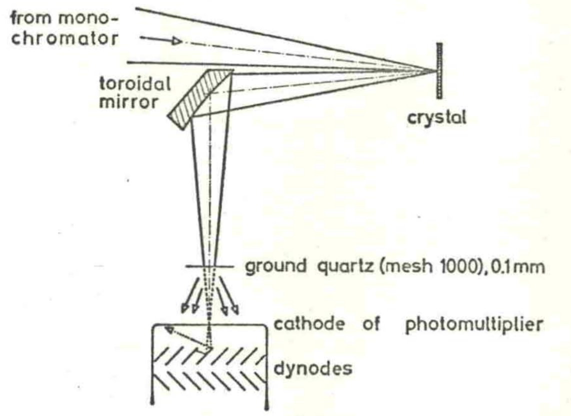

FIG. 5. The optical path of the beam behind the monochromator.

than the one we found, indicating a slightly thicker oxide layer on their sample (Fig. 4).

Figure 4 also contains ϵ_2, the imaginary part of the dielectric constant. It was obtained from a Kramers-Kronig analysis. Between 5.5 and 25 eV, Beaglehole's reflectance values were used. Above 25 eV, the slope of the reflectance was adjusted to reproduce the absolute magnitude of ϵ_2 given by Beaglehole.[22] The slope of the edge in $\epsilon_2(\hbar\omega)$ at 4.3 eV is approximately the same for the function reported here and the one reported by Ehrenreich and Philipp. The edge determined by Beaglehole is somewhat flatter because of the less detailed structure in the reflectance at this energy.

Optical Design and Error Signal

A major difficulty peculiar to modulation techniques such as described here and elsewhere[8,9,11] arises from error signals which might, for example, be generated by the mechanical motion of the crystal. Such an error signal is difficult to separate from the true signal, because both have the same frequency and phase.

In designing the optical path behind the monochromator, we tried to minimize such error signals. One potential source of an unwanted intensity modulation is the large inhomogeneity of the photocathode, which tends to convert small lateral motions of the light beam into intensity modulations. The optical setup is shown in Fig. 5. The beam was focused on the sample and on the semitransparent cathode of the multiplier. The light spot on the cathode is the image of the corresponding point on the sample. It will not change its position, although the reflected beam might sweep over the toroidal mirror because of a motion of the sample or change its solid angle because of a change in the curvature of the sample. However, part of the light is transmitted by the cathode. It will partly reach the cathode again, being scattered by the dynodes. These scattered rays move slightly with respect to the cathode. They were found to be responsible for a substantial error signal, which was strongly wavelength-dependent owing to the wavelength-dependent transmission of the cathode. This error signal was considerably reduced by placing a scattering plate 30 mm in front of the cathode. The plate consisted of a 0.1-mm-thick quartz disk, roughened on both sides with mesh-1000 carborundum. The intensity loss due to this plate was about 40% at 5.5 eV and less at lower energies.

As discussed above, one source of the error signal will be the change of the angle φ between the incident and the reflected beam due to the motion of the sample. This error signal was minimized by shifting the sample perpendicular to the beam in such a way that the beam was reflected at the dynamical center of the sample. In this position φ no longer changes, although the crystal is vibrating (Fig. 1). During this adjustment the error signal itself served to monitor the position of the light spot on the sample with respect to the dynamical center. It was drastically enhanced for that purpose by masking down part of the reflected beam.

In addition to the sources of the error signal discussed above, the small motion of the sample normal to its surface needs to be considered. This will easily produce an intensity modulation if the optical quality of the surface is not excellent. The freshly electropolished surfaces were of high perfection; they did not show any trace of light scattered at the surface. The measurements which will be discussed here were carried out within 2 h after the electropolishing. They contained an error signal of only 2% of the maximum signal. About five days after the electropolishing one could see some weak scattering of light at the surface, probably due to an oxide layer of considerably larger thickness. The error signal was then of the same order of magnitude as the true signal, i.e., it had increased by about a factor of 50, compared to the one immediately after the electropolishing.

The response of the multiplier to small ac magnetic fields (as produced by the driving coils) is another source of error signal. An effective magnetic shielding proved to be essential for the success of our measurements.

Optical Measurements

The reflectance was measured at 4.5° off normal incidence. The difference between near normal and normal incidence reflectance will be neglected in the analysis.

The reflectance of a bent sample contains two contributions. One comes from the discontinuity of ϵ, the complex dielectric constant at the surface. This contribution is identical to that of a sample with homogeneous strain equal to the strain at the surface of the sample. Another contribution is due to the small variation of ϵ, caused by the variation of the strain in the sample in the direction perpendicular to the surface. The second contribution is normally several orders of magnitude smaller than the first one, provided the change of ϵ over one wavelength is small compared to