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Neutron-Image Intensifier

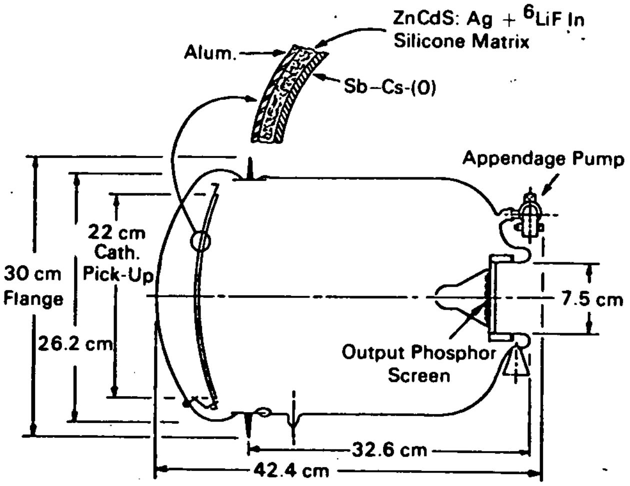

Diagram of a neutron-image intensifier tube; the expanded view shows a cross section of the neutron scintillator photoemissive target inside the tube.

The problem:

To enhance the usefulness of neutron-radiographic techniques by providing prompt display of neutron images.

The solution:

A neutron-image-intensification technique using a thermal-image intensifier tube similar to those used for detection of x-radiation. The tube, which detects and intensifies the pictorial image formed by neutrons, has a demagnification ratio of 9:1. The electronic intensifier tube comes in two sizes: one has a neutron-detection diameter of 22 cm; the other, 15 cm. In either case, a useful television signal can be obtained by optical coupling of a small-output phosphor-light image to a television camera.

How it's done:

The radiation beam is directed toward the evacuated intensifier tube, as shown in the figure, in which it is converted into light by a phosphor or scintillator layer. The emitted light causes photoelectron-emission from an adjacent photoemissive layer. These electrons are voltage accelerated toward a phosphor output screen where a small, bright, visible signal is obtained. The image is intensified in the tube by the acceleration of the electron image and by the minification of that electron signal.

The neutron scintillator is a mixture of ^{6}LiF and phosphor powders in a resin binder; the LiF contains 95.72% ^{6}Li. The optimum mixture for light yield is 1 part ^{6}LiF to 4 parts phosphor by weight. Two different phosphors, ZnCdS(Ag) and ZnS(Ag), have been used in the scintillator. The latter is preferred because (1) its emission spectrum provides a good match for the spectral response of the adjacent photoemitter surface, Sb-Cs-(0); and (2) its lower density yields less absorption for gamma radiation, thereby resulting in an improved neutron-gamma response ratio for the intensifier tube.

The detection mechanism with either phosphor is the same. The thermal neutrons are absorbed by the ^{6}Li; an alpha particle and a triton are promptly emitted. Each particle stimulates emission of light from the phosphor. A typical scintillator-target thickness of 0.4 mm absorbs about 30% of an incident thermal-neutron beam.

The light yield from a 15-cm-diameter neutron-intensifier tube provides linear response to thermal neutrons over at least four orders of neutron intensity. The excellent light-yield characteristics of the intensifier tube have permitted the observation of gross

(continued overleaf)

brightening of the output phosphor for incident thermal-neutron intensities as low as 100 neutrons per square centimeter-second for direct visual observation of the output-phosphor screen by dark-adapted observers. For television response, a vidicon television camera has provided similar gross images for incident thermal-neutron intensities as low as 2×10^4 neutrons per square centimeter-second; an image orthicon television system has improved light-level response by a factor of 100 over the vidicon system.

Applications of the neutron-image intensifier include dynamic neutron-image studies involving heated, irradiated, reactor-fuel materials; water-flow and bubble-pattern studies in heat-transfer systems; and casting of heavy metals. Stationary images also can be observed with excellent sensitivity and speed. The tube may be useful as a detector for neutron-diffraction patterns also.

Reference:

Berger, H.: Neutron Image Intensifier. In Encyclopedic Dictionary of Physics, J. Thewlis, ed. Pergamon Press, in press.

Notes:

1. Neutron radiographers may be interested.
2. Inquiries concerning this innovation may be directed to:

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Patent status:

Inquiries concerning rights for commercial use of this innovation may be made to:

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