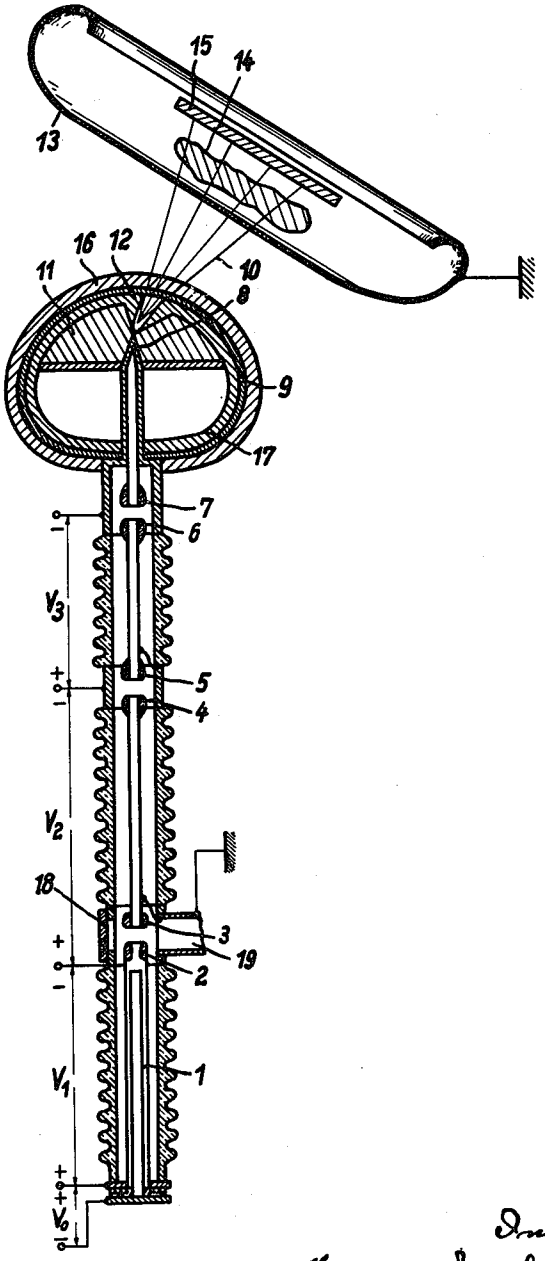
June 23, 1942. H. I. KALLMANN ET AL 2,287,620

DEVICE FOR IRRADIATING OBJECTS WITH NEUTRONS, ESPECIALLY FOR DEPICTING THEM BY MEANS OF NEUTRON-RADIATION

Filed June 8, 1940



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

Patented June 23, 1942 2,287,620

UNITED STATES PATENT OFFICE

2,287,620

DEVICE FOR IRRADIATING OBJECTS WITH NEUTRONS, ESPECIALLY FOR DEPICTING THEM BY MEANS OF NEUTRON-RADIATION

Hartmut Israel Kallmann, Berlin-Charlottenburg, and Ernst Kuhn, Berlin, Germany

Application June 8, 1940, Serial No. 339,561
In Germany June 9, 1939

8 Claims. (Cl. 250—51)

This invention relates to a device for irradiating objects with neutrons, especially for depicting them by means of neutron-radiation.

The construction of a source of neutrons with strong intensity is associated with difficulties, in that the acceleration of the preferably employed heavy hydrogen ions requires very high voltages, e. g., of the order of 1 million volts or more. A discharge tube suitable for the purpose in view consists of a source of ions, and accelerating tube having one or several accelerating stages, and of an ion-collector upon which the ions impinge and where they produce neutrons. For employing the source of neutrons it should be most convenient to connect said collector to ground, if possible. With such an arrangement all other parts of the tube would be on a very high potential relative to earth; especially the source of ions would show the full acceleration potential relative to the earth. In order to reduce the potentials occurring relative to earth it has already been suggested to ground the electrode having the middle potential and lying between those two electrodes that possess the full potential difference between each other. With this known arrangement the source of ions, as well as the source of neutrons, each has relative to earth, only one half of the whole accelerating potential. If this potential is very high, for instance 1 million volts or even more, it is with such an arrangement necessary to choose a very large distance between the source of neutrons and the objects to be irradiated, whereby the radiation intensity actually applied to the objects will be strongly reduced.

It is an object of the present invention to provide a neutron-irradiating device which is free from this drawback. This and other inventive objects are attained by arranging the source of neutrons, which source has a high potential relative to earth, inside the protection space of a discharge shield, and by housing the objects to be irradiated also inside the protection space of another discharge shield located opposite the firstmentioned one and being preferably grounded. By the expression "discharge shield" is here meant a conductive casing of the greatest possible radius of curvature and free from edges or projections which would facilitate discharge. While with the usual arrangement, if a potential of, say, 800,000 volts is employed a distance of nearly 3 meters is necessary to obviate flashing-over, the new arrangement of this invention requires under the same conditions as regards potential and earth a distance of only 40 centimeters. Furthermore, owing to the circumstance that the objects to be irradiated are likewise enclosed in the protection space of a discharge shield, there is no danger whatever for the attendants and no risk of the objects being damaged even if flashing-over should occur.

The means for slowing down the quick neutrons being preferably housed inside the discharge shield containing the source of quick neutrons are thus also protected from any damage by flashing over. Therefore the distance between the two discharge shields can be made so small that in general no flashing over occurs. It is by no means necessary to choose this distance considerably larger for reasons of safety. In general it is likewise suitable to provide the means for obtaining a narrower beam of neutrons also inside the discharge shield containing the source of neutrons.

It is frequently desirable to protect the objects to be irradiated from the action of X-rays which arise unavoidably if neutrons are produced. It is therefore recommended to provide one or both of the two discharge shields especially on their outer surface, with layers of substances capable of absorbing X-rays. If the objects are to be irradiated with slow neutrons or are to be depicted by means of slow neutrons, it is advantageous also to arrange the means for slowing down the speed of the quick neutrons also inside the protection space of the discharge shield containing the source of the quick neutrons. In order to produce a sharply limited beam of slow neutrons it is in general suitable to arrange these means in such a manner that the slow neutrons leave the discharge shield by preference from a narrowly restricted range thereof, and it is, further, more advantageous to provide additional means for absorbing the slow neutrons in the protection space, in the wall thereof, or/and upon its outer surfaces. In order to obviate a loss of intensity the thickness and the material of the wall of the discharge shield within the range where the neutrons leave said body may be so chosen that the intensity of the neutrons is as little as possible.

Furthermore, in order to make the distance between the source of neutrons and the objects to be irradiated as short as possible, it is in general suitable to place the source not in the middle of the discharge shield which is rather large in the case of the potential being high, but as near as possible to that part of the wall of the discharge shield where the neutrons leave this body.

The invention is illustrated diagrammatically

and by way of example in the accompanying drawing in which is shown a longitudinal section through a device according to this invention.

The discharge tube consists of three parts. 1 denotes the source of ions. The positive ions leave the part 1 at the end 2 and are accelerated by the field existing between this end and the oppositely located end 3. Then the ions pass through the second part, leave it at 4 and are again accelerated by the field existing between the ends 4 and 5. The ions leave the third part with a very high speed at 6, are again accelerated by the field existing between 6 and 7 and impinge now upon the intercepting member 8. This latter member is arranged within the discharge shield 9 near the part where the neutrons 10 tend to leave this body. In order to slow down the speed of the neutrons a substance 11, for example water, surrounds the intercepting member. Through a channel 12 free from the substance 11 the slow neutrons pass to the exterior of the device. They penetrate the wall of the oppositely located shielding electrode 13 and partly also the object 14 arranged behind said shielding electrode. The neutrons having traversed the object produce upon the plate 15 which is sensitive to neutrons, or upon a suitable fluorescent screen, an image of the respective object. The escaping neutrons 10 can also be used solely for irradiating the object, in which case the neutron-sensitive device 15 may be removed. The neutron-sensitive system may be formed for instance by a lithium foil covered with a fluorescent substance, or by lithium mixed with such a substance. The neutrons react with the lithium nuclei liberating heavy charged particle which excite the fluorescent substance. Or a lithium foil is arranged in the proximity of a photographic plate, in which case the emitted charged particles blacken said plate.

In order to obviate the emission of X-rays there is provided in the device illustrated by the drawing a layer 16 capable of absorbing X-rays, on the outside of the discharge shield 9. This body contains, furthermore, a lining 17 capable of absorbing the slow neutrons and consisting, for instance, of boron. The thickness of this layer is preferably very slight in the proximity of the part where the neutrons leave the body 9, or there is even provided a hole in said lining adjacent the zone of emission. If the layer absorbing X-rays allows the neutrons to pass in a satisfying degree, it is not necessary to provide also this layer with a separate aperture at the exit place. The distance between this place and the electrode 13 amounts to about 40 cm. at a potential of 800,000 volts if the electrode surface is carefully smoothed.

When designing the source of neutrons as suggested according to this inveniton it is not necessary to ground the device in the middle of potential difference, as is done with the known devices. On the contrary, it is particularly suitable to the purpose in view to effect the subdivision in such a manner that the positive electrode 3 of the appertaining accelerating stage is grounded. The device for the production of positive ions than shows only a comparatively low potential with respect to earth. This potential will never be higher than 400,000 volts relative to the earth. With such a low potential there exist no particular difficulties in insulating the auxiliary source of potential necessary for the ion-source towards the earth.

The accelereating stages, of which there are shown three in the example, have higher potential towards the earth in this arrangement than if they were grounded in the middle of the potential difference, but this is not attended with any difficulties whatever, as the acceleration stages require only such sources of potential which can be insulated in a comparatively simple manner. Thus, with a total difference of potential of for instance 1.2 million volts, the potential differences V_1, V_2 and V_3 will be chosen equal to 400,000 volts. If the total potential difference should amount to 2 million volts, it would be suitable to choose also equal to 400,000 volts and to overcome the remaining potential difference of 1.6 million with a corresponding number of stages, for instance 4. This arrangement presents, also, the further advantage that there exists near the end of the ion-producing tube the possibility of examining the centering of the beam of ions relatively to the entrance aperture of the electrode 3 and to the exit aperture 2 through the window 18 shown diagrammatically in the drawing, and of improving the centering if necessary, by shifting the electrodes with respect to one another. It may be suitable to join the high vacuum pump (not shown) to the apparatus at the place 19, as shown in the drawing.

We claim:

1. A device for irradiating an object with neutrons, comprising a source of neutrons, means for exciting the neutron source, means for maintaining the neutron source at a high potential relative to earth, a discharge shield substantially enclosing the neutron source, and a second discharge shield adapted to house an object to be irradiated, said second discharge shield being arranged opposite to the first named discharge shield.

2. A device for irradiating an object with neutrons, comprising a source of neutrons, means for exciting the neutron source, means for maintaining the neutron source at a high potential relative to earth, a discharge shield substantially enclosing the neutron source, means within said discharge shield and adjacent said neutron source for forming a sharply limited emergent beam of neutrons, and a second discharge shield adapted to house an object to be irradiated, said second discharge shield being arranged opposite to the first named discharge shield and in the path of such sharply limited emergent beam of neutrons.

3. A device as defined in claim 1, wherein at least one of the discharge shields is provided at least partially with a layer of X-rays-absorbing substance.

4. A device for irradiating an object with neutrons, comprising a source of quick neutrons, means for exciting the neutron source, means for maintaining the neutron source at a high potential relative to earth, a discharge shield substantially enclosing the neutron source, means within said discharge shield for slowing down quick neutrons, said means including a body of material capable of slowing down quick neutrons at least partially surrounding said neutron source, and a second discharge shield adapted to house an object to be irradiated, said second discharge shield being arranged opposite to the first named discharge shield.

5. A device as defined in claim 4 in which the means for slowing down quick neutrons is arranged in such a manner that neutrons pass to the exterior only through a limited area of the surface of the first named discharge shield.

6. A device as defined in claim 4 in which the discharge shield containing the means for slowing down the quick neutrons is provided with substances adapted to absorb slow neutrons.

7. A device as defined in claim 2, wherein said beam-forming means comprises a layer of slow neutron-absorbing material provided on the first named discharge shield and formed to define a neutron passageway leading from said neutron source to a zone of emergence of said discharge shield, said neutron source being disposed in proximity to said zone of emergence.

8. A device as defined in claim 2, wherein that portion of the first named discharge shield which is within the range of said beam of neutrons is composed of such material and has such thickness as to effect only a minimum of reduction in the intensity of the neutrons emergent therethrough.

HARTMUT ISRAEL KALLMANN.
ERNST KUHN.