translational (which on classical theory amounts to the same thing, so that

$$f_v = \frac{kT}{h\nu} = \frac{(2\pi\mu kT)^{1/2}}{h} \cdot 2\bar{A} = f_{tr} = \frac{(2\pi mkT)^{1/2}}{h},$$

if the accessible space is identified with twice the average amplitude $\bar{A}$, an approximation allowed for liquids³), then the coefficient of viscosity is, using Eyring's expression for the free volume⁴ and inserting the numerical values of the constants,

$$\eta' = 1.09 \times 10^{-3} \frac{M^{1/2} T^{3/2}}{V^{2/3} \Delta E_v} \exp(E/RT), \quad (2)$$

where E is the activation energy per mole for viscous flow.

Trying to fit the Andrade equation (see below) let us take M , the molecular weight of the substance, to be 121; ΔE_v , the molar heat of vaporization, as 5,000 cal.; V , the molar volume, as 125 c.c.; then at ordinary temperatures

$$\eta' = 0.4 \times 10^{-3} \exp(E/RT). \quad (3)$$

Comparing this with the equation of Andrade⁵, which is for many substances

$$\eta = 0.4 \times 10^{-3} \exp(b/vT) v^{1/3}, \quad (4)$$

we see at once that the coefficient of viscosity given by Eq. (4) is five times greater than that of Eq. (3) with the molar volume 125 c.c.⁶. If we take the correction of Hirschfelder into consideration, we obtain from Eq. (3) a coefficient of viscosity two to four times greater, which is a good agreement in view of the approximations.

Since the diffusion coefficient is, according to Eyring¹,

$$D' = \lambda^2 k',$$

we have to introduce the same correction, which gives

$$D/D' = 0.3 \text{ to } 0.5.$$

If D_{obs} is the observed value, then $D_{\text{obs}}/D' = 0.3$ to 0.5, that is, $D_{\text{obs}} = D$.

It seems worth while to use the correction in other rate processes which can be described as unimolecular and to calculate its exact numerical value in every process. On the other hand, the calculation of the correction from the experimental values may throw light on the molecular interactions in liquids.

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² Hirschfelder, J. O., *J. Chem. Phys.*, **16**, 22 (1948).

³ Frank, H. S., *J. Chem. Phys.*, **13**, 478 (1945).

⁴ Eyring, H., and Hirschfelder, J. O., *J. Phys. Chem.*, **41**, 249 (1937).

⁵ Andrade, E. N. da C., *Phil. Mag.*, **17**, 497, 698 (1934).

⁶ Glasstone, S., Laidler, K. J., and Eyring, H., "The Theory of Rate Processes", 486 (International Chemical Series, 1941).

Luminous Night Clouds

LUMINOUS night clouds were observed in the northern sky in Scotland on the nights of July 9–10 and July 10–11, the extensive display showing characteristic wave structure in the early morning of July 11 being quite magnificent. Brilliantly blue-white in colour, the night clouds appeared about half an hour after sunset in a sky almost clear of normal cloud, were most brilliant during the hour after midnight and faded in the growing light before sunrise. A series of simultaneous photographs (one pair is reproduced here) by Störmer–Krogness auroral cameras from Abernethy and Blairgowrie will yield measurements of height, direction and speed of movement, as also of distance between successive wave-crests.

Simultaneous photographs of luminous night clouds at 00h.19m. G.M.T. on July 11, 1949, from Abernethy (above) and Blairgowrie (below) (J. F. McKellican), 27.6 km. apart. Note the displacement of corresponding cloud features with respect to the star Capella, centre Blairgowrie picture, to the right on Abernethy picture.

These rare clouds, which are observed only in summer and in middle latitudes, were first studied by Jesse¹, and later by Störmer² using his auroral network. Occurring at heights of about 80 km., they provide valuable information concerning air movement at that level. On the evidence of their colour, it is generally believed that they consist of fine dust of cosmic or volcanic origin. It is significant that the present manifestation followed a few days after an eruption in the region of the Canary Islands.

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¹ Jesse, *Ast. Nachr.*, 140 (1896).

² Störmer, *Ast. Norv.*, **1**, No. 3 (1935); *Nature*, **134**, 219 (1934); **135**, 103 (1935).