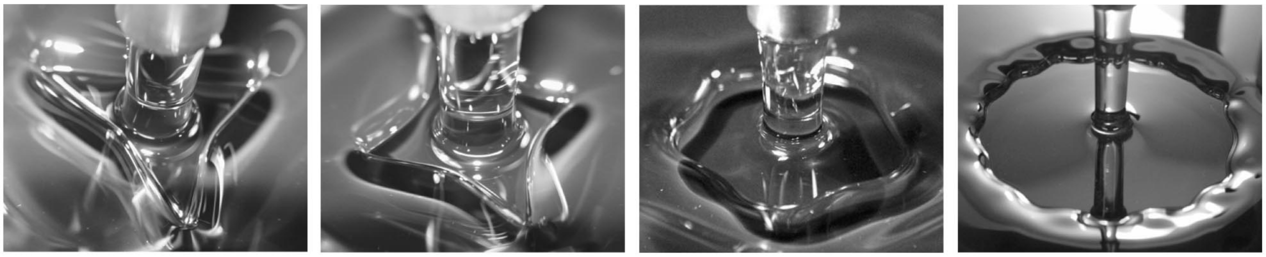

FIG. 1.

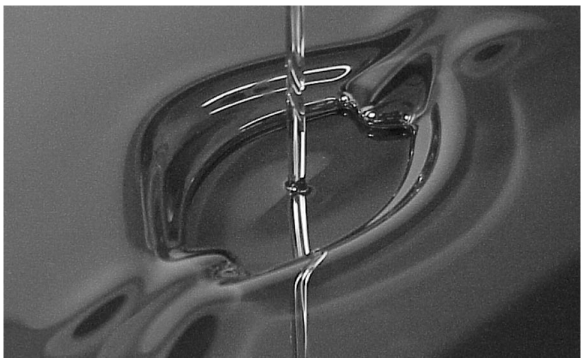

FIG. 2.

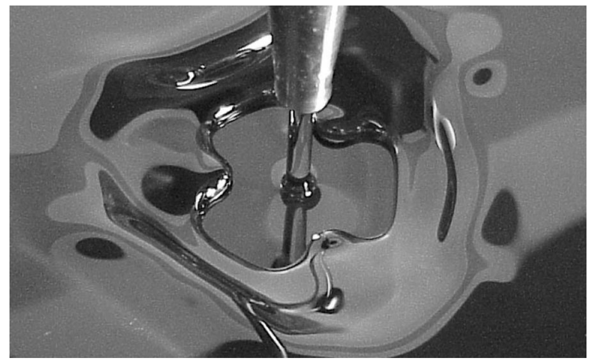

FIG. 3.

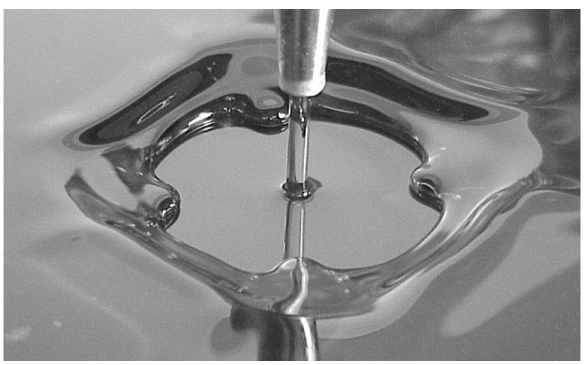

FIG. 4.

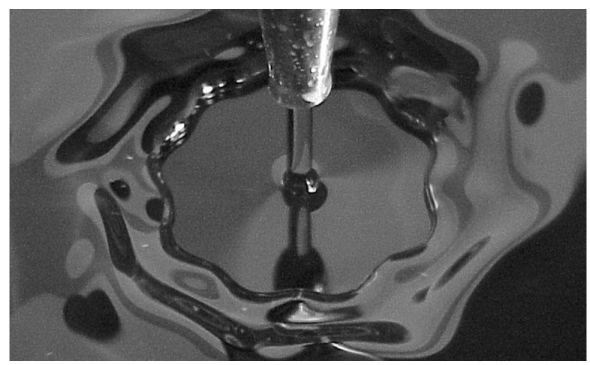

FIG. 5.

Viscous Hydraulic Jumps

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We examine the form of the viscous hydraulic jump that arises when a descending vertical fluid jet impacts a rigid horizontal boundary. Fluid is expelled radially, and the layer generally thins until reaching a critical radius at which the layer depth increases abruptly. In our study, glycerol–water solutions with viscosities of 10–40 cS were pumped at flow rates of 40–100 cc/s through source nozzles with diameters of 4–10 mm. The fluid impacted the center of a circular glass plate of diameter 36 cm that formed the base of a reservoir. The fluid then proceeded through the jump, and over the edges of the reservoir, whose depth was controlled by an outer wall of height 2–10 mm.

Elegaard *et al.*[1] first demonstrated that the axial symmetry of the viscous hydraulic jump may be broken, resulting in steady polygonal jumps (Fig. 1). Our investigation revealed a new class of steady asymmetric jumps that include cat's eyes, three- and four-leaf clovers, and sunflowers (Figs. 2–5). The addition of a drop of surfactant has two effects that underscore the importance of surface tension on the jump structure: the jump expands in radius,[2] and the circular symmetry is restored.

[1]C. Ellegaard, A. E. Hansen, A. Haaning, A. Marcussen, T. Bohr, J. L. Hansen, and S. Watanabe, ''Creating corners in kitchen sinks,'' Nature (London) **392**, 767 (1998).
[2]J. W. M. Bush and J. M. Aristoff, ''The influence of surface tension on the circular hydraulic jump,'' J. Fluid Mech **489**, 229 (2003).

1070-6631/2004/16(9)/4/1/$22.00