A simple ultraviolet radiation detector for museum use

Tim Padfield

Abstract

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A note about this digital version of the article first published in Studies in Conservation, volume 12, 1967, 1 – 4

This version shows each page as a picture. As for the content; the design may seem quaint but the principle of making a device to pinpoint an ultraviolet radiation leak into a museum gallery is still relevant, and practical devices are still not commercially available.

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A Simple Ultraviolet Radiation Detector for Museum Use

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ABSTRACT

An instrument is described which allows the eye to detect sources of ultraviolet radiation. Coincident ultraviolet and visible images of the scene are viewed through an eyepiece. The suspected source of radiation is centered in the field of view. The visible image is then extinguished by operating a shutter. Ultraviolet radiation is revealed by yellow-green fluorescence from a small target in the centre of the field.

INTRODUCTION

The usefulness of ultraviolet absorbers in reducing photochemical damage to art objects is now universally acknowledged.

There remains an administrative problem: how does one ensure that ultraviolet absorbers, which are colourless, transparent and subject to deterioration, are in fact present, and effective, where they should be? In large museums with thousands of fluorescent lamps and extensive skylights it is very difficult to ensure that ultraviolet absorbers are renewed when lamps or glass panes are replaced.

There is therefore a need for a simple instrument which allows a quick inspection of a museum gallery for chinks in its u.v.-absorbing armour.

GENERAL DESCRIPTION OF THE INSTRUMENT

The instrument (Fig. 1) consists of two optical systems with a common axis. One system is a simple telescope in which the lens (H) forms a real image of the scene in the plane of (E), which is viewed through an eyepiece (B).

The other system consists of a visually opaque, ultraviolet-transmitting filter (D) and an aluminium paraboloidal mirror (C) which forms an ultraviolet image of the scene in the same plane, and of the same size as the visible image formed by the lens.

A small fluorescent cone (F) is suspended in the centre of the image plane so that the eye sees the yellow-green fluorescent image in the centre of the field surrounded by the visible image of the source of the radiation.

The fluorescent image is of course much dimmer than the image formed by the light from the object. Only windows, skylights and bare fluorescent lamps give fluorescence clearly visible against the light. So a shutter G) is provided to extinguish the visible image and allow undisturbed scrutiny of the fluorescence. As a further refinement the visible image is made red by the filter (J) so that the dark adaptation of the eye is unimpaired by opening the shutter. The yellow-green fluorescence also shows up better against the red background.

The prism (A) changes the line of sight through 90° and presents to the eye an upright image, inverted from left to right. Its main purpose is to prevent uncomfortable bending of the observer's neck.

DETAILED DESCRIPTION OF THE OPTICAL SYSTEM

The dimensions of the instrument are governed by the size of the u.v.-transmitting

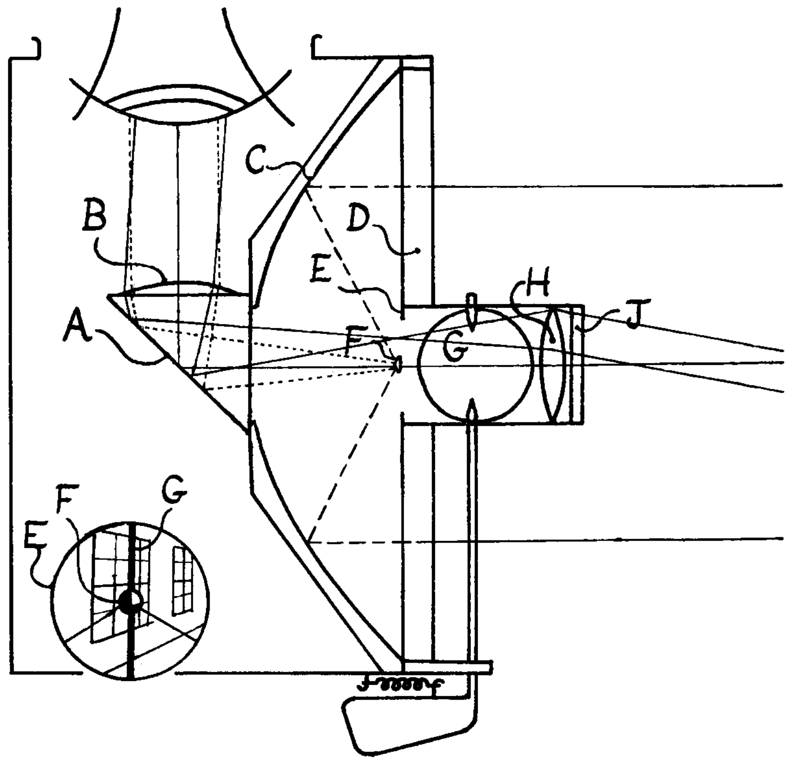

FIG. 1. Diagram of the ultraviolet radiation detector. The dashed rays represent u.v. radiation and the dotted rays fluorescent light. The circular inset presents the observer's view as he looks at a window of which one pane has not been varnished with a u.v. absorber.

filter: the only size easily obtainable in Britain is a two-inch square of Chance OX.1 u.v.-transmitting glass (Ilford Filter no. 828, Kodak Wratten Filter 18A), 3 mm thick. Its absorption curve is shown in Fig. 2.

The brightness of the fluorescent image depends on the aperture of the image-forming optics and on the efficiency of transmission of u.v. radiation through the various components of the system. Optical glass absorbs near-u.v. radiation to some extent, and lenses of high aperture either give a poorly defined image or are complex and expensive, with numerous partly reflecting surfaces.

Reflecting optics are therefore better. The u.v. imaging system is an aluminium paraboloidal mirror of focal length 1·25 cm and diameter 5 cm, with a shallow cone as the fluorescent target at its focus. The u.v. reflectance of pure aluminium is very high and the only partly reflecting surfaces are those of the filter.

To give a visible image of equal size the lens (H) must have a focal length equal to that of the mirror. The object can be considered to be at infinity, so the lens must be placed 1·25 cm in front of the focal point of the mirror to give a coincident image. If the lens is of 1 cm diameter there is just room for a thin disc shutter that can be rotated to stop the light.

The fluorescent material should have a yellow or yellow-green fluorescence because the eye is most sensitive to these colours. The fluorescence should be excited by wavelengths centered about 3600 Å because this is the spectral region to which the filter is most transparent. It is also the region in which the u.v. emission of daylight is considerable and in which the u.v. emission of the mercury vapour of fluorescent lamps is greatest.

The wavelength sensitivity and conversion efficiency of fluorescent materials can be roughly evaluated by seeing how brightly they glow under the high pressure mercury vapour lamp commonly used to examine museum objects.

I used 'Flare Yellow L' from Industrial Colours Ltd. 25 Parsons Green Lane, London S.W.6. This paint was applied to a paper support.

It is possible to use a solution of the sodium salt of fluorescein, sealed in a capillary tube of borosilicate glass (soda glass absorbs u.v. radiation), half of which is painted white to give a reflective background. The greatest brilliance is given by a 1 mm diameter capillary containing a solution of 1 g/l of fluorescein in dilute sodium carbonate solution.

The fluorescent material, which should ideally form a shallow cone of about 1·5 mm diameter, is suspended by fine fibres from the 1 cm diameter tube which holds the lens, shutter and red filter. It is placed at the focal point of the lens.

The mirror and the u.v.-transmitting filter are bored centrally with 1 cm diameter holes. The two are then fixed together. The lens tube is inserted through the hole in the filter and wiggled until the visible and fluorescent images coincide. The lens tube is then cemented in with 'Araldite' or some other rigid adhesive.

The image is small and inverted, so some convenient viewing system is necessary. To maintain high sensitivity to u.v. radiation it is essential that light losses be kept small. The totally internally reflecting prism (A) with a plano-convex lens (B) cemented to the upper surface presents a convenient image to the eye at the expense of partial reflection at two surfaces and a very small light absorption by the glass.

This eyepiece should be arranged to form a virtual image at about one metre from the eye. The geometry of the instrument demands that its focal length should be about twice that of the objective (H). Its diameter should be not less than 1 cm or the brilliance of the image will be dimmed. The exact focal length and prism dimensions are not critical: the spacing of prism and reflector can be adjusted to suit the pieces.

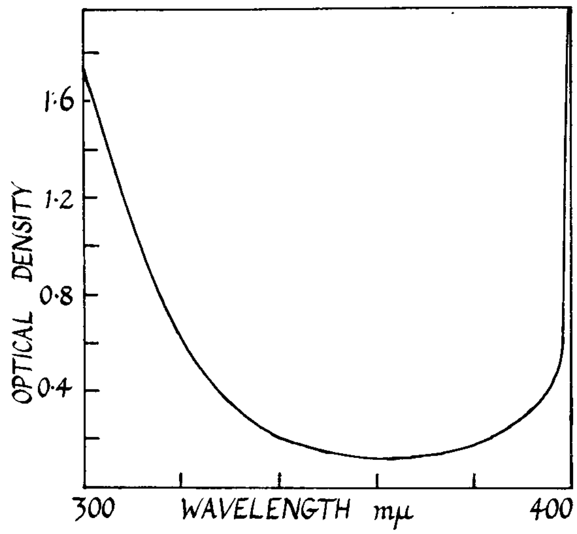

Fig. 2. The absorption curve of the ultraviolet transmitting filter. Light transmission is negligible except in the far red.

This optical system will give a vignetted image; that is, the brightness will diminish towards the edge. This is of no consequence, but it is neater to put a field stop (E) in the plane of the image. An aperture of 8 mm gives a good compromise between wide field of view and uniform illumination. The field stop also intercepts light creeping past the edge of the shutter.

The instrument has a field of view of 36° and an apparent field of view to the eye of half this angle.

USING THE INSTRUMENT

The instrument is pointed at each light source in turn and the shutter is closed. A yellow-green glow indicates that u.v. radiation is being emitted. This can be confirmed by placing an u.v.-absorbing filter in front of the instrument—the glow should be entirely extinguished.

This instrument is very sensitive and will detect u.v. from lamps shielded by diffusing screens and u.v. bounced from concealed lamps. The dark-adapted eye can readily detect the u.v. radiation from the night sky over London.

The user must take account of the luminance (brightness) of the source. A naked incandescent lamp gives a good yellow-green glow although the u.v. is a very small part of the total radiation. This is because of the very high luminance of the lamp: it is almost a point source. The u.v. radiation *incident on an object* would be quite small. Conversely, a comparatively feeble u.v. signal from an extended source such as fluorescent lamps behind diffusing screens can indicate a dangerously high u.v. component in the radiation striking an object.

In practice this defect is unimportant because incandescent lamps are readily recognized and all other museum light comes from extended sources of low luminance.

I must stress that this instrument is not a scientific device for measuring the radiation hazard to museum objects, which can only be done with an incident radiation meter measuring the u.v. energy striking an object. It is a snooping device, designed to detect omissions in the u.v. defences of museum lighting. Judging by my experience the need for it will be proved during its first few minutes of use.

ACKNOWLEDGEMENTS

I am grateful to Garry Thomson who suggested the need for an instrument such as this and with whom I have had many useful discussions. Part of the work needed for this article was done in the Conservation Laboratory of the Victoria & Albert Museum and it is published by permission of the Keeper of the Conservation Department, Mr Norman Brommelle.

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UN INDICATEUR SIMPLE DE RAYONS ULTRA-VIOLETS DESTINÉ AUX MUSÉES

L'instrument décrit permet à l'œil de dépister les sources de rayonnement ultra-violets. On peut voir à travers un oculaire la scène à la fois en images ultra-violettes et en spectre visible. La source soupçonnée de rayonnement ultra-violet est centrée sur le champ de vision. L'image visible est alors éteinte au moyen d'un obturateur. Les rayons ultra-violets sont révélés par une fluorescence jaune verte d'une petite cible au centre du champ.

EIN EINFACHES GERÄT ZUR FESTSTELLUNG ULTRAVIOLETTER STRAHLEN IN MUSEEN

Mit diesem Instrument kann das Auge Quellen ultravioletter Strahlung feststellen. Durch ein Okular werden übereinstimmende ultraviolette und sichtbare Bilder der vorhandenen Gegenstände betrachtet. Die vermutliche Quelle der Strahlung wird in die Mitte des Blickfeldes gebracht. Sodann wird ein Verschluß betätigt, durch den das sichtbare Bild ausgeschaltet wird. Ultraviolette Strahlung wird angezeigt durch gelblich-grüne Fluoreszenz in einem kleinen Kreis in der Mitte des Blickfeldes.

UN SEMPLICE RIVELATORE DI RADIAZIONI ULTRAVIOLETTE PER I MUSEI

Si descrive uno strumento che permette all'occhio di captare sorgenti di radiazioni ultraviolette. Le immagini visibili e ultra-violette coincidenti sono viste attraverso un oculare. La sorgente di radiazioni sospetta è centrata nel campo visivo. L'immagine visibile è quindi eliminata azionando un otturatore. La radiazione ultravioletta è rivelata da una fluorescenza giallo verde emanata da un piccolo bersaglio nel centro del campo.