FIG. 1.

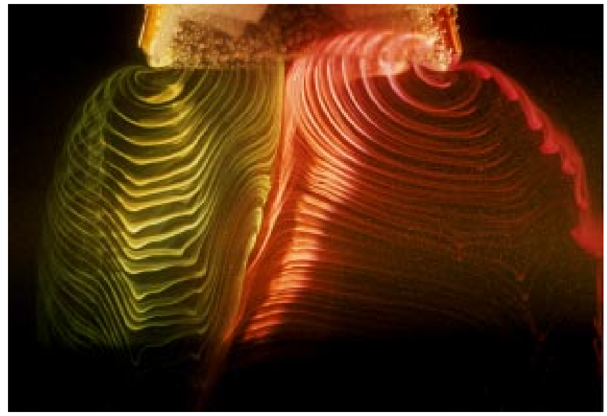

FIG. 2.

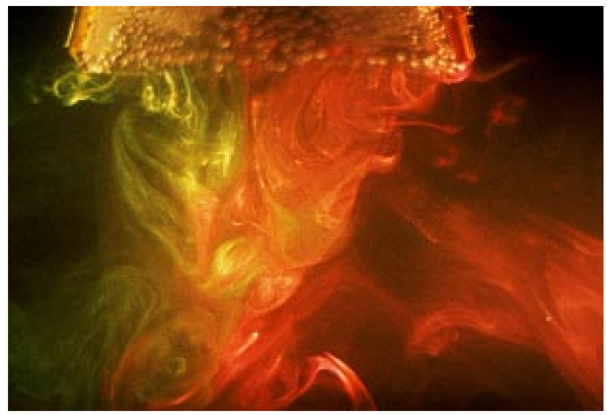

FIG. 3.

OSCILLATING FLOW THROUGH A FUNNEL

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Our interest in vortex suppression at the entrance of a wave-driven seawater pump leads us to study vortex formation at the exit of a diffuser due to an oscillating flow. In the experiment shown above, a piston produces an oscillating flow inside a partly submerged duct that ends in a diffuser. The diffuser is designed such that a constant relationship between centripetal and inertial forces is maintained along the profile. The flow in the near field of the mouth is visualized by injecting diluted fluorescent water paint just outside the diffuser.

Two non-dimensional numbers can be defined for this kind of flow: the usual Reynolds number, $R_e = DV/\nu$, where D is the diameter of the duct, V the mean velocity and ν the kinematic viscosity; and a modified Reynolds number, $R_m = D^2\omega/4\nu$, where ω is the frequency of oscillation of the flow. Oscillating flows are expected to become turbulent at $R_m = 2000$.[1]

Vortex formation for a wide range of R_e and R_m was studied. A vortex is formed at the exit of the diffuser in each half period, one when the flow goes out and another when the flow goes in. The mean direction along which each pair of vortices is shed and the angle between vortices are strongly dependent on the amplitude and the frequency of the oscillation.

Two different types of dyes were used to show mixing at various values of the parameters. In some cases (for example, Fig. 1, $R_e = 1800$ and $R_m = 506$) a pair of vortices is formed and convected away from the diffuser. In other cases (for example, Fig. 2, $R_e = 1500$ and $R_m = 850$) an almost stationary pattern is formed, and it moves slowly as a whole towards the bottom of the tank. When the flow is turbulent (for example, Fig. 3, $R_e = 2900$ and $R_m = 2000$) mixing between the two dyes injected at opposite sides of the diffuser is observed.

Diffusers with other geometry, not shown here, have also been studied. The flows have also been analyzed using PIV.

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