This would mean that the different media would damp the vibrations of the quartz differently, by a resistance or opposing pressure π, inherent as a characteristic of the liquid. The damping of vibration and π would be larger the larger the viscosity. This also explains the observed fall of power in castor oil, previously recorded in the work of one of us[4]. The observed values of $\Delta\mu$ would thus decrease with the increasing values of π. Thus the relation between $\Delta\mu$ and π for a small range can be represented by $\Delta\mu = a - b\pi$. This would transform the viscosity relation into the form, $\eta = \alpha \exp(\beta\pi)$. It is premature at this stage to make critical observations on α and β, which, within the conditions of experimental limitations, appear to be constants.

It may, however, be noted that Frenkel[5], from considerations of the kinetic theory of liquids, obtained the viscosity relation in the form $\eta = A \exp(\beta p)$, where p is the external pressure and η gives the viscosity of a particular liquid. It appears that the external pressure increases the stiffness of the liquid, measured in terms of π, and so increases the viscosity of the liquid.

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Indentation Hardness of Diamond

RECENTLY, S. Tolansky and V. R. Howes[1] published some data on indentation compression strength with a diamond ball (0·39 mm. radius) on differently orientated diamond faces. They obtained values for the pressure which caused cracking on different diamond faces ranging from $1{\cdot}2$ to $1{\cdot}8 \times 10^{11}$ dyne-cm.$^{-2}$ (1,200–1,800 kgm./mm.^{2}). By comparing these values with those quoted in the literature it appears that they are extremely low: F. Auerbach[2], absolute hardness of diamond 2,200 kgm./mm.^{2}; Knoop, hardness[3] of diamond 6,500–8,500 kgm./mm.^{2}; Russian tests with triangular pyramids[4] and my own tests[5] with the same type of indenter indicated hardnesses greater than 14,000 kgm./mm.^{2}. Recent tests with double cone indenters (radius 2 mm., included angle 154°) showed that diamond surfaces could be loaded to well over 3,000 kgm./mm.^{2} without showing any form of cracks even when investigated with the electron microscope (by courtesy of Mr. M. Seal, Cambridge).

It is astonishing that these high average pressures, usually called hardness, should behave so differently with diamond surfaces. An explanation of this phenomenon may be given by the Hertzian formulæ[6] for the maximum pressure $p_{\max.}$ between the surfaces.

The values of the average pressure and of the maximum pressure are shown in a histogram (Fig. 1) for a number of tests with various indenters. The average pressures with triangular and elongated pyramids are high, but with spheres and double cones relatively low. However, the relative stress

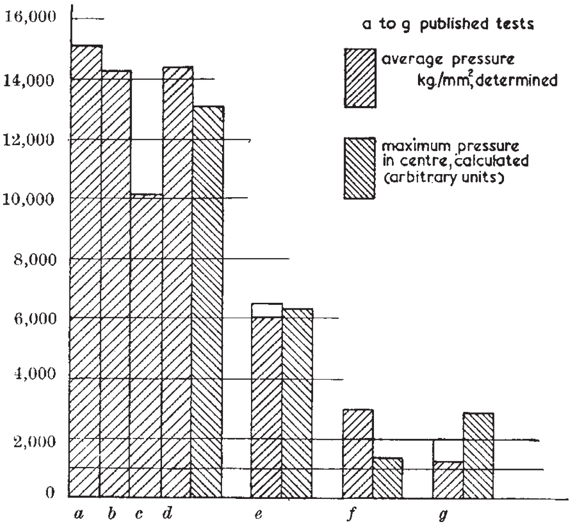

Fig. 1. Histogram of experimental values comparing average with maximum pressures.
a–c, M. M. Khrushchov and E. S. Berkovich (triangular pyramid). *d*, P. Grodzinski and W. Stern (triangular pyramid). *e*, Nat. Bur. Standards (Knoop elongated pyramid). *f*, P. Grodzinski (double cone, $r = 2$ mm., $\alpha = 77°$). *g*, V. R. Howes and S. Tolansky (sphere, $r = 0{\cdot}39$ mm.)

factor was based on the highest maximum pressure $p_{\max.}$ obtained with triangular pyramids, and made equal to 13,000 kgm./mm.^{2}, which is the average of the average pressures for tests *a*, *b* and *c*. For test *e* we obtain a value of 6,350 kgm./mm.^{2}, which is close to the experimental value. For test *f* the value 1,350 kgm./mm.^{2} is about half the experimental pressure; but here no plastic deformation or any kind of fracture was observed. In contrast to this, in test *g* where elastic deformation was always followed by fracture, the maximum pressure is almost 50 per cent higher than the maximum average value recorded; this obviously indicates that the elastic limit has been well exceeded.

In this way the widely differing values of average pressures in kgm./mm.^{2} of diamond indenters against diamond surfaces can be explained. Obviously, different mechanisms are involved. In the tests with a pointed indenter (triangular and square base pyramids), there is plastic flow at shear stresses, whereas with tests with the double cone and spheres mainly elastic deformations occur up to the moment of fracture, the latter being due to tensile stresses. Therefore the average stress usually designated as hardness has no physical significance without knowing the shape of the indenter and the load. It may also be suggested that this applies to the usual hardness of materials of lower hardness than diamond.

A more detailed account of this work will be published elsewhere. I thank Mrs. A. Hoselitz for carrying out the tests with the double-cone diamond and Prof. S. Tolansky and V. R. Howes for useful comments.

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