multi-function machines. However, all share a common feature in that various measuring geometries can be used; often these have been concentric cylinder (or couette) and cone-plate, although parallel-plate is becoming more widely used.

Concentric cylinder. In this geometry there are two coaxial cylinders of different diameters, the outer forming the cup containing the fluid in which the inner cylinder or bob is positioned centrally (Fig. 6.13). In older types of instrument the outer cylinder is rotated and the viscous drag exerted by the fluid is transmitted to the inner cylinder as a torque inducing its rotation which can be measured by a transducer or a fine torsion wire. The stress on this inner cylinder (when, for example, it is suspended on a torsion wire) is indicated by the angular deflection, θ, once equilibrium (i.e. steady flow) has been attained. The torque, T, can then be calculated from:

$$C\theta = T \tag{6.31}$$

where C is the torsional constant of the wire. The viscosity is then given by:

$$\eta = \frac{\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right)}{4\pi h\omega} \tag{6.32}$$

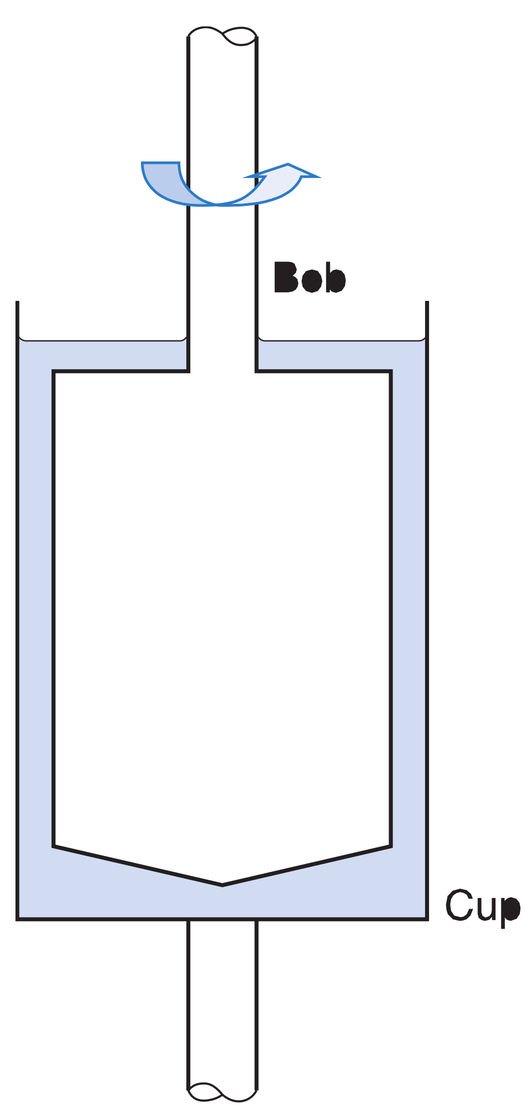

Fig. 6.13 • Concentric cylinder geometry.

where r_1 and r_2 are the radii of the inner and outer cylinders respectively, h is the height of the inner cylinder, and ω is the angular velocity of the outer cylinder.

Cone-plate. The cone-plate geometry comprises a flat circular plate with a wide-angle cone placed centrally above it (Fig. 6.14). The tip of the cone just touches the plate and the sample is loaded into the included gap. When the plate is rotated the cone will be caused to rotate against a torsion wire in the same way as the inner cylinder described above. Provided the gap angle is small (less than 1°), the viscosity will be given by:

$$\eta = \frac{3\omega T}{2\pi r^3 \alpha} \tag{6.33}$$

where ω is the angular velocity of the plate, T is the torque, r is the radius of the cone and α is the angle between the cone and the plate.

Parallel plate. This only differs from cone-plate in that the cone is replaced by a flat plate which is similar to the opposing part of the geometry (Fig. 6.15). The viscosity is given by:

$$\eta = \frac{2hT}{\pi r^4 \omega} \tag{6.34}$$

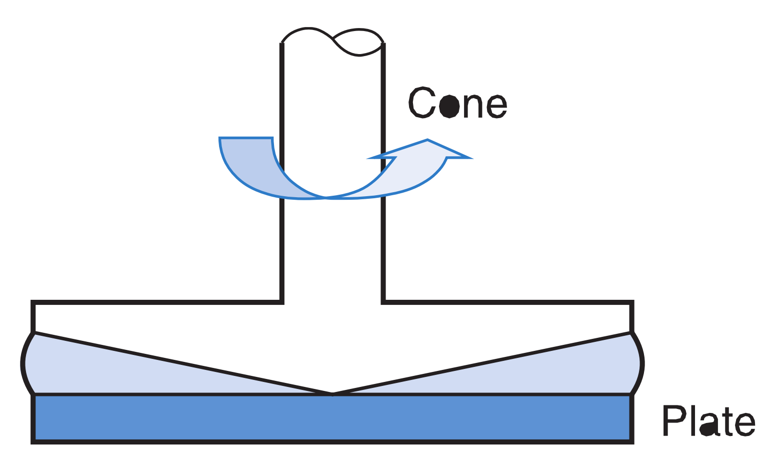

Fig. 6.14 • Cone-plate geometry.

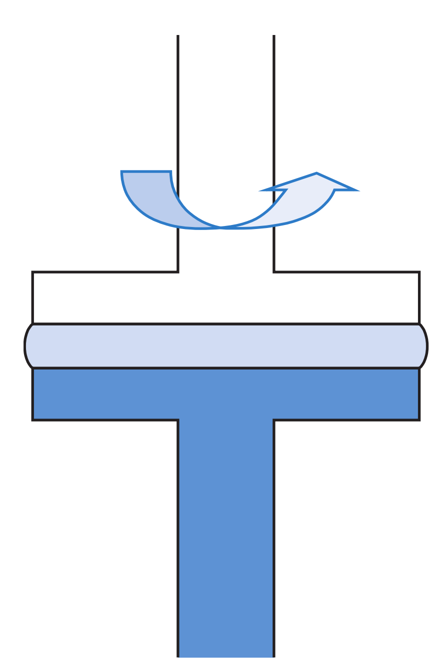

Fig. 6.15 • Parallel plate geometry.