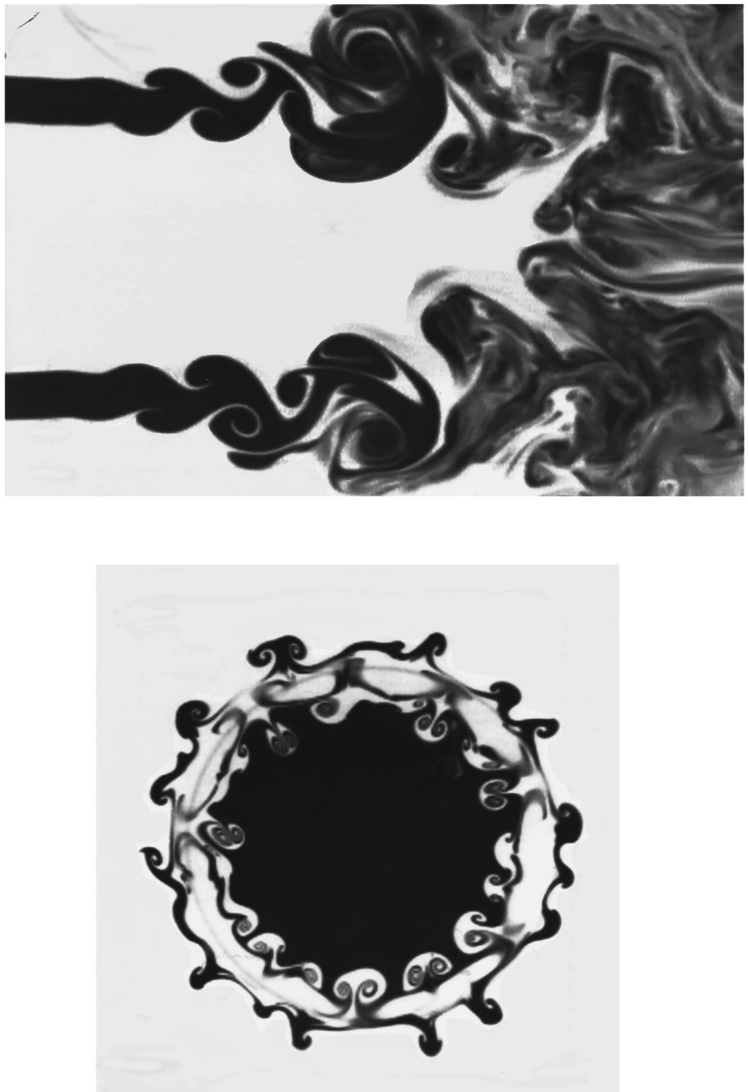

FIG. 1.

SHEAR INSTABILITIES IN THE NEAR FIELD OF COAXIAL JETS

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Snapshots of the destabilization of a slow round jet (velocity u_1) by a fast coflowing annular jet (velocity u_2) in water with $u_2/u_1=3$ as manifested by the mixing of a high Schmidt number dye are shown. The Reynolds number based on the outer diameter and velocity $\mathrm{Re}=u_2D_2/\nu$ is 2×10^4. The wavelength $\lambda_\parallel$ of the longitudinal shear instability at the interface between the two streams (top picture, outer jet seeded) is about six times the vorticity thickness δ of the fast stream velocity profile at the lip of the annular tube, and the wavelength in the transverse direction $\lambda_\perp$ (bottom picture, transverse cut perpendicular to the direction of the flow at one inner diameter D_1 downstream of the exit plane) is about 3δ.

The development of the longitudinal and transverse instabilities is nearly concomitant and they both grow at the same rate. The longitudinal vortices from the transverse instability (mushroom-like structures on the bottom picture) connect rapidly the injection scale with the dissipative scale, resulting in an efficient mixing in the near field. The overall entrainment process is completed at a distance $[6/(u_2/u_1)]D_1$ downstream of the injection plane.[1]

When the velocity ratio is further increased beyond about 8, a transition to an unsteady, wake-type recirculation regime is observed.[1,2] The recirculation bubble oscillates periodically with a low frequency f, distinct from the jet mode, characterized by a Strouhal number based on the inner diameter and the outer velocity fD_1/u_2 of the order of 0.035.

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