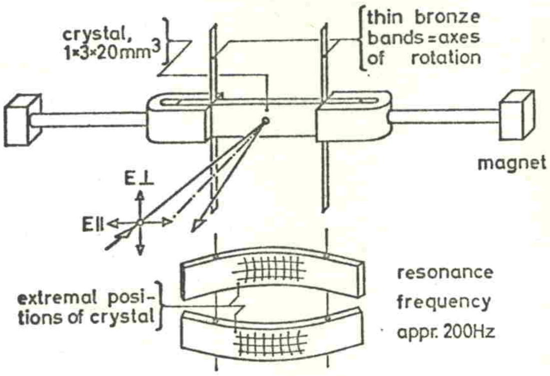

FIG. 1. The mechanical oscillator. The extremal positions of the crystal are shown in the lower half of the figure. The oscillator is driven by an inhomogeneous ac magnetic field which acts on the small permanent magnets at the ends of the level arms.

is due to nonlocalized transitions. In addition, it is used to determine the deformation potentials of the observed transitions. The consistency of the assignment deduced from experiment with the calculated electronic structure of Cu is discussed. The effect of a general strain on the electronic structure is treated theoretically. The results obtained here are compared with those deduced from other experiments (e.g., photoemission[19]) and with theoretical calculations.

EXPERIMENTAL METHOD

Mechanical and Electronic Setup

An ac bending of rectangular single crystalline bars ($1\times3\times20$ mm^3) was used to produce an ac strain at the surface of the crystal. The motion of the crystal is sketched in the lower half of Fig. 1. The two axes of rotation near the ends of the crystal (lower half) are realized by thin bronze bands, soldered to the two clamps which hold the crystal (upper half). Two lever arms are attached to the clamps, carrying small permanent magnets at their ends. The driving forces acting on these magnets were produced by the inhomogeneous ac magnetic field of two electromagnets. The frequency of the current passing through the electromagnets was tuned to the bending mode resonance frequency of the mechanical system.

There are also counterweights attached to the clamps (omitted in Fig. 1 for sake of clarity), which balance the mass of the permanent magnet, the lever arm, and the clamp. After removing the sample, the bronze bands will be a main axis of the moment of inertia for each assembly (magnet, lever arm, clamp, counterweight) individually. Thus, no forces are transmitted through the bronze bands. Otherwise, these forces might give an unwanted wavelength modulation by coupling the mechanical vibration to the monochromator or give acoustical feedback by coupling the vibration to the photomultiplier.

The reflected-light intensity, slightly modulated by the strain-induced change of the reflectance, was detected by a photomultiplier with quartz window (EMI 9558Q, Trialkali). The dc current of the multiplier did not change when the wavelength setting of the monochromator was changed. This was achieved by using an electronic feedback control of the photomultiplier. Thus the ac component of the anode current of the multiplier was proportional to $\Delta R/R$, the relative change of the reflectance. This component was measured as a function of wavelength by means of a phase-sensitive detector and displayed on an x-y recorder. The linearity of the system was checked with a photodiode; the ac to dc ratio was found to be correct to within $\pm3\%$.

Strain Measurement

The strain at the surface of the sample will be the same as that of a closed ring, formed by joining the ends of a previously straight bar with rectangular cross section, as shown in Fig. 2. This is true if the influence of the clamps can be neglected. The cross section of the ring will generally be no longer rectangular. There are two limiting cases for the stress tensor $\boldsymbol{\sigma}$ and the strain tensor $\mathbf{e}$ at the middle line of the surface of the ring. One limit is approached if the radius ρ_1 and the thickness d of the ring are large and the width b is small. In this case, the stress tensor and the strain tensor take the form

$$\boldsymbol{\sigma}'=\begin{pmatrix}0&&\\&0&\\&&\sigma_{zz}'\end{pmatrix};\quad \mathbf{e}'=\begin{pmatrix}e_{xx}'&&\\&e_{yy}'&\\&&e_{zz}'\end{pmatrix}. \qquad (1$$

We tried to approach this limit in our measurements. The quantitative conditions for the validity of Eqs. (1) were found experimentally by measuring ρ_1 and ρ_2 of bent aluminum bars of various thicknesses and widths. The strain at the middle part of the surface is given by $|e_{zz}'|=d/2\rho_1$ and $|e_{yy}'|=d/2\rho_2$. On the other hand, the ratio $|e_{zz}'/e_{yy}'|$ can be calculated using the stress-strain relation and the form of the stress tensor. Using

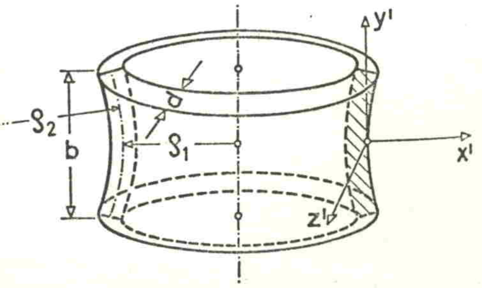

FIG. 2. A closed ring, formed by joining the ends of a previously straight bar with rectangular cross section. The stress axis is

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[19] C. N. Berglund and W. E. Spicer, Phys. Rev. **136**, A1030; **136**, A1044 (1964); *Colloquium on the Optical Properties and the Electronic Structure of Metals and Alloys, Pairs, 1965*, edited by F. Abelès (North-Holland Publishing Co., Amsterdam, 1966), pp. 285 and 296.