

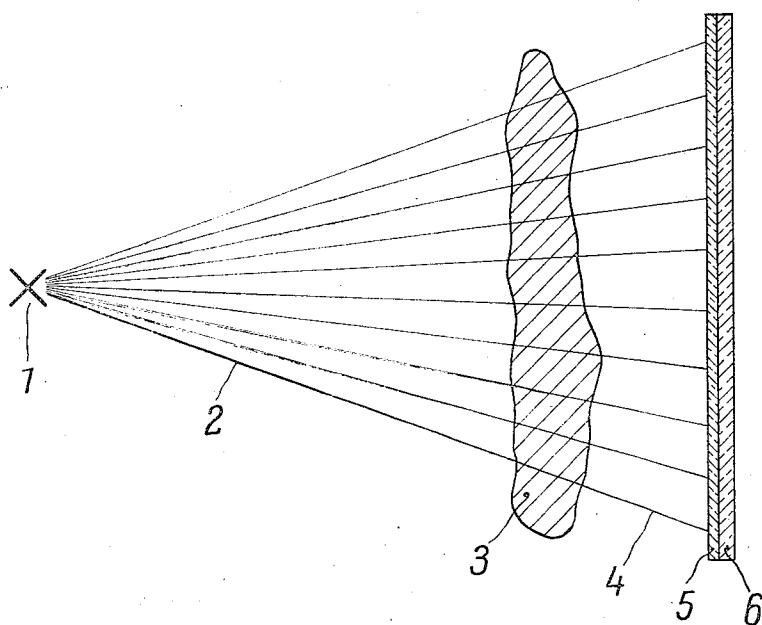
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METHOD FOR THE INVESTIGATION OF SUBSTANCES WITH THE AID OF NEUTRONS

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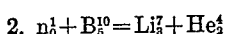
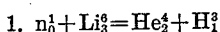
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17 Claims. (Cl. 250—65)

The present invention relates to improvements in methods of, and means for, investigating objects or substances with the aid of neutrons.

It has already been suggested to investigate substances by depicting them with the aid of neutrons. This investigation may be carried out by directing a beam of neutrons through the body or substance under investigation and causing the neutrons that emerge from it to encounter a layer in which heavy charged particles or electrons (+ and -) or gamma rays are produced under the action of the impinging neutrons upon an element, contained in said layer, which is reactive toward neutrons. These particles are in turn caused to act upon a layer of fluorescent material, or an adjacent photographic layer or a combination thereof, thus depicting the investigated body or substance visibly or photographically. Neutron reactive layers particularly suited for this purpose are, for instance, such containing lithium or boron. In these two substances the following reactions take place under the influence of the impinging neutrons:



In the lithium or lithium compounds existing in nature the contents of the effective Li_3^6 amounts only to about 10%, and in the boron and boron compounds existing in nature the contents of the effective B_5^{10} amounts only to about 20%. The main mass of these elements consists of Li_3^7 , or B_5^{11} , respectively.

It is an object of the present invention to increase the sensitiveness of the above-mentioned method of depicting objects by means of neutrons. Another object of the invention is to provide improved means for depicting objects by means of neutrons.

This inventive object is attained by using as neutron reactive layer containing an element in which the neutron reactive sort of isotopes is enriched beyond the proportion corresponding to the natural distribution of this isotope in the respective element. Using the above mentioned special reactions the neutron reactive sorts of isotopes being artificially enriched are Li_3^6 or B_5^{10} . The enrichment may be accomplished by any of the known methods for separating or concentrating isotopes, i. e. diffusion, mass spectrograph, electrolysis and chemical processes.

With a given intensity of the neutron radiation the number of the emitted heavy particles and therewith the blackening of the photographic plate, or the excitation of the fluorescent

screen respectively, is, determined not by the thickness of the intermediate layer, but by the range of the heavy particles liberated from said layer if the thickness of said intermediate layer is larger than said range. The number of the heavy particles emitted per neutron is the greatest if within a layer adjacent to the surface the thickness of which corresponds to the range as many neutrons as possible cause the emission of heavy particles by collision with neutron reactive atomic nuclei. As in general within a layer the thickness of which being equal to the range of said particles only a small fraction of the neutrons passing through liberate heavy particles, it is extremely important, as regards the output, to provide in said layer as many neutron reactive atomic nuclei as possible. An increase of the number of the neutron reactive atomic nuclei is obtained, by artificially enriching the intermediate element with Li_3^6 or B_5^{10} , respectively, beyond the proportion of its natural distribution in the respective element.

This method can advantageously be used also in connection with intermediate layers which do not emit heavy particles, but which emit electrons or gamma rays under the action of impinging neutrons, if the mixture of isotopes of the respective element, as existing in nature, is not the most favorable one for one of said neutron reactions. Therefore, the present improved method is not restricted to boron and lithium, but it will prove advantageous with every other neutron reactive element if only a fraction of all neutrons passing through the neutron-reactive layer is being absorbed in it, or if very thin neutron-reactive layers are used, or if the neutrons in the neutron-reactive layer are also absorbed by atomic nuclei which only contribute very little to the blackening of the photographic layer, or to the excitation of the fluorescent screen respectively by the emission of particles or gamma rays. The present improved method becomes particularly important if the neutron reactive element is applied as an emulsion upon the photographic layer or upon the fluorescent screen. Such emulsions are able to contain a small concentration of the neutron reactive element only. If, therefore the element contained in the emulsion is artificially enriched with the effective sort of isotopes beyond the proportion of its nature distribution in the respective element, an extraordinarily great increase of the sensitiveness can be attained.

Also neutron reactive layers containing cadmium may be used in which the cadmium is ar-

tificially enriched with its active isotope beyond the proportion corresponding to its natural distribution in cadmium. The isotope of cadmium to be used in each instance depends upon the neutron energy employed. The choice is made by observing which gives the greatest effect.

The accompanying drawing is a diagrammatic representation of an embodiment of the invention. The neutron beam 2 emitted by the neutron source 1 passes through the investigated substance or body 3. The emerging neutrons 4 impinge upon the neutron reactive layer 5 which is enriched with the effective sort of isotopes beyond the proportion corresponding to its natural distribution in the respective elements. In this layer 5 the neutrons liberate charged particles or gamma rays which energize the adjacent layer 6 which consists of fluorescent or photo-sensitive material thus producing a visible or photographic image of the investigated substance or body 3.

We claim:

1. In a method of obtaining an image of an object by directing a beam of neutrons upon the object, causing the emergent beam of neutrons to impinge upon a layer comprising an element which reacts with neutrons to produce radiation, and forming a visible image of said object by means of the resulting radiation, the improvement which consists in using a neutron-reactive layer in which the neutron-reactive element thereof has been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element.

2. In a method of obtaining an image of an object by directing a beam of neutrons upon the object, causing the emergent beam of neutrons to impinge upon a layer comprising an element which reacts with neutrons to produce radiation, and forming a visible image of said object by means of the resulting radiation, the improvement which consists in using a neutron-reactive layer in which the neutron-reactive element thereof has been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element and in which the neutron-reactive isotope-enriched element is contained in said layer in the form of an emulsion.

3. In a method of obtaining an image of an object by directing a beam of neutrons upon the object, causing the emergent beam of neutrons to impinge upon a layer comprising an element which reacts with neutrons to produce radiation of charged particles, and forming a visible image of said object by means of the resulting radiation, the improvement which consists in using a neutron-reactive layer in which the neutron-reactive element thereof has been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element.

4. The invention defined in claim 3, in which lithium which has been enriched with Li^6 beyond the proportion of its natural distribution in lithium constitutes the neutron-reactive element employed.

5. The invention defined in claim 3, in which boron which has been enriched with B^{10} beyond the proportion of its natural distribution in boron constitutes the neutron-reactive element employed.

6. A device for forming an image of the distribution of the intensity of a beam of neutron which comprises a layer containing an element which reacts with neutrons to produce radiation, said element having been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element, and a substance sensitive to emitted radiation.

7. A device for forming an image of the distribution of the intensity of a beam of neutron which comprises a layer containing an element which reacts with neutrons to produce radiation, said element having been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element, and a layer containing a substance sensitive to emitted radiation.

8. A device for forming an image of the distribution of the intensity of a beam of neutron which comprises a layer containing an element which reacts with neutrons to produce radiation, said element having been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element, and a layer comprising fluorescent material sensitive to emitted radiation.

9. A device for forming an image of the distribution of the intensity of a beam of neutron which comprises a layer containing an element which reacts with neutrons to produce radiation, said element having been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element, and a layer comprising photosensitive material sensitive to emitted radiation.

10. A device for forming an image of the distribution of the intensity of a beam of neutrons which comprises a layer containing an element which reacts with neutrons to produce radiation of charged particles, said element having been enriched with a neutron-reactive isotope of said element in an amount greater than the proportion of its natural distribution in said element and a substance sensitive to emitted radiation.

11. The device defined in claim 10, in which the neutron-reactive element is lithium which has been enriched with Li^6 beyond the proportion of its natural distribution in lithium.

12. The device defined in claim 10, in which the neutron-reactive element is boron which has been enriched with B^{10} beyond the proportion of its natural distribution in boron.

13. The device defined in claim 6, in which the neutron-reactive isotope-enriched element is contained in said neutron-reactive layer in the form of an emulsion.

14. A method of obtaining an image as defined in claim 1 in which the radiation is gamma radiation.

15. A method as defined in claim 1 in which the element is cadmium.

16. A device as defined in claim 6 in which the radiation is gamma radiation.

17. A device as defined in claim 6 in which the element is cadmium.

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