are shown as structured surfaces covering 90 per cent of the particles[4]. As can be seen, the Chinese particles have a very low specific activity—about a factor 100 less than has been normal for Soviet and American particles.

The colours and visual appearances show scarcely anything peculiar; they are colourless to yellow-red-brownish as from the Soviet and American tests. Unlike some Soviet samples[6,7] the Chinese samples show no differences in the specific activities for lightly and deeply coloured particles. A remarkably large number of the particles are perfectly spherical.

The low specific activity may depend on the Chinese test being a near-ground shot and a very large amount of inactive material is incorporated in the fire ball[1].

These findings are in good agreement with those published by Mamuro *et al.*[8].

JAN SISEFSKY

Research Institute of National Defence,
Stockholm, Sweden.

Persson, G., *F.O.A. Rep., A*, 4424 (1965).
[2] Sisefsky, J., *Brit. J. App. Phys.*, **10**, 526 (1959).
[3] Sisefsky, J., *F.O.A.* 4 *Rep., A*, 4217 (1961).
[4] Sisefsky, J., *F.O.A. Rep.*, 4 *A*, 4407 (1964).
[5] Sisefsky, J., *Science*, **133**, 735 (1961).
[6] Sisefsky, J., *F.O.A.* 4 *Rep., A*, 4130 (1960).
[7] Mamuro, T., *et al.*, *Nature*, **196**, 529 (1962).
[8] Mamuro, T., *et al.*, *Ann. Rep. Rad. Cent. Osaka Prefecture*, **5**, 1 (1964).

Optical Amplification of the Apparent Rate of Rotation of a Reflector in Q-switching a Laser Resonator

GIANT pulses of output radiation are produced by a laser when the quality factor (or Q) of the resonant reflecting structure of the laser cavity is suddenly increased after establishing a strongly inverted population distribution in the laser material[1]. The change in Q may be produced by rotating one reflector of the resonant cavity rapidly about an axis perpendicular to the emission direction, phasing the pumping of the laser medium so that the mirror comes into the position giving maximum Q just after maximum inversion has been attained (Fig. 1*A*). The optimum rate of switching depends on the transit time of light in the resonant cavity of the laser, and high rotational speeds are required. A limit to the maximum rotational speed is often set by the practical difficulty of driving the mirror, and this limit may be well within the ultimate limit at which mechanical distortion and risk of failure in the mirror under the rotational forces is incurred. The maximum peak power output which may be extracted

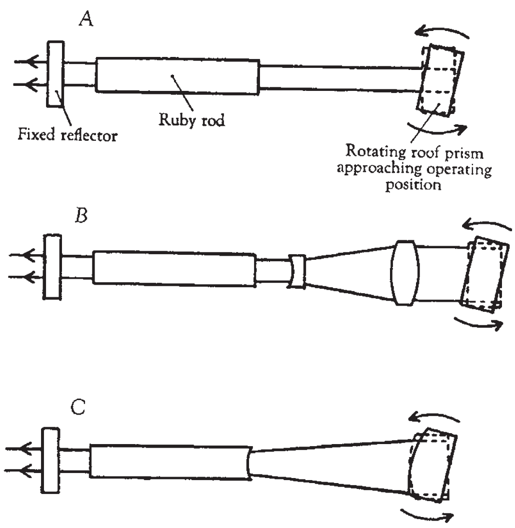

Fig. 1. *A*, Q-switched ruby laser; *B*, afocal system amplifying the rate of Q-switching; *C*, afocal system integral with ruby and reflecting prism

from the laser as a single pulse will be restricted : (1) if the switching is too slow; (2) if the peak power density on the reflector may damage it; (3) if an accidental resonant structure exists, independent of the rotating reflector (and possibly with a lower Q), which may drain off some or all of the available energy before the rotating mirror comes into position.

This communication describes an optical arrangement which helps to extend the possibility of Q switching beyond these limits, without introducing further optical components or increasing the number of reflecting and transmitting surfaces.

If an afocal system of magnification m (for example, a telescope) is introduced between the ruby rod and the rotating roof prism of a typical Q-switched laser (Fig. 1*B*), the (linear) aperture of the prism filled by the beam will be increased by a factor m, and the rate of angular sweep of the reflected beam across the fixed reflector will be increased by the same factor, giving an improvement in Q-switching. An increase in the linear dimensions of the reflecting prism will be necessary and the rotational forces will then be larger by a factor m^2 if the rotational speed remains the same. This is the same factor of increase as that which would have resulted from speeding up the original reflector m times, so the limit on Q-switching speed imposed by the risks of distortion and mechanical failure is the same. However, when the magnifying system is used, the rotational speed required is much more easily obtained, and the intensity of illumination on the prism is m^2 times lower.

In realizing this scheme, it is not necessary to use a separate afocal system. The positive element of a Galilean afocal system may be incorporated in a rotating prism in the form of a convex curvature on the entrance (refracting) face of the roof prism, and the negative component may take the form of a strongly curved concave surface on the end of the laser rod (Fig. 1*C*). In a trial of the system a ruby rod 100 mm long and 10 mm diam. was given a concave end surface with radius of curvature 21·6 mm, and coated to reduce reflexion. The other end of the ruby rod was flat and carried a coating with a reflectivity of about 50 per cent. The rotating roof prism was of silica with an entrance face about 20 mm clear aperture and a convex spherical curvature of radius 91 mm. This combination, when the separation is adjusted to the afocal condition, has a magnification of about 7·8. The prism was mounted directly on the shaft of a 3,000 r.p.m. synchronous motor, driven from 50-cycle single-phase mains, and the mains wave-form was used to phase the pumping flash with the rotation of the prism. The energy in the capacitor bank for each flash was about 1,000 joules, and the flash tube, which was 130 mm long, was equipped with an elliptic cylinder reflector. The laser output observed consisted of typical 'giant pulse' spikes of peak powers from 0·5 to 0·7 MW and a total duration of about 2×10^{-6} sec. These results demonstrate that the optical system works in practice, and the use of such a relatively slow motor emphasizes the advantage. Motors capable of operating at many times this speed would, of course, normally be used for optimum results.

In conclusion, the arrangement offers advantages in respect of the three limitations listed above : (1) the speed of switching is increased ; (2) the peak power density in the reflecting prism is reduced ; (3) the divergent form of the laser rod makes the competing non-Q-switched resonant structure much more lossy and less likely to sustain oscillation[2].

J. W. GATES
R. G. N. HALL

National Physical Laboratory,
Teddington, Middlesex.

[1] Hellwarth, R. W., *Quantum Electronics III*, **2**, 1203 (Columbia, New York, 1964).
[2] Fox, A. G., and Tingye Li, *Quantum Electronics III*, **2**, 1263 (Columbia, New York, 1964).