[17] Fano, U., *Symp. Radiobiology*, 13 (John Wiley and Sons, Inc., New York, 1952).
[18] Fluke, D. J., Brostad, T., and Birge, A. C., *Rad. Res.*, **13**, 788 (1960).
[19] Bradt, H. L., and Peters, B., *Phys. Rev.*, **74**, 1828 (1948).
[20] Fulmer, C. B., Thesis, North Carolina State College (1957).
[21] Katz, L., and Penfold, A. S., *Revs. Mod. Phys.*, **24**, 28 (1952).
[22] Seitz, F., *Phys. Fluids*, **1**, 2 (1958).
[23] Davis, M., *Phys. Rev.*, **94**, 243 (1954).
[24] Williams, E. J., *Proc. Roy. Soc.*, A, **130**, 310 (1930).
[25] Pollard, E., and Barrett, N., *Rad. Res.*, **11**, 781 (1959).
[26] Gross, D., and Amster, A. B., *Eighth Intern. Symp. Combustion*, 728 (Williams and Wilkins Co., Baltimore, 1962).
[27] Tonegutti, M., *Z. ges. Schiss-u. Sprengstoffu*, **32**, 93 (1937).
[28] Tomlinson, jun., W. R., *Picatinny Arsenal Tech. Rep.*, 1740, Rev. 1 (1958).
[29] Belajev, A. F., and Matyushko, N., *C.R. U.R.S.S.*, **30**, 629 (1941).
[30] Taylor, J., and Hall, C. R. L., *J. Phys. and Coll. Chem.*, **51**, 580 (1947).
[31] Robertson, A. J. B., *J. Soc. Chem. Indust.*, **67**, 221 (1948).
[32] Roginsky, S., *Physikal. Z. Soviet Union*, **1**, 640 (1932).
[33] Cook, M. A., and Abegg, M. T., *Indust. Eng. Chem.*, **48**, 1090 (1956).
[34] Velicky, R., Lenchitz, C., and Beach, W., *Picatinny Arsenal Tech. Rep.*, 2504 (1959).
[35] Johnson, O. H., *NAVORD Rep.* 4371 (Oct., 1956).
[36] Robertson, A. J. B., *Trans. Faraday Soc.*, **45**, 85 (1949).
[37] Patton, T. C., *Indust. Eng. Chem.*, **36**, 990 (1944).
[38] Goldansky, V. I., and Kagan, Y. M., *Chemical Effects of Nuclear Transformations* (IAEA), **1**, 47 (1961).
[39] Dodd, J. G., *Proc. Eleventh Basic Research Group Contractors' Conf. and Symp.*, 215 (1962).
[40] Ling, jun., D. S., *Proc. Eleventh Basic Research Group Contractors' Conf. and Symp.*, 225 (1962).
[41] Copp, J. L., and Ubbelohde, A. R., *Trans. Faraday Soc.*, **44**, 658 (1948).
[42] Mader, C. L., *Los Alamos Sci. Lab. Rep. LA* 2703.
[43] Hubbard, H. W., and Johnson, M. H., *J. App. Phys.*, **30**, 765 (1959).
[44] Vineyard, G. H., *Disc. Faraday Soc.*, **31**, 7 (1961).

This attempt to calculate the temperature and the behaviour of a hot spot formed in an explosive crystal by the passage of a fission fragment is a courageous one, but is fraught with some danger.

It is true that the energy which a fission fragment dissipates within a crystalline material is delivered to the lattice, but the rate and the way in which it appears as lattice vibrations (heat) are complex and poorly understood processes. The two major way in which energy is lost are those of fragment/electron interactions (in a Coulomb fashion) and those of fragment/nucleus collisions (in a Rutherford fashion). The division of energy-loss to these two processes is sensitively dependent on the nature of the theoretical model chosen for the atomic interaction potential. Since a considerable amount of the energy delivered directly to the lattice atoms may be carried long distances down close-packed rows of atoms or molecules at shock-wave velocities, the temperatures produced at the centre of the track may well be less than 25 per cent of those suggested by the authors. Moreover, since the diameter of the tube is only 10 Å (approximately 6 atoms) the material should not be considered as a continuum, and it has been shown that the effective thermal conductivity may be greater than the macroscopic conductivity by a factor as large as 10.

The rate at which heat is evolved owing to chemical reaction is proportional to the rate constant, which the authors take as about 10^{20}/sec by extrapolating low-temperature kinetic data over 10^5 °C. This extrapolation is open to some criticism and in fact the rate constant is more likely to be of the order of 10^{14}/sec, that is, the same order of magnitude as the lattice vibration frequency. Hence it is possible that the ratio:

$$\frac{\text{heat evolved due to chemical reaction}}{\text{heat lost due to conduction}}$$

has been overestimated by many orders of magnitude. In addition, the computed temperature profiles would not necessarily lead to a macroscopic explosion. In all three figures the putative flame front is heavily supported from behind (nearer to the particle trajectory) by an intense 'hot spot' (radius approx. 20 Å, temperature greater than 2×10^4 °K). If the calculations were continued until this hot spot became significantly eroded, would the flame front continue to propagate unsupported ?

The critical hot spot size between 10^{-5} and 10^{-3} cm is partly derived on a theoretical basis but mainly from relatively macroscopic experimental observations. Although there is no *a priori* reason why the theory should not be valid outside this range, the theory should not be taken too far. First of all the number of molecules involved in the excitation of a typical track is small and an atomistic approach may be necessary. Secondly, there is the problem of the growth to explosion from the region of initiation. This growth stage can be a delicate one and under many conditions may be quenched.

The scope of classical explosion theory is more modest than the authors imply. It is customary to calculate the evolution of the temperature profile from the basic equation until the end of the induction period, that is, from $\theta = 0$ to $\theta \sim 2$, where θ is the Frank–Kamenetski reduced temperature increase $E(T - T_0)/RT_0^2$. Neglect of hydrodynamic processes is justified in this case for the conventional explosives because the ratio, temperature increase/adiabatic explosion temperature, cRT_0^2/qE, and thus the fractional decomposition is small ($\sim$ 5 per cent). Thus the classical theory enables us to determine whether a hot spot grows or decays in its early life but cannot be applied to considerations of its subsequent fate.

In conclusion we would agree with the title of this article that there is an inadequacy of thermal explosion theory when applied to fission-fragment bombardment of explosive solids. It would seem, however, that it is not possible to make sensible calculations at this stage since the necessary parameters under these extreme conditions are not known.

T. Boddington
F. P. Bowden
L. T. Chadderton
A. D. Yoffe
Laboratory for the Physics and Chemistry of Solids,
Free School Lane,
Cambridge.

SPECTRUM-LINE-REVERSAL TEMPERATURE MEASUREMENTS THROUGH UNSTEADY RAREFACTION WAVES IN VIBRATIONALLY RELAXING OXYGEN

By Dr. T. A. HOLBECHE
Aerodynamics Department, Royal Aircraft Establishment, Farnborough, Hants

THIS article describes some preliminary investigations of the effect of vibrational relaxation on the structure of unsteady expansion waves produced in a shock tube by the bursting of a second diaphragm. Fig. 1 illustrates in distance-time co-ordinates the idealized flow pattern which would result from instantaneous rupture of this diaphragm by the initial (or primary) shock. The expansion being investigated takes place in the gas heated by the initial shock; in other words, behind the secondary contact surface. By a measurement of the time-variation of temperature and of static pressure at some fixed point B, the effect of the lag in vibrational de-excitation (and