attributed to deformation oscillation of the benzene rings against each other. Further discussion of the results is not possible at present for want of data concerning the Raman spectrum of cadinene.

Physics Department, V. M. PADMANABHAN.
Indian Institute of Science,
Bangalore,
August 2, 1949.

---

1. Sukh Dev Lala, "Thesis for Ph.D.," East Punjab University, 1948.

AN EQUATION FOR THE COMPARISON OF SURFACE TENSIONS BY UNSTABLE PENDANT DROPS

WORTHINGTON[1] has shown that whatever the liquid, if the quantity $\beta = 2b^2/a^2$ (where b is the radius of curvature at the apex, and a^2 is the capillary constant) is the same for two drops coming from tips of different radii r_1 and r_2, then the conditions for similar shape of the two drops are that

$$\frac{2b_1^2}{a_1^2} = \frac{2b_2^2}{a_2^2}.$$

When drops have similar shape, all corresponding linear dimensions of the two drops will be proportional to one another so that

$$\frac{b_1}{b_2} = \frac{a_1}{a_2} = \frac{r_1}{r_2}$$

and for a given shape, the equatorial diameter de of a drop is proportional to b.

$$i.e., \quad \frac{b_1}{b_2} = \frac{\dfrac{de_1}{r_1} \times r_1}{\dfrac{de_2}{r_2} \times r_2} = \frac{de_1}{de_2}, \qquad \text{(i)}$$

where the subscripts 1 and 2 refer to similar drops of two different liquids. Recently R. C. Brown and H. McCormick[2] in considering the detachment of drops from a conical tip, have shown that, provided the angle of contact between the liquid and the surface of a conical tip is the same, *all* drops forming on a cone of given angle are similar in shape at the unstable stage. The condition of constant contact angle is, of course, achieved in practice by ensuring that the angle is zero, *i.e.*, that the liquid wets the tip.

Therefore for a given shape (say S)

$$\beta = \frac{g\,\sigma_1 b_1^2}{\gamma_1} = \frac{g\,\sigma_2 b_2^2}{\gamma_2}.$$

where σ_1 and σ_2 are the effective densities and γ_1 and γ_2 are the surface tensions of the two liquids respectively.

$$i.e., \quad \frac{\gamma_1}{\gamma_2} = \frac{\sigma_1 b_1^2}{\sigma_2 b_2^2}$$

and using equation (i),

$$\frac{\gamma_1}{\gamma_2} = \frac{\sigma_1\, de_1^2}{\sigma_2\, de_2^2}. \qquad \text{(ii)}$$

Equation (ii) permits one to calculate the ratio of surface tensions of two liquids, if it is possible to photograph hanging drops at the unstable stage.

This work arose as a result of my similar experimental investigations on surface tension problems under the direction of Dr. N. R. Tawde of this Institute to whom I offer my grateful thanks.

Physics Department,
Royal Inst. of Science, K. G. PARVATIKAR.
Bombay,
June 22, 1949.

---

1. Worthington, *Proc. Roy. Soc.*, 1881, **32**, 332.
2. Brown, R. C., and McCormick, H., *Phil. Mag.*, 1948, **39**, 420.

THE MILLERIAN DIRECT SINE FORMULA AND THE CONVERSE COTANGENT FORMULA

THE Millerian Direct Sine Formula

$$\frac{\sin AB}{\sin AC} \times \frac{\sin DC}{\sin DB} = \frac{\begin{matrix} h\,k\,l \\ h'k'l' \end{matrix}}{\begin{matrix} h\,k\,l \\ p\,q\,r \end{matrix}} \times \frac{\begin{matrix} p'q'r' \\ p\,q\,r \end{matrix}}{\begin{matrix} p'q'r' \\ h'k'l' \end{matrix}}$$

and its converse cotangent equivalent, $p \cot AB - q \cot AC = (p - q) \cot AD$ (for anharmonic cases) and $\cot AB + \cot AD = 2 \cot AC$ (for harmonic cases) is without proof in text-books of crystallography, possibly because it is simple. Tutton[1] remarks, "it is readily capable of proof"

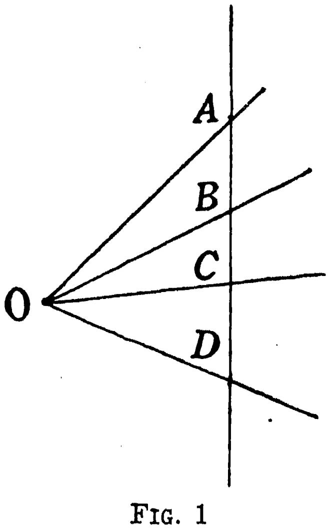

FIG. 1

Barker[2] remarks, "Miller showed that the four sines of the above formula can be rearranged into another from involving cotangents." Since 1933, I have been giving the following proofs to my classes in crystallography. Let OA, OB, OC and OD be a zone sheaf intersected by a fifth zone ABCD forming a cozonal quartette.

$$\text{Then } \frac{AB}{OB}=\frac{\sin AOB}{\sin OAB} \qquad (1)$$

$$\frac{AC}{OC}=\frac{\sin AOC}{\sin OAC} \qquad (2)$$

$$\frac{DC}{OC}=\frac{\sin DOC}{\sin OCD} \qquad (3)$$

$$\text{and } \frac{DB}{OB}=\frac{\sin DOB}{\sin OBD} \qquad (4)$$

Dividing (1) by (2) and (3) by (4), and multiplying the quotients and cancelling common factors, we get $\frac{\sin AB}{\sin AC}\times\frac{\sin DC}{\sin DB}=\frac{AB}{AC}\times\frac{DC}{DB}$. The right side of the equation is the geometrical analogue to $\frac{\begin{matrix} h\,k\,l \\ h'k'l' \end{matrix}}{\begin{matrix} h\,k\,l \\ p\,q\,r \end{matrix}}\times\frac{\begin{matrix} p'q'r' \\ p\,q\,r \end{matrix}}{\begin{matrix} p'q'r' \\ h'k'l' \end{matrix}}$ of the sine formula, the identity of which with the ratios of the sines of the angles requires a very elaborate proof and is lucidly stated by the Cambridge crystallographer, Prof. C. Lewis.[3]

If we express the left side of the sine formula as $\frac{\sin AB}{\text{in } AC}\times\frac{\sin (AD-AC)}{\sin (AD-AB)}$ thereby eliminating DC and DB, and put the product of the right side of the equation $=\frac{d}{q}$, then by expanding the left side and dividing it by sine AB sin AC sin AD, we get,

$$\frac{\cot AC-\cot AD}{\cot AB-\cot AD}=\frac{p}{q},$$

which by cross-multiplication and transposition becomes $p \cot AB - q \cot AC=(p-q) \cot AD$. In harmonic cases the value $\frac{p}{q}=\frac{1}{2}$; substituting $p=1$ and $q=2$ in the above formula and transposing, it simplifies to

$$\cot AB + \cot AD = 2 \cot AC.$$

Mysore University, P. R. J. Naidu.
Central College,
June 27, 1949.

---

1. Tutton, A. E. H., "Crystallography and Practical Crystal Measurement," 1922, 1, p. 89. 2. Barker, T. V., "Graphical and Tabular Methods in Crystallography," 1922, p. 61. 3. Lewis, W. J. "Crystallography," 1899, pp. 87-93.

BEREK'S COMPENSATER

In a note on Berek's compensater,[1] a correction was made that log $f(i)$ values should be used instead of log (i) values. The log $f(i)$ values are computed from the formula of Berek :—

$$\log f(i) = \log \sin^2 i \, \{1 + \cdot 2040 \sin^2 i + \cdot 0627 \sin^4 i\}.$$

Substituting the values of (i), in the case of hypersthene, *viz.*, 14·55° and 24·95° in the equation, it is seen that the values of log $f(i)$ for these angles correspond to 8·806 and 9·266 as given in the tables. The proof of this correction factor is given, after Berek,[2] as follows:—

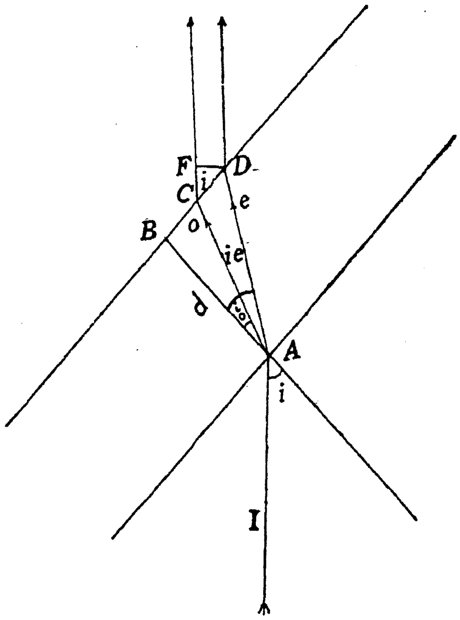

Fig. 1

The incident ray (I) is refracted in the calcite plate into the rays o and e, which on emergence from the plate, are parallel; and at the point D, o has travelled the distance AC + CF, and e the distance AD. Therefore,

$$\Gamma=\frac{AC}{\lambda_1}+\frac{CF}{\lambda}-\frac{AD}{\lambda_2} \qquad (1)$$

If d be the thickness of the plate