally, customs are different in different countries and you have at any rate really discovered something, while I have mostly taken out patents on subsequent discoveries of other people. Our cases are different, and I ~~know~~ ~~do not~~ do not think it right for me to have any financial advantages or any other privileges through patents which are connected with nuclear physics.

Please give my kind regards to all and thank your wife for her excellent German typing.

Yours sincerely,

(LEO SZILARD)

c/o Clarendon Laboratory,
Parks Road,
Oxford.

30th March, 1936.

Dear Segrè,

Many thanks for your letter. If you are now going to discuss the question of taking out patents in the field of nuclear physics with the others, would you kindly convey to them some general ^{some more} and/personal remarks of mine on this subject?

1) If a body were to exist which we could trust to administer such patents in the public interest and to use the income which may be derived from them for the promoting of further research, we could all hand over our patents to such a body and remain more or less aloof. Such a body might then grant non-exclusive rights for the use of such patents to manufacturers under the condition that they contribute to a fund which is used for promoting further research and on the further condition that the manufacturer does not block the way for others by patents of his own. The funds provided in this way could be used for setting up systematic investigations which fit in well with the work already in progress in university laboratories, but which may have a more direct ~~application~~ bearing on practical applications. The results of such investigations ought to be automatically available to all manufacturers who contributed their share to such a research fund.

For example, if such a fund existed, it could now be used for the hiring of radium (mixed with beryllium) for use in laboratories which are badly off in this respect. With a view to medical applications, a systematic investigation of long half-life periods and gamma-ray emission could be started in some laboratory where it fits in well with the work already in progress etc. etc.

2) No such body at present exists in Europe, though the American Research Corporation is based ^{on} more or less ~~on~~ similar ideas.

Since we are not certain that important applications of our patents at present exist and that funds will shortly be forthcoming, we cannot very well take steps to create such a body. We could, however, in the assumption that such important applications will arise later, ask two of such men like Chadwick, Cockroft or Fermi to act as trustees in this matter, jointly to decide about these patents if any decision is required and jointly to decide about the use of funds for further research if any funds are forthcoming.

3) I am unable to consider the patents which I have taken out as anything but public property. The only right way for me to deal with them therefore is to hand over the responsibility for whatever happens to them in future to those on whose preceding discoveries these patents are based or whose subsequent discoveries the patents anticipated.

This was my intention right from the beginning when I applied for these patents between March and September 1934 and my chief motive was not so much the idea that these patents should be used for raising funds for research purposes, as the belief that in case of revolutionary applications of nuclear physics an attempt should be made to exercise some measure of control by disinterested scientists.

It is quite obvious that we cannot consider such patents as my private property. The one contribution which is made towards practical applications is the method for the chemical concentration of radio-active isotopes. The rest of the patents is based on preceding discoveries of others or is foreshadowing subsequent discoveries of others. It is impossible to think of any practical application which would not make use of discoveries of physicists who publish their results, but who did not wish to patent them and in these circumstances it is out of the question for me to derive any privileges from the small contribution which I may consider is really mine and the only proper course is to hand over the control of the patents to some persons who might claim the right and to whom

we may impute the duty to take control in such matters.

Unfortunately I am in the meantime in the uncomfortable position of a man who during a fire (either real or existent perhaps only in his imagination) tries to remove some jewellery which does not belong to him to some place of safety. Some passers-by who meet him in the street with the jewellery in his hands must inevitably take him for a thief, even if they are too well-bred to say so. While I am quite prepared to face this if necessary, you will appreciate that I should like to get out of this situation as quickly as possible.

Bl. for No. 1

D

Please address reply—
THE DIRECTOR OF NAVY CONTRACTS,
ADMIRALTY,
LONDON, S.W.1,



Telegraphic Address:—
CONTRACTS, ADMIRALTY, LONDON.
Telephone No. WHITEHALL 9000, EXTENSION. 70.

and quote—
C.P. Branch 10.
Patents 8142/36.

ADMIRALTY,
LONDON, S.W.1.

26 March, 1936.

Sir,

With reference to your letter dated 25th March I note that you are in agreement with the terms of paragraph 2 of Admiralty letter dated 24th March, C.P. Patents 8142/36 and that you are agreeable to the certificate of secrecy being lodged. Arrangements to lodge this certificate have now been made.

It is confirmed that the patent will be reassigned to you if and when secrecy of the patent is waived.

I am, Sir,

Your obedient Servant,

[Handwritten signature]

[Handwritten initials] DIRECTOR OF NAVY CONTRACTS.

L. Szilard, Esq.,
C/o Clarendon Laboratory,
Parks Road,
OXFORD.

✓

36.5.18

o/o Clarendon Laboratory,
Parks Road,
Oxford.

24th March, 1936.

The Admiralty,
Whitehall,
S. W. 1.

For the attention of H.G. Law, Esq. - C.P. Branch 10.

Sir,

I thank you for your letter of March 20th and I beg to state that paragraphs 3, 4 and 5 are not acceptable to me, since they limit my freedom of action not only as far as the manufacturing of war materials goes, but also as far as the commercial exploitation of other material goes, which has no connection whatever with war material. Also these paragraphs would limit my freedom of action in relation to my scientific publications and my private communications to other scientists.

I am returning to you the deed of assignment which you have sent me and I am signing it on the understanding that I have, from the day of assignment on, your permission to communicate my invention to others except as follows:-

1) I must not allow premature publication of any patents which I have filed or which I may file in the United States of America or in countries belonging to the British Empire on the subject of this invention. I shall defer their publication as long as possible ~~without abandoning these patents and at least for two years from~~

as possible without abandoning these patents and in any case at least for two years from the date of acceptance of the present English patent (March 30th, 1936).

2) I must not have any patents on file in countries other than those belonging to the British Empire and the United States of America until March 1st, 1937. I may file patents in some such countries after that date if I am satisfied that no useful purpose would be served by further secrecy, but before doing so, I would inform the Admiralty that in my personal opinion the secrecy of the present English patent ought to be waived.

3) I must not, without an explicit permission of the Admiralty in each case that might arise, approach any person for the purpose of developing the invention for purposes of war or of starting manufacture of war material on the basis of the invention.

A further understanding on which I^{am} signing the deed of assignment is the following: If a manufacturer shall want to enter into a license agreement under the present patent, I shall be free to set such terms as seem to me advisable and you will grant a license under such terms to him, making royalties or other considerations payable to me or my nominee if, for reasons of secrecy, you do not wish to re-assign the patent to me. This, however, is subject to the proviso that you are satisfied that the manufacturer is not likely to exceed the limits set by the proposed agreement by manufacturing war material, or, alternatively, if the proposed agreement foresees the manufacture of war material, that there is no objection to the agreement from the point of view of national defence.

I shall be very pleased if this is convenient to you and I should appreciate it if you would confirm it.

Alternatively, if this is not acceptable to you, I would ask you not to make use of the deed of assignment and in this case I should appreciate it if you could advise me by Saturday, the 28th of March.

In explanation of the above I may add that I am fully aware of the fact that there would be no point in sealing the British patent secret if I were not to do my best in every other respect to keep the subject matter secret and I shall take all precautions which are possible in the circumstances. I wish, however, to retain full freedom as far as my scientific publications and private communications to other scientists are concerned and wish to remain free to decide on each case which arises, according to the circumstances and to the best of my knowledge. It is also essential that I should not be limited in my efforts to raise funds for further research work from private persons or manufacturers who are interested in promoting industrial development along the lines of the present invention.

I am, Sir,

Yours very truly,

(LEO SZILARD)

P.S. Paragraph 4 on Page 2 is, of course, subject to the further proviso that no financial or other obligations should arise to the Admiralty from granting a license under the proposed license agreement.

c/o Clarendon Laboratory,
Parks Road,
Oxford.

19th March, 1936.

Dear Segrè,

I was very pleased to see Giannini about whom you wrote to me and I believe that his co-operation might be of very great value at some later date. For the present I am inclined to think that the manufacturing of radio-active elements would be somewhat premature.

It is quite conceivable, however, that nuclear physics will find important applications in a not too distant future and we may as well make up our minds now whether we ought to keep aloof or whether we are to take out patents now and, if so, to what use they ought to be put.

I feel that I ought not to consider any patents in the field of nuclear physics as my private property and that, if important applications become possible, such patents should be used along the lines indicated in my letter to Fermi, of which I sent you a copy. If possible, they should be administered by the same men who made the discoveries to which the patents relate. ~~On the other hand~~ ~~if the possible applications are not sufficiently important~~ If, however, the applications are not sufficiently important to bother about the administration of such patents, we may as well withdraw them, rather than have them float about.

Here are a few comments on a question of principle on which we ought to make up our minds. The patent law in its present form make it possible to practise piracy of the worst kind. Let me illustrate this with my patent of March 12th, 1934, which protects the generation of radio-active elements by neutrons, i.e., the Fermi effect. The patent law does not require that one ^{should} perform an experiment and demonstrate the effect before applying for a patent. All it requires is that one should describe a process and state that it is workable; obviously it invites to piracy and this particular

patent is a clean cut example of it.

But even if I had actually performed the experiment and discovered the Fermi effect - which I certainly did not do - I should still feel unable to consider this patent as my private property. It may make some difference, but hardly a very big one, whether we take out a patent for the future discoveries of others or for the past discoveries of our own. As long as we take out patents at all, we may as well play the game according to its rules and formulate the patent to include everything that anybody may discover in the next hundred years.

c/o The Clarendon Laboratory,
Parks Road,
OXFORD.

11th March, 1936.

Dear Mr. Giannini,

I should be very pleased to see you.

I am living in Oxford - my private address is 8, Keble Rd,
and I am working at the Clarendon Laboratory, Parks Rd.
My telephone numbers are Oxford 2826 (private) and 3545
at the Laboratory.

My movements in the next few days are
somewhat uncertain, and I may be in London when you arrive.
If I am in London, I am staying at the Harewood Hotel,
74, Gower Street, Telephone No. Museum 3941.

I believe it would be most convenient
for both of us if you would send me a wire both to my
Oxford and my London addresses as soon as you arrive in
London and let me know your London address and telephone
number; I would then telephone you and we could make an
appointment. It might be advisable for us to meet not
later than the 17th.

Should you be in London for the first
time, you might like to know something about Hotels. I
believe you would find the Warldorff Hotel, Kingsway,
quite convenient, or if you want a more expensive hotel

you would probably find Grosvenor House, Park Lane,
satisfactory.

Looking forward to seeing you soon,

I remain,

Yours faithfully,

G. M. Gianni, Esq.,
Hotel Royal,
BIRNHOVEN.
HOLLAND.

R-1 X

COPY

March 8th 1936.

Dear Mr. Szilard,

Last summer I wrote you asking for some information about your artificial radio-activity patents and received no answer: probably the letter was improperly addressed. I must therefore introduce myself: I am a pupil of Prof. Fermi of Rome, and studied with Amaldi, Segre and Rasetti whom you will know either personally or by name. I am now a consultant physicist and engineer in New York.

There I am handling some patents on artificial radio-activity taken by Fermi and his collaborators. A few days ago I was in Rome and understood by Amaldi and Segre that you have met several times.

Now their applications and patents, fortunately enough, do not interfere with yours, namely the 440,023, but rather complete each other. I think therefore that it would be useful for us to meet. It may interest you that we are organizing in the U.S. a company for the manufacture of substances covered by some of our applications.

I am travelling Europe and am quite pressed. I expect to be in London the 16, 17, 18, 19; Segre tells me that you are at the Clarendon Laboratory in Oxford, but he was not positive. We could meet in London if this is convenient to you, or otherwise I may come to Oxford or wherever you may be. Would you be kind enough to write or telegraph me an appointment for any of the above days to Hotel Royal, Rindah weg, Holland, by the 18th?

Looking forward with pleasure to meeting
you,

I remain,
Yours very truly,

From G.M. Giannini
(K.W.)