determined directly from the record provided that shock wave data for the two materials are known. (Using two air-gaps only, Paterson and Lamb[3] have measured the Chapman–Jouget pressure in commercial explosives in a similar manner.)

In principle, one should also be able to find the whole of the original pressure profile from an analysis of the record. Even without an elaborate analysis, however, the record can often give a valuable qualitative picture of the pressure profile.

From the records in Fig. 3, one finds: first, that along the axis of the receptor charge the shock wave velocity and amplitude increase quite steadily towards detonation, and not at all so abruptly as one might be led to believe from an observation of the surface of the charge.

Secondly, the shock wave velocity in the 'Perspex' seems to increase as the wave travels into the 'Perspex' in such cases where the receptor charge has a thickness less than the expected depth of initiation. The experiments indicate that there is, in that part of the receptor charge, a region behind the shock front where the instantaneous pressure is greater behind the front than at it.

Thirdly, this region of greater pressure appears to contract and draw closer to the front as the wave moves farther into the receptor charge.

The pressures in the explosive were estimated using the Hugoniot data for detonation products of composition B (64/35/1 RDX/TNT/wax) given by Deal[4]. The uncertainty in this estimate is undoubtedly greater at low pressures than at pressures near the C–J pressure, where the chemical reaction is closer to completion.

The estimated front pressure in the experiment with the thickest receptor charge (30 mm) agrees well with the C–J pressure given by Deal[4].

No sign of a von Neumann spike can be observed in these records. We intend to carry out experiments with very thin 'Perspex' plates in order to look specifically for this phenomenon.

U. BERG
P. A. PERSSON

Research Institute of National Defence,
Division of Physics,
Stockholm 80.

[1] Walsh, J. M., and Rice, M. H., J. Chem. Phys., 26, 815 (1957).
[2] Buchanan, J. S., James, H. J., and Teague, G. W., Phil. Mag., 3, 1432 (1958).
[3] Paterson, S., and Lamb, P., J. Phot. Sci., 9, 363 (1961).
[4] Deal, W. E., Phys. Fluids, 1, 523 (1958).

Effect of Grinding on Quartz Particles

WHETHER a vitreous or otherwise 'disturbed' layer forms on particles of quartz produced by size reduction processes has been the subject of a controversy for some time. In an earlier communication[1] we reported evidence for the absence of a vitreous or mosaic sub-surface layer. A recent paper by Sakabe et al.[2] leaves little doubt that, in their experiments, a thick vitreous layer was formed by the grinding procedure used. Samples were ground in a mechanical agate mortar for varying times up to 300 h and fractions of mean particle size of approximately 0.5μ were prepared by centrifuging. Some of their observations are summarized here.

(1) The initially angular particles became rounded, almost spherical, after 24-h grinding.

(2) The initial rate of solution in 10 per cent sodium hydroxide was greatly enhanced by grinding and in all cases diminished to the same steady value after about 10 h.

(3) The intensity of the (101) X-ray Bragg reflexion diminished rapidly with increasing grinding time. After 300 h of grinding the peak disappeared. Little or no broadening of the peak was observed.

(4) In the electron diffraction patterns increasing grinding time resulted in a diminution in the number of spectra observed and an increase in the background intensity. No arcs or rings were observed.

We interpret these observations as indicating that the change from the quartz to the vitreous phase occurs directly without passing through a mosaic or other semi-crystalline state, as suggested by King and Nagelschmidt[3].

Samples ground under acetone in our own laboratory, either for 44 h by hand in an agate mortar or for 10 h in an agate phial using a 'Wig-L-Bug', failed to exhibit any of the foregoing phenomena suggesting the formation of vitreous material. In both cases marked broadening of the (101) X-ray reflexion was observed, but only a very slight diminution in the integrated intensity. The particles were observed to retain their angular shapes and efficient size reduction was achieved.

The difference between our results and those of Sakabe et al. obviously lies in the method of grinding. It is possible that in dry grinding with the high pestle pressures usual with mechanical mortars, the friction between the particles and the mortar or pestle may at times become so great that a region of the particle near the surface melts momentarily and assumes the vitreous phase on cooling.

Further investigations are necessary to determine the exact conditions under which a vitreous layer will form. From our own experiments it would seem that efficient size reduction of quartz particles can be achieved without the formation of a relatively thick vitreous sub-surface layer.

This communication is published with the permission of the Transvaal and Orange Free State Chamber of Mines.

J. H. TALBOT
E. B. KEMPIS

Dust and Ventilation Laboratory,
Transvaal and Orange Free State Chamber of Mines,
Johannesburg,
South Africa.

[1] Talbot, J. H., and Kempis, E. B., Nature, 188, 927 (1960).
[2] Sakabe et al., Bull. Nat. Inst. Indust. Health, 4, 1 (1960).
[3] King, E. J., and Nagelschmidt, G., Proc. Pneumoconiosis Conf., Johannesburg, 1959, 78 (J. and A. Churchill, Ltd., London, 1960).

Bond Energy of Vacancies and Interstitial Atoms in Graphite

BAKER and Kelly[1] have estimated that the energy to form a vacancy in graphite (that is, the energy to remove an atom from the lattice and place it on the free surface) is $U_f = 3.3 \pm 0.9$ eV. (The symbol $\pm$ refers to maximum limit of values.) They comment that this is less than the heat of sublimation, $U_s = 7.5$ eV per atom, indicating an energy-relaxation of 4.2 ± 0.9 eV at the vacancy. Equality should occur[2] if the broken lattice bonds around the vacancy remain broken. In graphite, however, all the lattice bonds are unsaturated, and we would expect that the unpaired electrons of the three atoms around the vacancy would form covalent bonds with electrons derived from unsaturated bonds of adjacent atoms (cf. ref. 3). These we will call partial bonds. The net energy associated with their formation (denoted by $3U_1$ per vacancy) we identify with the required energy relaxation. Thus:

$$U_1 = 1.4 \pm 0.3 \text{ eV} \tag{1}$$

An interstitial atom should likewise form partial bonds with adjacent lattice atoms, the net energy of formation of which will be denoted by $3U_2$ per interstitial. Strain energy around a vacancy or interstitial in graphite is small, and is neglected, as is also the energy associated with any electron-trapping processes. The energy, U_p, of a well-separated vacancy-interstitial pair is therefore equal to the energy to break all three lattice bonds around a lattice atom, $2U_s$, less the energy-relaxation around the vacancy and the interstitial, $3(U_1 + U_2)$. However, U_p is greater than U_f, as otherwise the surface atoms will spontaneously take up interstitial positions. From this we obtain: