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REMARKS TO MR. DRUMOND'S LETTER OF JULY 20, 1949
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(1) Prior Publication.

The pertinent passage in the article published by F. Joliot and I. Curie which antedates my patent application of March 12, 1934 reads as follows :

"These elements and similar ones may possibly be formed in different nuclear reactions with other bombarding particles; protons, deuterons, neutrons. For example, N^{13} could perhaps be formed by the capture of a deuteron in C^{12} followed by the emission of a neutron." (Underlining by me, Szilard.)

It seems necessary to discuss what Joliot meant by the expression "These elements and similar ones". The radioactive elements produced by Joliot were all produced from a natural element by a process in which a heavy particle (i.e. an alpha particle) is absorbed by the nucleus and another heavy particle (i.e. a neutron) is emitted. Joliot in suggesting that a neutron might be used as the bombarding particle had in mind that a neutron might enter the nucleus of a natural element and another heavy particle, e.g. a proton or an alpha particle might be emitted. He was not sure that even this will in fact place and hence the use of the word "possibly".

If one thinks of processes of this type and if one uses neutrons of a few million volts and does not go to neutrons of exceedingly high energy (such as are available to-day but were not available in 1934) one does not expect that neutrons should produce radioactive elements from heavy elements for the so called Coulomb barrier will not permit processes of this type in heavy elements.

As one goes from light elements ^{to} heavier elements the cross section

for the production of radioactive elements by neutrons by means of the process considered by Joliot diminishes and it becomes practically zero for elements heavier than zinc. When Fermi and his group towards the end of March 1934 exposed heavy elements to neutrons and saw that they became radioactive they were most surprised and were for a short time at a loss for an explanation. Neutrons of a few million volts energy produce radioactive elements from heavy elements by a process different from that envisaged by Joliot, i.e. they produce radioactive elements by entering into the nucleus and causing emission of a gamma ray rather than the emission of a heavy charged particle.

My point is that - prior to Fermi's discovery at the end of March 1934- those versed in the art were led to expect that only light elements will yield such radioactive elements from natural elements under neutron bombardment.

The first statement that it is possible to produce radioactive substances from heavy as well as from light elements is contained in lines 94 and 95 of page one of my application of March 12, 1934.

(2) Proposal to replace the present claim one by an amended claim:

In order to amend the present first claim so as not to cover what - on the basis of Joliot's suggestion - anyone versed in the art might have expected to happen and also in order to meet other ~~xxxxxxxx~~ conceivable objections I propose ~~an~~ amended claim along the following line:

a) The new claim should cover only the production of radioactive elements from natural elements by neutrons of moderate energy (say an average energy below five million volts).

b) The new claim should cover only the production of radioactive elements from natural elements by means of exposing to such neutrons

a thick layer of substance containing heavy elements (or if permissible we could say "at least one heavy element").

c) The new claim might, if desirable, contain a definition of the term "thick" as meaning "of the order of magnitude of the mean free path of the neutron for causing nuclear transmutation in the substance".

(3) Discussion of the above outlined amended claim.

a. Does the patent contain a patentable invention described in the specification?

In my opinion the patent contains the invention that radioactive elements will be produced from the heavier elements by means of neutrons of moderately high energies. This could not have been anticipated on the basis of Joliot's work and the opposite was in fact believed by those versed in the art. We ought not support the proposed amendment on the ground that the bombardment of heavy elements leads to more desirable radioactive elements than the bombardment of light elements but rather on the ground that it leads to different radioactive elements. Each such radioactive element has unique properties, and the production of radioactive elements by means of neutrons of moderate energy ~~XXXXXXXXXXXXXXXXXXXX~~ - other than those obtainable by the bombardment of light elements - is of value and an advance beyond what those versed in the art considered possible on March 9, 1934.

b. Does the invention lack definiteness?

It is true that my patent application does not assert about any one specific element that it will in fact transmute into a radioactive element. But the application treats the transmutation of natural elements into radioactive elements under the action of neutrons as if it were the rule rather than

the exception. It happens to be a fact-~~as we have already shown~~ that if a thick layer of any natural element is exposed for a sufficiently long time to a sufficiently strong neutron radiation radioactive elements will make their appearance in the layer because the element will capture neutrons and if the resulting new element is not radioactive it will accumulate in the layer and in turn will capture neutrons producing another new element and so forth and so forth until the original natural element has been built up to the point where it becomes radioactive. In this sense it may be said that the prescription contained in lines ~~20~~⁴⁶ to 55 of the second page of the patent application of March 12 does ^{/not} have the purpose of determining which of the natural elements yields some radioactive element but rather to determine which of the natural elements yields the one radioactive element we wish to produce (~~see lines 48, 49 and 50 of page two of the patent application~~), e.g. the one which has the desired half life period.

Moreover, in a mixture of elements, as described in lines 20 to 26 of page two of the patent application, in which the heavy elements preponderate by weight because they are included in masses proportional to their atomic weight, a large fraction of the neutrons will be absorbed by elements that will transmute directly into radioactive elements.

It seems to me that the prescription given in lines 21 to 45 of page two of the application of March 12, 1934 for the production of radioactive elements from heavy natural elements is perfectly workable without requiring any further inventions or discoveries. According to this prescription a mixture of elements, in certain proportions, is exposed to neutrons. It is a matter of routine chemistry to separate out from such a mixture - after bombardment - the individual chemical elements. It is a matter ^{of} routine measurements to determine, for each such element, its

half life period . To offer all these radioactive elements for sale , to let the market determine which one of them is in demand and to leave out subsequently from the mixture those of the natural elements which do not lead to radioactive elements that are in demand - appears to be perfectly acceptable commercial procedure that could be carried out on the basis of the prescription contained in the specification.

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