



Control of vertically polarized glare

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ABSTRACT—*Reflected glare often interferes with vision. Since such glare is usually polarized it can be controlled with polarizers. The use of polarized filters to eliminate vertically polarized glare from blackboards and glossy printed material is presented. Practical means for the construction of such filters are discussed.*

KEY WORDS—*reflected glare, polarized lenses, classroom blackboard, low vision, visual environment.*

Introduction

Light reflected from smooth surfaces in the field of view is often uncomfortable, distracting, and reduces visibility for targets near the glare source.^{1,2} A severe reduction of contrast occurs when such glare is reflected from a specular part of a target and the reduction of visibility may be sufficient to make a visual task impossible in certain conditions. Such reflected glare can be reduced by relocation or redirection of the light source when possible, or by reducing the specular properties (i.e. smoothness) of the target. As an example, mat paper is much less susceptible to reflected glare than glossy magazine paper.

Specularly reflected light is linearly polarized to a considerable extent. Therefore, it can easily be controlled with polarizing filters. Commercially available polarized sun glasses make use of such polarization to reduce reflected glare

from horizontal surfaces. They are very effective in reducing reflected sunlight from the highway and carhood for drivers,³ glare from the snow for skiers, and glare from the surface of a pond for fishermen. However, reflected glare is not always horizontally polarized and hence some specular glare sources require a different solution.

The management of reflected glare which is vertically polarized will be discussed in this paper. Two cases of such glare will be considered: (1) difficulties experienced by a student when bright light is specularly reflected from the classroom blackboard; (2) difficulties experienced by the low vision patient with a very high near add. These patients have to hold their reading material very close and the reflected light can practically obscure a book or magazine print.

Polarization of reflected light

When a beam of light is obliquely incident on a smooth surface of dielectric material (e.g. glass) the reflected beam is found to be in part linearly or plane polarized. The vibrations of the light are confined to one definite plane, as compared to ordinary light (non-polarized) in which the directions of vibrations are continually changing. The plane of vibrations in polarized reflected light is always perpendicular to the plane containing the incident and reflected beam. When, for example, the sunlight is re-

flected from a horizontal surface, such as water in a pond, the predominant plane of vibration will be horizontal (this light will be referred to as horizontally polarized light). This reflected light can be eliminated with the use of a polarizer for which the absorption axis is horizontal. Such a filter transmits light for which the vibrations are in a vertical plane and absorbs that part of the wave for which the vibrations are horizontal. The extent of polarization of the reflected beam varies as a function of the angle of incidence. At some particular incident angle, known as Brewster's angle, the reflected light is almost completely plane polarized. Brewster's angle is defined as the incident angle for which the refracted ray is 90° away from the reflected ray.⁴ Brewster's angle depends on n —the index of refraction, and therefore is different for every wave length. For white light then, we find a range of angles of incidence in which significant polarization occurs.

Blackboard glare

The surfaces of many blackboards are partially glossy. Reflection of light on the blackboard becomes specular for large angles of incidence. When considerable light from a window falls on a blackboard, the brightness of the board is increased much more than the brightness of the mat (diffusely reflecting) chalk letters. The in-

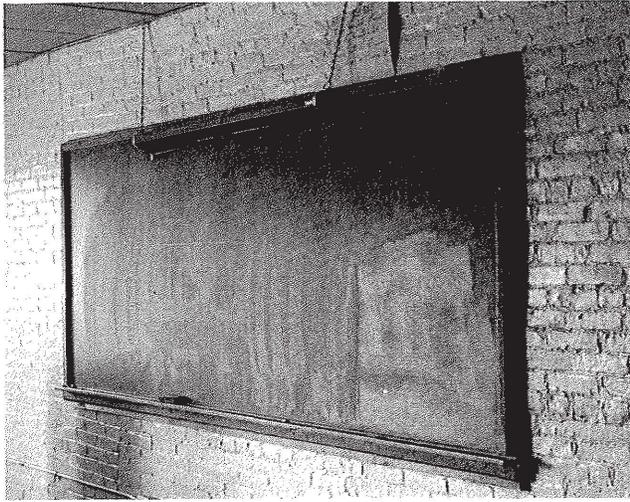


Figure 1a

Figure 1: Control of blackboard glare with vertical Polaroid filter.
A. The reflected glare makes it impossible to read the board.
Note the actual reversal of contrast in the right lower corner

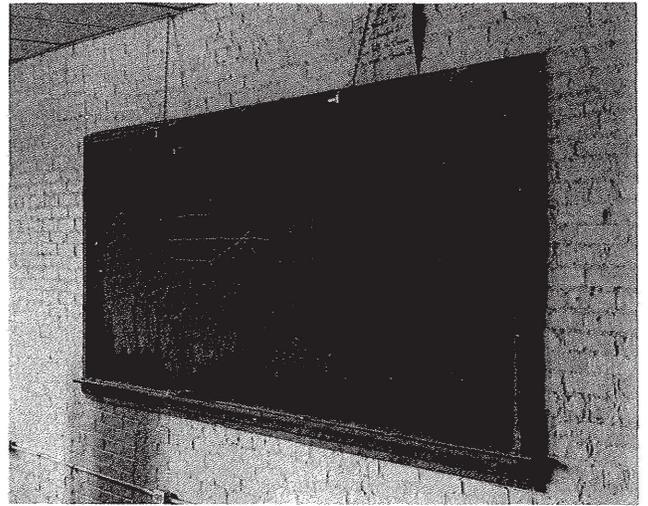


Figure 1b

of the board.
B. Same picture taken through a polarized filter with a vertical absorption axis vertically.

creased brightness of the blackboard reduces the contrast between the letters and the blackboard with a consequent diminished visibility. This reduction of visibility can be so great that reading is nearly impossible (Fig. 1a). When the glare interferes with visual performance it is defined as disability glare.⁵ In a classroom with windows on one side most of the disturbing reflectance affects the few students sitting in the front rows across the room from the windows. This is because with respect to specular reflection the blackboard acts as a mirror.

One solution to blackboard glare, perhaps the best, is to illuminate the board from another direction. This is best achieved by using direct lighting of the blackboard either by fluorescent lights over the board, or by spot lights suspended from the ceiling.² Another solution is to cover the window and block the glare source. This solution is not recommended as it reduces the ambient light in the classroom needed for all students for their desk work. Here is an area where optometrists can get involved in solving lighting problems in schools. The matter of the proper

blackboard lighting should be discussed with teachers, parents, and schoolboard officials. Changing lighting in a classroom is, however, often a long process. It requires budgets and installation by certified electricians, not always available on the school maintenance team. We do have an obligation to the student-patient who might be referred to the optometric office because he cannot read the blackboard from his seat.

My proposed solution takes advantage of the fact that blackboard reflected light is polarized vertically. A pair of polaroid glasses with the absorption axis 90° for both eyes will reduce the reflected light almost completely (Fig. 1b). The resultant contrast is very good and the reduction of overall light is not enough to interfere with desk work in an adequately lit room. Spectacle-worn filters, however, do reduce brightness. To overcome this disadvantage hand held polarized filter can be used by the student to spot the board. "Clip-on" polarized filters, mounted on the student's spectacles, can be swung out of the way when not needed. Such "clip-ons" can be fabricated by simple modification of common Polaroid

"clip-ons." The filters should be disconnected from the frame, turned 90° , reshaped with scissors and remounted to the frame using ophthalmic bolts and nuts. Caps and beach visors are available with colored acetate filters placed in the visor. The acetate filter can be easily replaced with polarized filters and used by the student to spot the board without interfering with his desk work.

Polarized spectacles with lenses at axis 90° are not available commercially to my knowledge. However, the vectographic spectacles (axis 45° and 135°) sold by Bernell Corporation can be easily and appropriately modified. The small point of glue at the top of the filter should be broken. The filter then can be rotated and remounted at the required angle. To achieve a good fit of the filter in the frame some cutting and reshaping of the filter may be needed. These modified spectacles are recommended rather than the more commonly available Polaroid sun glasses as they have a better transmittance (optical density of 0.30-0.40). For a patient with a spectacle Rx, the filters can also be incorporated into the spectacles by ordering Polaroid

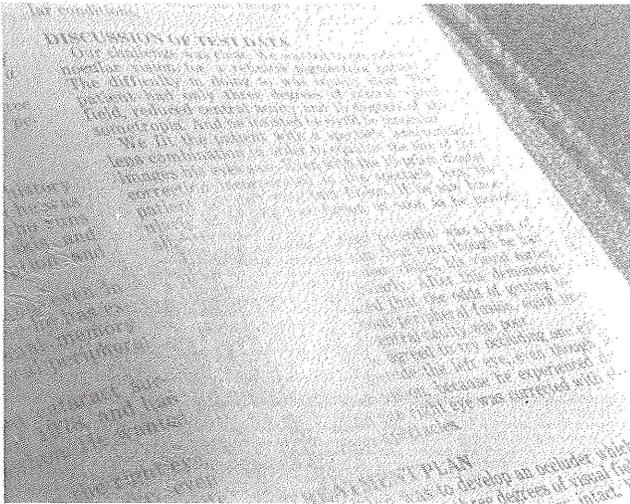


Figure 2a

Figure 2: Glare reflected from magazine.
A. The reflected glare from the glossy page and specularly reflecting ink obscure the visibility of the text. The specular quality of the glare is difficult to reproduce in a photograph.

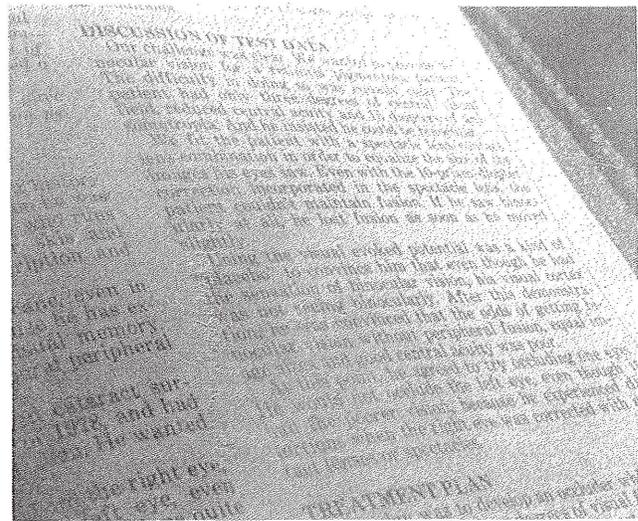


Figure 2b

The camera does not suffer from the scattering of light as does the eye.
B. The same picture taken through a Polaroid filter with a vertical absorption axis.

prescription lenses with the absorption axis at 90° O.U. The Polaroid spectacles will not be met with the usual rejection by grade school students. They can demonstrate to their peers the “magical powers” of the lenses in reducing the black-board glare, and thus present them as a toy instead of glasses.

Control of glare from reading materials

There are two possible sources for specular reflection when reading: The glossy smooth paper used in most magazines, and specularly reflecting printing ink.⁶ These specular reflections reduce the contrast and can impair vision. The effect of such specular glare is demonstrated in Fig. 2a. The reflections and contrast loss can be reduced again with the repositioning of light. For some situations this solution is not so simple to apply. For example, 80% of all low vision patients who use a high power reading add have had their vision improved to the extent that they can read magazines and newsprint.⁷ When using such high additions the patient has to hold the magazine at the focal distance of the lens (7-20 cm). At this short reading distance, the light source

usually must be positioned to the side.⁸ This lack of choice in light direction and position makes control of specular glare difficult. The fact that many patients prefer to move the page in front of their eyes imposes further difficulty. Use of mat paper and non-specular ink will eliminate the glare problem almost completely. Indeed, the large print editions of “Readers Digest” and “New York Times” use these measures. Most other magazines, however, use glossy paper and specular ink.

This glare is, again, vertically polarized when light is directed from the side, and thus can be eliminated with vertically oriented polarized lenses (i.e. the transmittance axis horizontal). The plane of vibrations, however, can vary significantly with the position of the light source and the angle at which the magazine is being held. A single Polaroid filter that will provide optional reduction of glare is impossible, unless the reading environment is rigidly maintained. A rotatable polaroid filter that can be adjusted by the patient is thus a better solution. Such filters are available in every photography store, and can be easily mounted as a

“clip-on” over the patient’s glasses. These camera Polaroid lenses have fairly high light transmission and will not reduce the light to an intolerable level. The contrast on the other hand will be improved significantly (fig. 2b).

Placing Polaroid sheets directly on the reading material can eliminate the glare too, but it reduces the brightness more than the other techniques. Color acetate filters (yellow) placed upon the magazine will increase the contrast, but will not affect the glare significantly.

Another solution is to polarize the light source. This can be done by installing a polarizer with the absorption axis horizontally in front of the lamp. Very little light will be specularly reflected this way. Only light that has been diffusely reflected from the paper will reach the eye. With this approach it will be unnecessary for the patient to employ the Polaroid filter in his prescription. This idea had been patented by Land (Land, E. H., U.S. Patent 2,302,613 (1942) polarizing desk lamp). I have no knowledge of the availability of this lamp commercially. The difficulty involved in building such a lamp relates to the effect of the heat on

the Polaroid filter. K type polarizers⁹ are well suited for the task. Plastic laminated K-type polarizers can stand a temperature of 215°F for long periods.

Summary

There are a variety of ways to solve a glare problem. One way is to prescribe Polaroid filters at the proper orientation. All the techniques offered here have the added advantages of being inexpensive and require only minor modifications of available supplies. These techniques, however, are not the best solution, and should only be used as a last measure. The best solutions involve controlling environmental factors affecting glare such as lighting and the type of finish on surfaces. The rectification of the environmental problems will reduce glare significantly or even eliminate it completely. In order to

be able to help patients with glare problems, the optometrist, therefore, should be aware of proper lighting techniques. He should be familiar with light sources and their desirable directions, the control of daylight in windows, and the preferred reflection characteristics required for surfaces in working or studying situations.² AOA

Submitted for publication 12/81

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ACKNOWLEDGMENT

I would like to thank Dr. Paul Pease for valuable discussions, Dr. Frank Kozol and Dr. Glen McCormack for reading the manuscript, and Mr. Andrew Baker for helping with the photography.

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