High explosive analogue of the Tunguska event

THE Tunguska event of 1908, which has been described in detail by Krinov[1], is generally accepted as having been caused by a detonating bolide. Zotkin and Tsikulin[2] concluded, on the basis of laboratory experimentation, that the event could best be fitted by a travelling wave striking the forest at an angle of 30° to the horizon, culminating in a detonation at a height roughly eight times that of the forest canopy. The pattern of tree blowdown consisted of a radially symmetric zone 35 km in diameter, on which was superimposed a bi-lobed pattern caused by the travelling wave. Stanyukovich and Bronshten[3] quote a total energy of 10^{23} erg for the event. In August 1966 an experiment was carried out in a mixed forest of Pine, Spruce and Fir near Hinton, Alberta, Canada, which has some features in common with the Tunguska event. In the experiment a hemispherical stack of TNT, 100,000 lb (50 short tons) in weight, was detonated on the forest floor. The resulting pattern of tree blowdown is shown in Fig. 1.

Fig. 1 Effect of 50-t charge in a mixed forest.

The blowdown zone is 130 m in diameter, and may be compared with the zone of symmetric blowdown at Tunguska. Simple cube root scaling of the dimensions lead to an estimate of 10^5 tons TNT for the Tunguska event. On the basis of a 50% partition of energy, this is equivalent to a 200-kiloton (kt) nuclear event. Taking 1.2 kcal g^{-1} for TNT, the estimated energy for Tunguska is 4×10^{21} erg, two orders of magnitude smaller than the estimate given above. This lower estimate, however, may be a close approximation to the energy of the final detonation, that is to say ignoring the contribution from the travelling wave.

Note, however, that the experiment was a surface explosion, whereas the Tunguska event is believed to be a low 'air burst'. Thus, a refinement of the estimate could be made using the standard height of burst curves. The expected difference in the pattern of blowdown at the full scale—that is, due to a 200-kt detonation at, say, 200 m height—is unlikely, however, to approach an order of magnitude, and will probably be closer to unity. In view of the uncertainties inherent in comparing conventional, nuclear and kinetic energy events in terms of their residual effects, such a refinement of the calculation would be quite unjustified.

Permission to publish this note has been given by the Defence Research Board of Canada.

G. H. S. JONES

Defence Research Board Staff,
Department of National Defence,
101 Colonel By Drive,
Ottawa, Ontario, Canada

Received 19 April; accepted 20 April 1977.

1 Krinov, E. L. *Giant Meteorites* (Pergamon, Oxford, 1966).
2 Zotkin, I. T. & Tsikulin, M. A. *Dok. Akad. Nauk S.S.S.R.*, **167**, 59–62 (1966).
3 Stanyukovich, K. P. & Bronshten, V. A. *Dok. Akad. Nauk S.S.S.R.*, **140**, 583–586 (1961).

Body-centred cubic cylinder packing and the garnet structure

ANALYSIS of the symmetry of periodic packings of identical (circular) cylinders has been found to be useful in analysis of crystal structures. To provide a description of a crystal structure, the cylinders are replaced by rods[1] of atoms or groups of atoms. The densest cubic packing of cylinders is of particular interest: we show how the garnet structure can be described simply in terms of this packing.

Periodic packings of simple geometric objects such as spheres and polyhedra have long had an important role in crystal structure description but little attention has been paid to the problem of cylinder packings in this connection. Periodic packings of cylinders with parallel axes or with axes in parallel planes are fairly easy to visualise, but packings with cubic symmetry are less obvious. One of these, described here, is of special importance to the description of complex cubic structures previously considered enigmatic.

In this packing, cylinders in contact with each other lie with their axes parallel to four cubic $\langle 111 \rangle$ directions. A sketch of a fragment of the packing is shown in the figure. The space symmetry group[2] of the arrangement is $I4_1/a\bar{3}2/d$ ($Ia\bar{3}d$) so we propose to call it body-centred cubic cylinder (or rod) packing. The fraction of space filled by cylinders in contact is $\sqrt{3}\pi/8 = 0.680$; this is considerably less than for the densest cylinder packing (which is the familiar honeycomb arrangement with hexagonal symmetry) for which the space-filling fraction is $\pi/\sqrt{12} = 0.907$. Nevertheless it seems to be a safe conjecture that this is the densest cubic packing of identical cylinders.

In applying the cylinder packing to crystal structure description we notice that each cylinder axis lies on a threefold symmetry axis so that a characteristic feature of the symmetry is the presence of four non-intersecting threefold axes. Crystal structures that will lend themselves to description in terms of

Fig. 1 A fragment of body-centred cubic cylinder packing viewed down a trigonal axis.