Control of Glare for VDT Operators
1. Transmission of fluorescent light through UV filters and pink lenses.

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Introduction

Since the introduction of video display terminals (VDTs) into offices, "glare" has become a source of patient complaints and a major triggering factor of migraine attacks among VDT users. Many patients are bothered by direct glare from fluorescent lamps or reflected glare from the surface of the screen. In order to reduce the impact of glare on VDT operators, some manufacturers have installed anti-glare filters on the screen to reduce the reflective glare. Special luminaires with mirrored louvers directing the luminous flux downwards are recommended for lighting systems in VDT areas, but most offices are still illuminated by fluorescent lamp fittings not designed for this type of work.

It is likely that some of the experienced discomfort termed "glare" is caused by the short-wavelength (less than 400 nm) rays emitted by overhead fluorescent lamps. Short-wavelength rays scatter more than long-wavelength rays in the cornea, according to the formula $1/\lambda^2$ as demonstrated by Farrell et al.[1] Thus, short-wavelength rays can cause discomfort glare induced by scattered light in the cornea and crystalline lens. Hemenger[2] has demonstrated that scattered light in the lens is proportional to $1/\lambda^2$. Thus, short-wavelength radiation would scatter more in both the cornea and the lens.

For patients bothered by glare from fluorescent lights, optometrists have customarily provided pink lenses (Cruxite, Tonelite) without knowing the exact effects of these.[3] It is the objective of this paper to study the effect of two kinds of tinted lenses on the spectral distribution of fluorescent lights, comparing the traditionally used pink lenses (Cruxite, Tonelite) to the relatively new UV filters (UV400, Uni-Lite).

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Methods

1. Transmittance curves of tinted lenses.

Transmittance measurements of the two groups of tinted lenses used in this study have been made using a Zeiss DMR21 dual-beam recording spectrophotometer. Measurements have been made over the waveband 200 nm to 2500 nm. In the visible and infra-red regions, the monochromator of this instrument has a resolution of 1.0 nm and the accuracy of transmittance measured is 0.3%. Resolution of the spectrophotometer is 0.1 nm in the ultraviolet (Figs. 1 and 2).

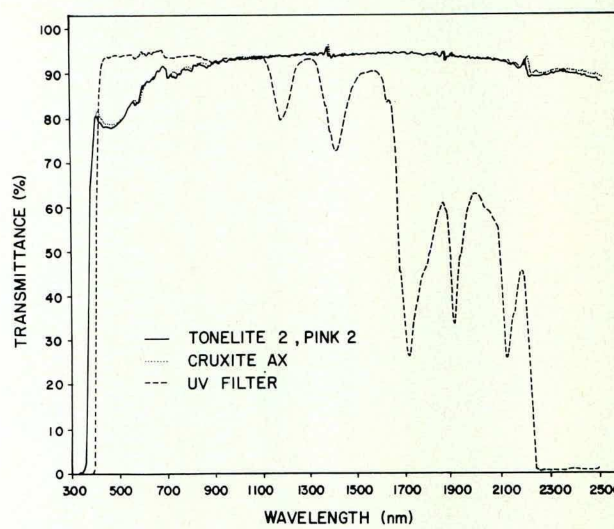

Fig. 1

2. Percentage of power transmission of fluorescent light through the optical filters.

When the spectral emittance of the fluorescent lamp was combined with the transmittance of the lenses, we found that the UV filters eliminated the four peaks of emission between 300 nm and 400 nm (Fig. 3). These peaks are the emission bands of the low-pressure mercury gas discharge, which are approximately at 312-313, 330-332, 365-366 and 404-405 nm. The continuous curve is the emission of the phosphors located inside the glass tube. The

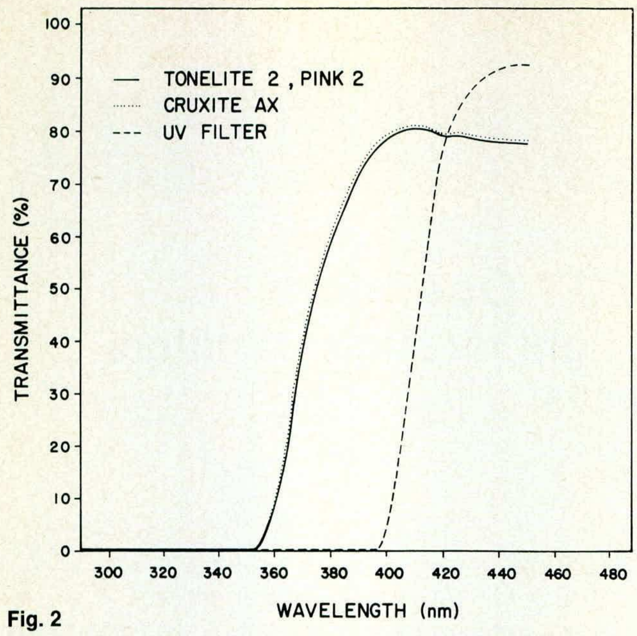

Fig. 2

pink lenses, on the other hand, reduced the overall radiant power, especially between 450 nm and 550 nm, where most of the radiant energy is produced.

In order to determine the effect of these filters on the spectral irradiance of the fluorescent light at the eye, the percentage of cool white light transmitted was calculated: Using 10 nm width increments, the area under the transmittance curve (broken line) was divided by the area under the cool white power spectrum (Figs. 3 and 4).

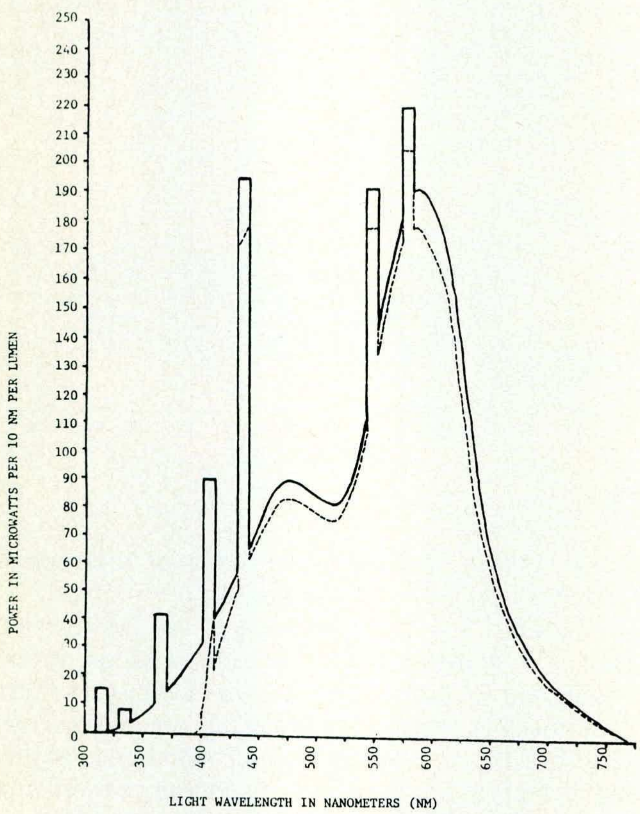

Fig. 3
(Solid Line) "COOL WHITE" Fluorescent Lamp Power Spectrum
(Broken Line) "COOL WHITE" Power Spectrum through UV Filter

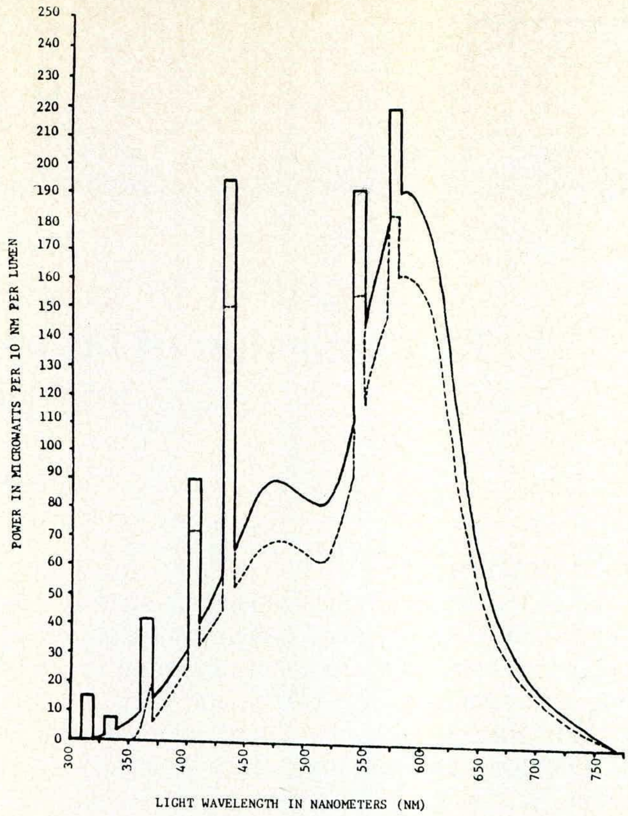

Fig. 4
(Solid Line) "COOL WHITE" Fluorescent Lamp Power Spectrum
(Broken Line) "COOL WHITE" Power Spectrum through Cruxite AX, Tonelite or Pink 2

The power distribution spectrum of a standard Cool White fluorescent lamp[4] was re-plotted in terms of percentage of its peak output at 575 nm. The filtered Cool White was plotted for each lens, its value at a given wavelength λ being $P_\lambda\ t_\lambda$ where P_λ is the percentage of peak power of the lamp at that wavelength and t_λ is the transmittance of the lens material at the same wavelength.

It was desired to find what percentage of the lamp's ultra-violet radiation was being transmitted between 300 and 400 nm as compared to its transmission in the visible band (400 to 770 nm) through the lenses used in this investigation.

The equation for percent transmission over a waveband between λ_1 and λ_2 is:

$$\%T_{(\lambda_1 \rightarrow \lambda_2)} = \frac{100 \times \sum_{\lambda_1}^{\lambda_2} P_\lambda\, t_\lambda\, \Delta\lambda}{\sum_{\lambda_1}^{\lambda_2} P_\lambda\, \Delta\lambda} \quad (1)$$

Results and Discussion

The transmission curves of the two types of lenses showed that UV filters eliminated radiation shorter than 400 nm, while the pink lenses reduced the overall transmission of light between 400 and 700 nm (Fig. 1). When the shorter-wavelength portion in

Fig. 1 was expanded, it showed that the UV filters transmitted only 3.2% of radiation at 400 nm, while the pink lenses transmitted 78% of radiation at 400 nm (Fig. 2). On the other hand, in the longer-wavelength portion the UV filters transmitted more infra-red radiation than did the pink lenses (Fig. 1). These findings are in agreement with Chou and Cullen.[5] When the emittance of the fluorescent lamp was combined with the transmittance curves of the two groups of tinted lenses, the following values of % transmittance (Table 1) were obtained for UV filter (Fig. 3) and pink lenses (Fig. 4):

Table 1
Percentage of Cool White Transmittance Through Tinted Lenses

	UV (300 - 400 nm)	**Visible** (400 - 700 nm)
UV filter	0.2%	90.4%
Pink Lenses (Cruxite AX, Tonelite 2, Pink 2)	36.4%	82.9%

These results indicate that UV filters do not reduce the visible light significantly, but they eliminate UV radiation between 300 - 400 nm. On the other hand, pink lenses reduce UV radiation between 300 - 400 nm by 63.6% and eliminate UV radiation below 350 nm. However, pink lenses are more effective in reducing visible light by 17.1%. These transmission curves (Figs. 3 and 4) suggest that UV filters and pink lenses reduce the discomfort possibly caused by stray light by different means: UV filters eliminate UV radiation which is scattered in the cornea and the lens more than the long-wavelength rays[1] and UV induces fluorescence of tyrosine and other molecules in the lens[6], whereas pink lenses reduce the overall illumination. This in itself could be effective, since most offices are over-illuminated for VDT operation. Ostberg[7] suggested that lower illumination is required for offices with VDT terminals, because the contrast between the high ambient illumination and the dark screen can cause problems in transient adaptation when the eyes have to change frequently between the very high luminance of the paper on the desk and the low luminance of the screen.

Acknowledgement

This research was supported by a grant from COETF to Dr. G.Y. Mousa. Thanks are due to Drs. B. R. Chou and W. K. Adrian for their help in the measurements of the transmittance curves of the tinted lenses and for their critical reading of the manuscript.

Editor's Note: Next Issue: Part II — Evaluation of Different Lenses by Subjects

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