apparent if the relationship is plotted over a wider range of balance readings.

This point is at present being investigated and further results are being analysed.

C. C. HARRIS
A. JOWETT

Department of Mining,
University of Leeds.

¹ Bostock, W., *J. Sci. Inst.*, **29**, 209 (1952).

² Harris, C. C., *J. App. Phys.*, **31**, 215 (1960).

³ Heywood, H., *Recent Developments in Mineral Dressing*, 31 (I.M.M. London, 1953).

⁴ Frangiskos, N. Z., Harris, C. C., and Jowett, A., *Third Intern. Cong. Surface Activity*, Paper D46 (Cologne, 1960).

Very Precise Thickness Measurement of Thin Films

It has already been pointed out¹ that the Smith type of interference microscope, using a Wollaston prism in the rear focal plane of the objective, is a suitable instrument for measuring thin films. The film is deposited, with a reasonably sharp edge, on a flat surface and covered with a reflecting metallic film, using, for example, silver or aluminium. The image of an illuminated slit, doubled by the Wollaston prism, is projected by the objective, via a prism type of vertical illuminator, normally on to the specimen. The reflected beams are polarized mutually at right angles and the path-difference between them is zero if both slit images fall either on to the substrate only or on to the film only. If one image falls on to the film and the other on to the substrate the path-difference is equal to twice the film thickness, and the problem becomes the polarimetric one of measuring this path-difference.

A suitable form of compensator for performing this measurement has been described¹, together with a visual half-shade device for making the settings and an optical device for translating the slit images across the specimen. However, as the visual method is found to be very fatiguing under the conditions imposed by the microscope, a photo-electric method was sought.

A satisfactory method has been developed using the electro-optical effect in ammonium dihydrogen phosphate². The slit image formed in the image plane of the microscope passes through a plate of ammonium dihydrogen phosphate, cut normal to the optic axis and provided with transparent electrodes, then through an analyser and into a photo-multiplier. An a.c. voltage is applied between the electrodes. It can then be shown that the photo-multiplier output contains a component of frequency equal to that of the a.c. which is zero only when the path-difference between the two component beams is a whole number of half-wave-lengths. This fundamental component is detected by a phase-conscious rectifier which feeds a centre-zero meter. The setting operation then merely consists of operating the compensator until the meter reads zero.

By this means it has been found possible to make settings with a standard deviation corresponding to an uncertainty in film thickness of only 0.1 Å. The uncertainty is due largely to air currents, although the two beams are separated by only 0.2 mm.

This degree of accuracy is, of course, largely academic, as it is unlikely that a substrate as flat as this over 0.5 mm or so can be found. However, it is clear that settings to 1 Å unit can be made with certainty.

I thank Dr. T. E. Allibone, director of the Laboratory, for permission to publish this article.

J. DYSON

Research Laboratory,
Associated Electrical Industries,
Aldermaston Court,
Aldermaston, Berks.

¹ Dyson, J., *Physica*, **24**, 532 (1958).

² Billings, B. H., *J. Opt. Soc. Amer.*, **39**, 797 (1949). Takasaki, Hiroshi, *ibid.*, **51**, 462, 463, 1146 (1961).

MINERALOGY

Paragonite from the Dalradian

Two muscovite-rich red phyllites, one of chemical composition (per cent): SiO₂ 59.6, TiO₂ 0.9, Al₂O₃ 18.1, Fe₂O₃ 3.4, FeO 4.6, MnO 0.1, MgO 3.4, CaO 0.2, Na₂O 0.9, K₂O 4.7, H₂O 3.4, P₂O₅ 0.2, CO₂ nil, total 99.5, carry a quartz-paragonite-muscovite-chlorite-haematite-rutile-apatite mineral assemblage. They come from the Dunoon phyllite, a low-grade horizon of the Dalradian, $\frac{1}{2}$ and $\frac{3}{4}$ mile north along the coast from Dunoon, Argyllshire. This is the first recorded appearance of paragonite as a rock-forming mineral from the Scottish metamorphic rocks, and its appearance elsewhere in low-grade rocks without albite is considered likely.

Fig. 1

The basal spacings of the co-existing muscovite and paragonite, calculated from the 002 peaks on a diffractometer trace, are 9.946 Å and 9.612 Å, respectively. Rosenfeld *et al.*¹ report the basal spacings of co-existing muscovite and paragonite from two biotite zone rocks to be: (1) 9.981 Å and 9.623 Å; (2) 9.975 Å and 9.623 Å. Paragonite is about 5 per cent of the total white mica. The diffractometer traces over the 001 and 002 peaks using copper K radiation are reproduced in Fig. 1.

M. J. McNAMARA

Queens' College, Cambridge.

¹ Rosenfeld, J. L., Thompson, J. B., and Zen, E., *Amer. Mineral.*, **69**, 1637 (1958).

CRYSTALLOGRAPHY

Molecular Structure of Tutin

TUTIN (C₁₅H₁₈O₆) was first isolated by Easterfield and Aston¹ and identified as the convulsive poison present in the leaves and seeds of the New Zealand species of *Coriaria*, a shrub known by the Maori as 'toi toi'. The molecular structure of tutin is now inferred from an X-ray crystal structure analysis of α-bromo-iso-tutin.

Tutin is one of a series of chemically and pharmacologically similar compounds of which picrotoxinin (C₁₅H₁₆O₆)^{2,3} and coriamyrtin (C₁₅H₁₈O₆)⁴ have been most intensively studied. The structure (I) for picrotoxinin was proposed by Conroy^{5,6} and this was confirmed by X-ray crystallographic studies which also determined the absolute configuration of the molecule^{7,8}. On the basis of the picrotoxinin structure and chemical degradation studies, Karyone and Okuda proposed structures (II) and (III) for coriamyrtin and tutin⁴ respectively. Further chemical evidence⁹ led to the dilactone structure (IV) for tutin proposed by Johns and Markham.

The crystal structures of four bromo-derivatives have been examined in order to determine their suitability for complete structure analysis by the heavy atom method. The crystal data for these compounds are given in