LETTERS TO THE EDITORS

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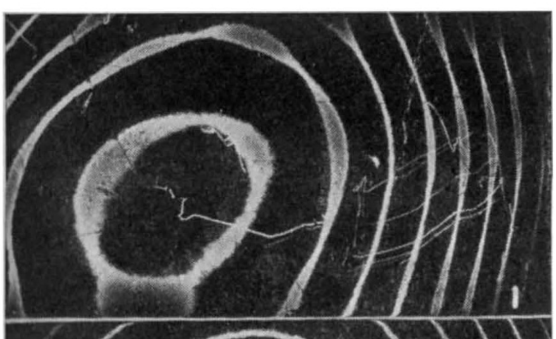
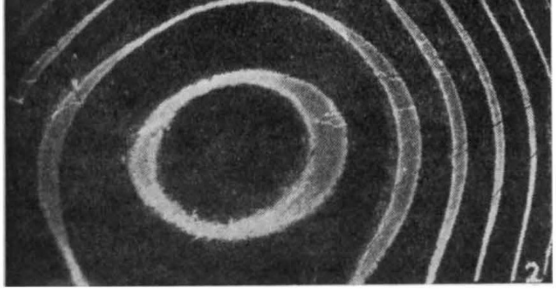
Application of Multiple-Beam Interferometry to the Study of Oscillating Quartz Crystals

We have succeeded in applying multiple-beam interference methods to the study of the surface movements of oscillating quartz crystals, and the striking results obtained indicate that this has opened up a considerable field for investigation. The technique is simple. The quartz crystal (kindly prepared for us by Dr. W. G. Radley of the Post Office Research Laboratory) was polished to a slightly higher degree than that usually adopted for oscillators, in order to give sharp interference fringes. It was silvered very lightly on one side, and on the opposite face with a high reflecting silver layer. The high reflecting face was placed resting in contact with a silvered optical flat, and electrical connexion made (by gentle contact) between the lightly silvered face of the crystal and the silver layer on the flat. The two connecting leads were taken to an oscillator circuit. There were no constraints on the crystal.

On illumination with correctly collimated monochromatic light (5461 A.), sharp multiple-beam Fizeau fringes form in the air film between the surfaces of the crystal and the flat, providing the crystal is not oscillating. The particular crystal used was rectangular, 3 cm. × 1 cm., and about 3 mm. thick. The final optical polish was such that the face in contact with the flat had a slight curvature, as a result of which the field of view, when the crystal was not oscillating, was covered by a few sharp, yet highly dispersed approximately circular fringes. When oscillations are excited, the fringes take on the remarkable appearance shown in the accompanying reproductions. Fig. 1 shows about three-quarters of the crystal surface, the remainder (the left-hand quarter) being obscured by the particular microscope stage available. One can see in a striking manner the whole distribution of oscillation on the crystal surface. More than one type of oscillation can, of course, be excited, and in that illustrated in Fig. 1 it can be clearly seen that there exist clear-cut nodal lines which are roughly the diagonals of the rectangular crystal face, forming a St. Andrew's cross. Other secondary features are readily interpreted from the interferogram, the fringe-width at any point being an exact measure of the local amplitude of oscillation. In Fig. 2, an oscillation of another type is illustrated, different nodal regions being readily discernible. Under the particular excitation conditions employed here, observed amplitudes vary from zero to a maximum of about 750 A.





A remarkable feature is the extreme sharpness of the fringes in the nodal positions. It is evident that in these regions the fringes remain quite undisplaced over the length of the time of exposure (several minutes), and indeed from visual observation they appear to remain quite still indefinitely. An amplitude of oscillation of only $\lambda/100$ can certainly be detected even with the relatively imperfectly surfaced crystal used here. This quantity is about 50 A.; hence the nodal regions have certainly less amplitude than this small amount, if any at all, and may quite possibly be at rest to within the dimension of the crystal lattice spacing. It should be possible to test this conjecture by using the high-dispersion crossed fringe technique already in use in this laboratory; but such an approach requires a higher surface finish than that of the crystal used. When sufficiently well-worked surfaces become available, this sensitive technique will be adopted.

A surprising feature is the complete stability of the fringe pattern given by the oscillating surface, particularly when the sensitivity of the multiple-beam fringes is recalled. It is clear to us that an intensive programme of investigation is called for, and this is being undertaken. We intend also to attempt to extend the technique by the application of stroboscopic methods of illumination. We note here that some earlier attempts in this direction have been reported, using two-beam interference methods (see Vigoureux, "Quartz Oscillators and their Applications" (1939)), but of course, as is always the case, the sensitivity of a two-beam interference method is not to be compared with that of the far more powerful multiple-beam technique.

A fuller report, including details of measurements, will be communicated elsewhere at an early date.

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Feb. 20.

Transfer Rates in Liquid Helium Films

The superfluidity of liquid helium II can be very conveniently studied by making observations on the flow of the thick mobile films ('Rollin films'[1]) which cover all surfaces in contact with the liquid. In previous investigations of these films by Daunt and Mendelssohn[2], the rate of flow was observed to be almost independent of such factors as the pressure head or the height of the film, and varied only with the temperature, rising from zero at the λ-point to $7 \cdot 5 \times 10^{-5}$ cm.^{3}/sec. per cm. width of film below 1·5° K. We have extended these investigations and