

suppression following the eye movement must take place in the retina. One possible explanation is that the shearing forces between the vitreous and the sclera might cause changes of electrical potentials within the retina which lead to an increase of the threshold for detecting the neural signal. Alternately, shearing of the vitreous gel itself could generate a potential which affects the neurons or the associated membranes.⁷

If any such potentials arise as a consequence of the acceleration of the eyeball, then visual suppression immediately before saccadic eye movements also does not need to be attributed to central factors. We must instead consider that the visual stimulus may be delayed by 5 to 80 msec at the photoreceptor level, with further delays introduced by the neural summation processes. Thus, if the hypothetical alterations of potential occur near the bipolar cells, then, for maximum suppression, the visual stimulus may have to be presented up to 80 msec before the onset of the eye movement in order to compensate for the delay of the photo-transduction processes. Because the photoreceptor latency increases as the stimulus luminance is decreased,⁸ the stimulus time for maximum suppression should precede the onset of the eye movement by greater and greater intervals as the light level is decreased. This effect has been observed by Zuber.¹ Clearly, there is no need to resort to cortical explanations for these suppression effects, which occur prior to the eye movement. One final advantage of the notion that saccadic suppression occurs in the retina rather than in the cortex is that the correlated suppression of the pupillary response⁹ is explained simply because the suppression effect would occur before any bifurcation in the visual pathways.

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¹ R. Dodge, *Psychol. Rev.* 7, 454 (1900); E. B. Holt, *Harvard Psychol. Studies* 1, 3 (1903); R. W. Ditchburn, *Opt. Acta* 1, 171 (1955); R. W. Ebberts, *J. Opt. Soc. Am.* 55, 1577A (1965); P. L. Latour, *Vision Res.* 2, 261 (1962); F. C. Volkman, *J. Opt. Soc. Am.* 52, 571 (1962); B. L. Zuber and L. Stark, *Exptl. Neurol.* 16, 65 (1966). Note: No suppression was observed by J. Krauskopf, V. Graf, and K. Gaarder [*Am. J. Psychol.* 71, 73 (1966)].

² R. M. Chapman, *Vision Res.* 2, 89 (1962); M. A. Lennox-Buchtal, *Vision Res.* 2, 1 (1962); T. Ogawa, P. O. Bishop, and W. R. Levick, *J. Neurophysiol.* 29, 1 (1966); P. Gouras, *J. Physiol. (London)* 192, 747 (1967).

³ A. L. Yarbus has also mentioned this possibility. See *Eye Movements and Vision* (Plenum Press, Inc., New York, 1967), p. 145.

⁴ L. Stark, G. Vossius, and L. R. Young, *IRE Trans. HFE-3*, 52 (1962).

⁵ This similarity should not be attributed to the passive movement having a voluntary saccadic component, for such an additional voluntary component would cause the eye to overshoot its initial resting position on the return phase of movement. In addition, if any voluntary saccade were triggered by the tap, then the expected delay of this voluntary component would be about 200 msec—after the passive movement had been completed. Figure 1 shows no evidence of such voluntary saccades superimposed upon the passive-eye-movement condition.

⁶ G. Wasserman, *J. Opt. Soc. Am.* 56, 242 (1966).

⁷ The potential change appears to depolarize the neurons, producing a brief discharge. [J. M. Rhodes, J. Lenoir, J. Saier, and R. Naquet, *Rev. Neurol.* 107, 177 (1962).]

⁸ R. M. Chapman, *Vision Res.* 2, 89 (1962); R. A. Cone, *J. Gen. Physiol.* 47, 1089 (1964).

⁹ B. L. Zuber, L. Stark, and M. Lorber, *Exptl. Neurol.* 14, 351 (1966).

Two-Layer Phase Compensation of Total Internal Reflection

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A THREE-LAYER coating has been proposed for phase compensation of the reflection of polarized light from internal surfaces at angles well beyond the critical angle.¹

Using the same concept of the symmetric three-layer LHL combination, but considering the medium itself to comprise the first low-index layer, we have found that only two layers have to

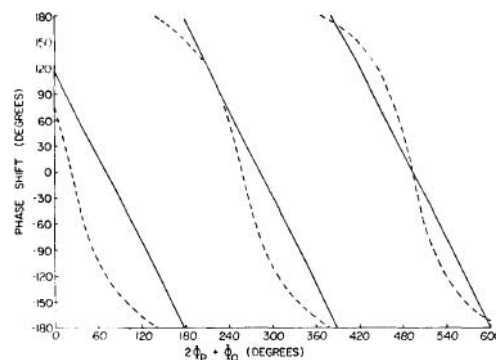


FIG. 1. Phase shift on internal reflection of S (---) and P (—) polarizations from two-layer coated fused-quartz surface. $2\Phi_P/\Phi_Q = 4/9$, angle of incidence = 54.73° [see text for definition of $\Phi_{P(Q)}$].

be deposited to achieve phase compensation. A sample calculation has been performed for the conditions present in a fused-quartz corner cube, coated with TiO_2 ($n = 2.3$) and SiO_2 ($n = 1.457$). Figure 1 is a plot of the results, where Φ_P is the equivalent phase thickness of SiO_2 and Φ_Q the equivalent phase thickness of TiO_2 , both taken at the angle of propagation in the particular medium, $(\theta_{P(Q)})$; θ_P in this case is the same as the angle of incidence in the corner cube, 54.73° , and θ_Q is 31.15° . $\Phi_{P(Q)} = 360n_{P(Q)}k_0t_{P(Q)} \times \cos\theta_{P(Q)}$, where n is the refractive index, k_0 the vacuum wave-number, and t the physical thickness of the layer. The optimum ratio, $2\Phi_P/\Phi_Q = 4/9$, is very close to the best ratio found for the conditions described in the reference,¹ $2\Phi_P/\Phi_Q = 3/7$.

¹ P. B. Mauer, *J. Opt. Soc. Am.* 56, 1219 (1966).

Spot-Diagram of Maximum Sharpness

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INDEX HEADINGS: Lens design; Ray tracing.

WHEN a lens system is designed with the aid of spot diagrams, the nominal image plane is not necessarily the plane of maximum sharpness. It is, however, a simple additional step to locate the plane of maximum sharpness once the ray-tracing data to the nominal image plane have been obtained, provided the plane of maximum sharpness is defined to be the plane of minimum squared error.

Let X_i and Y_i be the transverse coordinates of the intersection of the i th ray from a single object point with the nominal image plane. The coordinate system origin will be located in this plane. Then the coordinates of the intersection of the ray with some other transverse plane are given by

$$x_i = X_i + zA_i$$

$$y_i = Y_i + zB_i,$$

where z is the coordinate of the new plane, A_i is the ratio of the x component to the z component of the direction vector for the i th ray, and B_i is the ratio of the y component to the z component of the same vector. We can average the above equations to obtain

$$\bar{x} = \bar{X} + z\bar{A}$$

$$\bar{y} = \bar{Y} + z\bar{B},$$

where $\bar{x} = (1/N) \sum x_i$, $\bar{X} = (1/N) \sum X_i$, and so forth. N is the number of rays from the object point.