March 14, 1944. H. I. KALLMANN ET AL 2,344,042

NEUTRON IMAGE CONVERTER

Filed July 3, 1941

Fig. 1.

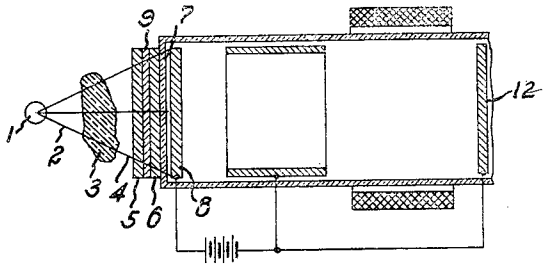


Fig. 2.

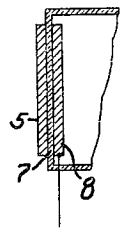
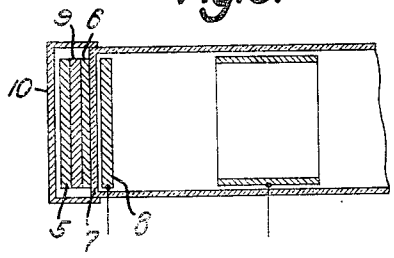


Fig. 3.



Inventors:
Hartmut Israel Kallmann
Ernst Kuhn
By Pierce & Scheffler
Attorneys.

Patented Mar. 14, 1944 2,344,042

UNITED STATES PATENT OFFICE

2,344,042

NEUTRON IMAGE CONVERTER

Hartmut Israel Kallmann, Berlin-Charlottenburg, and Ernst Kuhn, Berlin, Germany; vested in the Alien Property Custodian

Application July 3, 1941, Serial No. 401,038
In Germany March 15, 1940

5 Claims. (Cl. 250—65)

A device for the production of visible or photographic images of objects with employment of neutrons as depicting radiation has been proposed, in which in a neutron-reactive layer heavily charged particles or electrons are produced by the depicting neutrons, and these charged particles or electrons release in the neutron-reactive layer or in a neighboring layer slow electrons, which are accelerated by electric fields and, after they have passed through an electron-optical system, produce a picture on a luminescent screen or on a photographic layer. With this device it is possible to produce pictures very rich in contrast even with a neutron radiation of low intensity.

In the production of such a neutron-image-converter difficulties are caused by the fact that the neutron-reactive layer and the layer from which the slow electrons are released react the one with the other in undesired manner during the production of the image-converter, for instance during the baking out of the vacuum tube. Some neutron-reactive layers also partly lose their efficiency during the heating to the higher temperatures which cannot conveniently be avoided in the course of the production of the image-converter.

It is an object of the present invention to obviate these difficulties involved in the production of the apparatus formerly described. For this and other inventive purposes the neutron-reactive layer is positioned outside the vacuum space, and at this point the wall of the vessel is made transparent to the radiation serving for releasing the slow electrons.

In a neutron-image-converter, in which the heavily charged particles or electrons produced in the neutron-reactive layer by the depicting neutrons release in a neighboring luminescent mass a radiation, which in turn releases slow electrons in a neighbouring layer, it is advisable under certain circumstances to position the luminescent mass also outside the vacuum tube. For intensifying the effect, a surface which reflects the radiation emitted by the luminescent mass and transmits the charged particles which excite the luminescent mass, is preferably provided on the side of the luminescent mass remote from the vacuum space.

For reducing unsharpness and losses from reflection on the wall of the tube, it is advisable to apply directly upon the wall the neutron-reactive mass or the luminescent mass, or, if desired, both masses mixed together.

If in the neutron-reactive mass electrons are produced which in turn have to release slow electrons in the interior of the vacuum space from another layer, the wall of the tube at this point must transmit the electrons released from the neutron-reactive layer.

Some substances for the neutron-reactive layer, for instance metallic lithium, are especially affected by moist air, so that their efficiency decreases gradually. For increasing their durability it is therefore advisable in such masses for neutron-reactive layers and similar sensitive luminescent masses, to house the neutron-reactive mass, if desired together with the luminescent mass and the reflecting layer, in the interior of a closed space adjoining the wall of the vacuum tube, said space being evacuated or filled with a gas which does not affect said substances.

Embodiments of the arrangement according to the invention are shown partly in diagrammatic illustration in the figures of the accompanying drawing, in which

Fig. 1 is a section through a complete apparatus,

Fig. 2 is a fragmentary section of a modified arrangement in which layers 6 and 9 are omitted,

Fig. 3 is a fragmentary section in which layers 5, 6 and 9 are enclosed.

Referring to the drawing, the neutron beam 2 serving for depicting starts from the source of neutrons 1 and traverses the body 3 to be depicted. The depicting neutron radiation 4 impinges upon the neutron-reactive layer 5 arranged outside the vacuum space and produces in this layer heavily charged particles or electrons. The intensity or concentration of the thus produced heavily charged particles or electrons is different from place to place according to the intensity distribution of the neutron radiation locally weakened by passage through the body 3. The heavily charged particles or electrons release in the adjacent layer 6 of luminescent mass a radiation, which passes through the wall 7 of the tube, which at this point is transparent to such radiation, into the vacuum space and releases there slow electrons from a photosensitive layer 8. These slow electrons are accelerated and can be collected electron-optically in a manner known per se upon a luminescent screen 12 or upon a photographic layer to produce an image of the object.

Between the layer 6 of luminescent mass and the neutron-reactive layer 5 a reflecting surface 9 may be provided for intensifying the effect, said surface reflecting the radiation emitted by the luminescent mass through this mass itself into

the interior of the vacuum space upon the photosensitive layer. This surface 8 transmits the heavily charged particles or electrons produced by the neutrons in the layer 5.

The luminescent mass and the neutron-reactive layer mass may be applied directly onto the wall 7 of the tube the one mixed with the other as well as singly.

The wall must be such that it transmits electrons in case electrons are emitted from the neutron-reactive layer 5 which, in the form of construction shown in Fig. 2, is directly adjacent to the wall, said electrons having to release slow electrons from the layer 8 which is in the interior.

In the embodiment shown in Fig. 3, the neutron-reactive layer 5, the luminescent mass 6 and the reflecting layer 9 are housed in a cap 10 directly adjacent to the wall and evacuated or filled with a gas which does not affect the said masses.

An advantage of the arrangement according to the invention consists in that, without alteration of the evacuated image-converter-tube, the neutron-reactive layer in which the heavily charged particles or electrons are produced by the depicting neutrons can be exchanged. It is therefore possible to adapt the apparatus to neutrons of different speeds with the same image-converter-tube merely by exchanging the neutron-reactive layer or luminescent mass.

As examples of the compositions of the various elements disclosed, the neutron reacting plate 5 may be of lithium where the plate is enclosed, as in Fig. 3, or boron or uranium where the plate is exposed, or it may be a composition containing these elements. Reflector 9 may be a thin sheet of white or optically opaque glass or ceramic material. There are many materials which may be employed as the fluorescent screens 6 and 12; among them are barium platino-cyanide or calcium-tungstate. The wall of the exhausted container may be of thin glass.

As a source of neutrons a device may be employed which subjects beryllium to a bombardment of alpha particles.

We claim:

1. A device for the production of visible or photographic images by means of neutrons, comprising a vacuum tube, a source of neutrons located outside the tube, a neutron reactive layer located outside the tube and adjacent a wall thereof and in the path of neutrons from said source, a luminescent mass located outside the vacuum tube and adjacent said wall, said mass being exposed to and capable of being energized by charged particles liberated by the neutron reactive layer, a reflecting surface capable of transmitting charged particles liberated by the neutron reactive layer and reflecting the radiation liberated by the luminescent mass, said surface being positioned on the side of said mass opposite that nearest to the wall of the tube, a photosensitive layer within said vacuum tube adjacent said wall, said layer being capable of liberating slow electrons under the action of the radiation transmitted through said wall, means for accelerating said slow electrons, an electron-sensitive screen and an electron optical system for focusing the electrons, after acceleration, on said screen.

2. A device as defined in claim 1 in which the wall of the vacuum tube between the neutron reactive layer and the photosensitive layer is capable of transmitting charged particles liberated by said neutron reactive layer.

3. A device as defined in claim 1 comprising a luminescent mass located outside of the vacuum tube and adjacent to said wall, said mass being exposed to and capable of being energized by charged particles liberated by the neutron reactive layer, the material constituting the neutron reactive layer and the material constituting the luminescent mass being in the form of a mixture constituting a layer on the wall of the vacuum tube.

4. A device as defined in claim 1 comprising an enclosed space outside the vacuum tube surrounding the neutron sensitive layer.

5. A device as defined in claim 1 comprising a luminescent mass located outside of the vacuum tube and adjacent to said wall thereof and an enclosed space outside the vacuum tube enclosing said luminescent mass and the neutron sensitive layer.

HARTMUT ISRAEL KALLMANN.
ERNST KUHN.