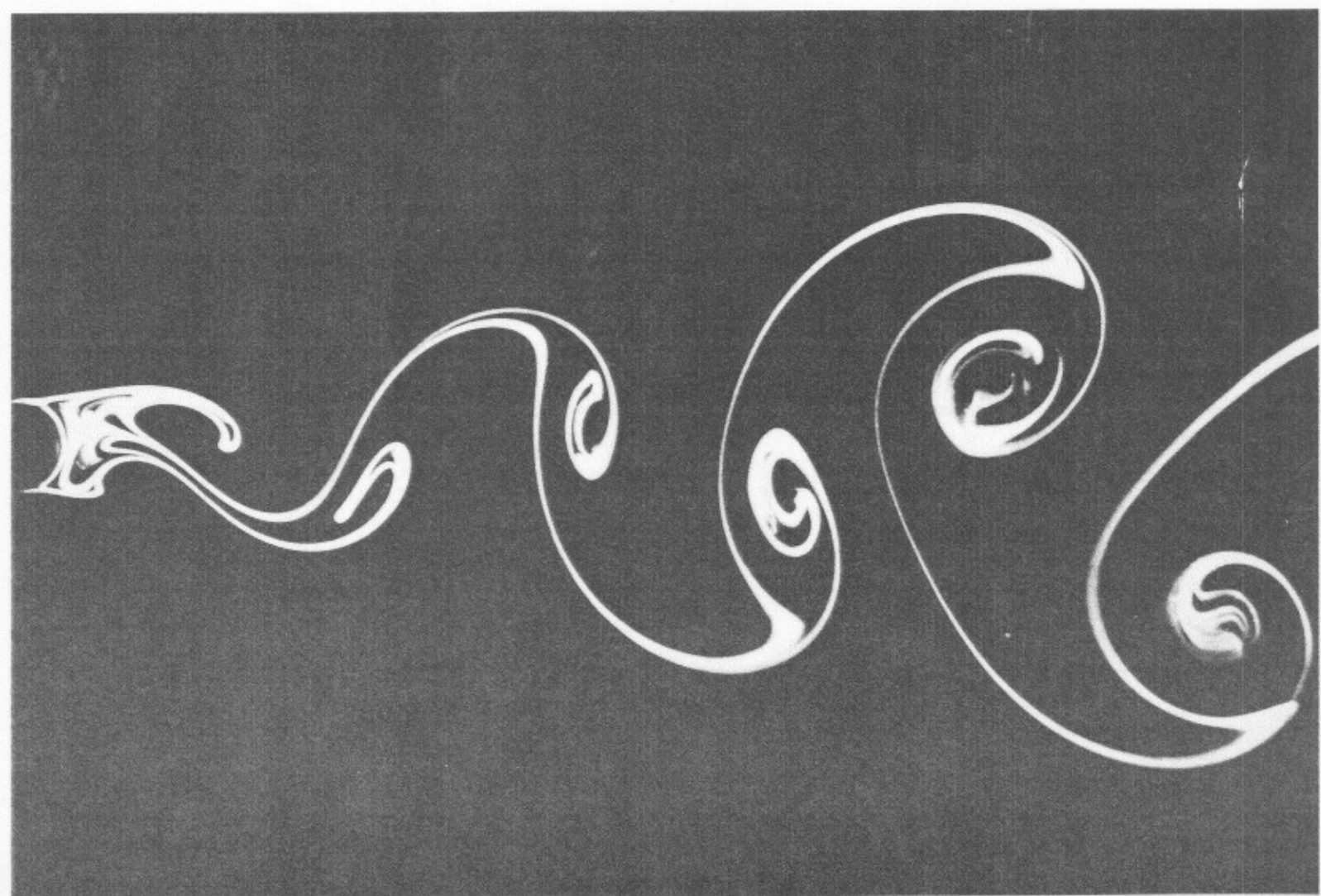
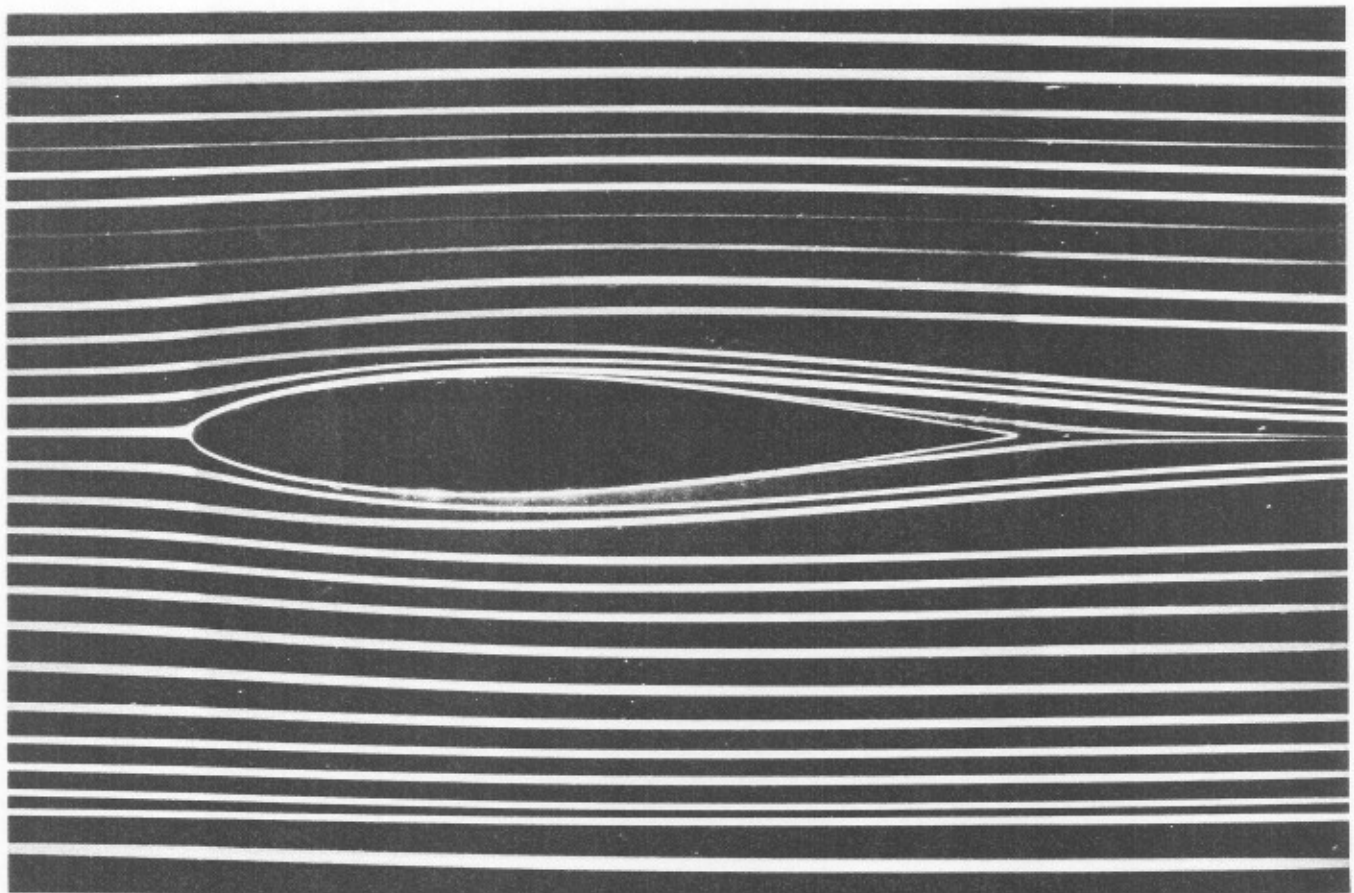
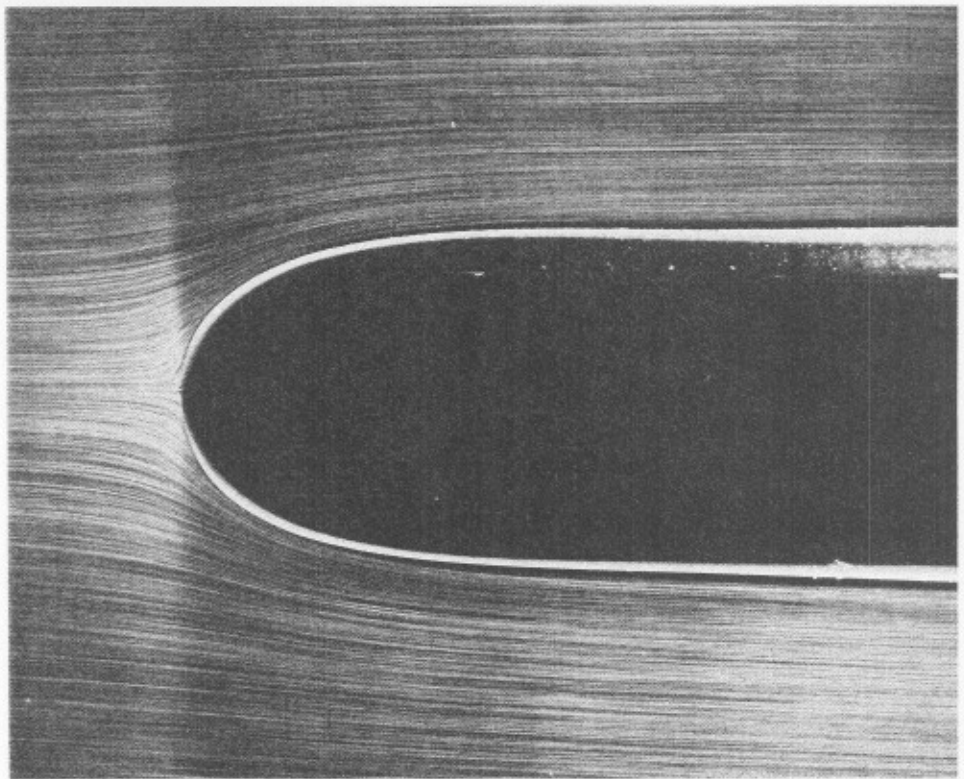


An Album of Fluid Motion

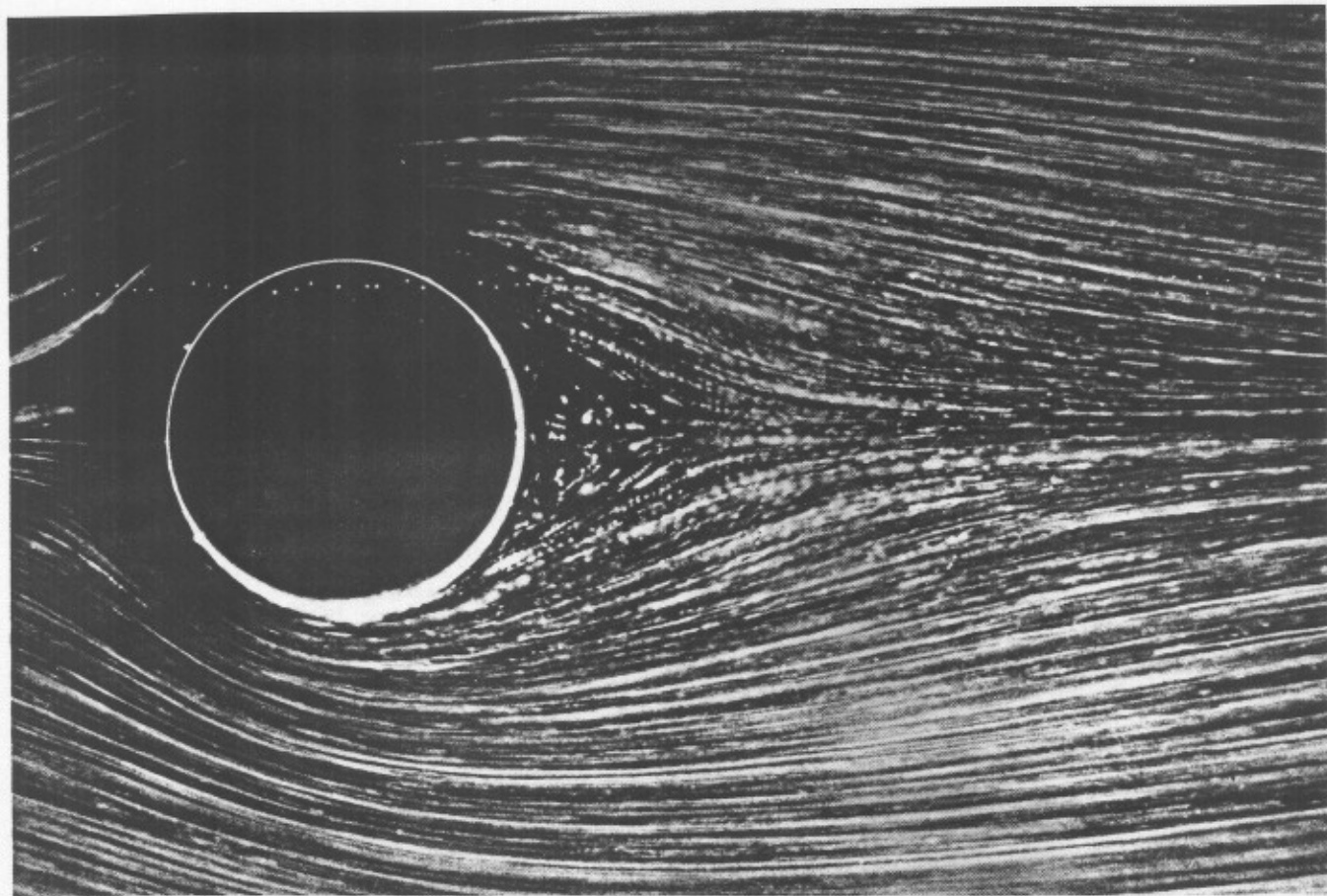


22. **Axisymmetric flow past a Rankine ogive.** This is the body of revolution that would be produced by a point potential source in a uniform stream—the axisymmetric counterpart of the plane half-body of figure 2. Its shape is so gentle that at zero incidence and a Reynolds number of 6000 based on diameter the flow remains attached and laminar. Streamlines are made visible by tiny air bubbles in water, illuminated by a sheet of light in the mid-plane. ONERA photograph, Werlé 1962



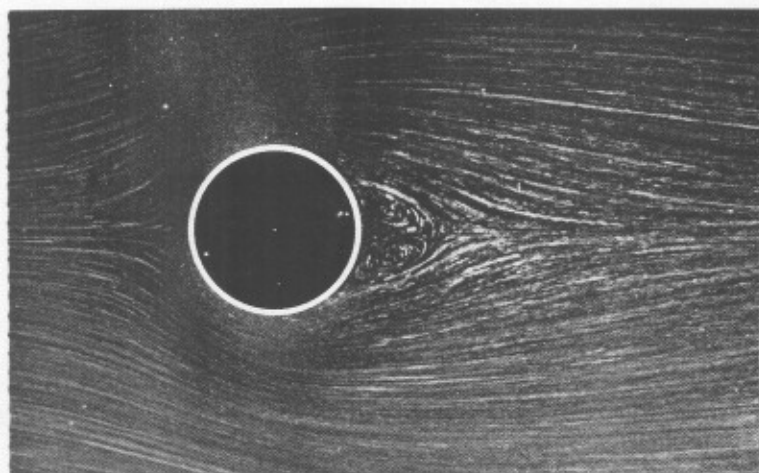
23. **Symmetric plane flow past an airfoil.** An NACA 64A015 profile is at zero incidence in a water tunnel. The Reynolds number is 7000 based on the chordlength. Streamlines are shown by colored fluid introduced up-

stream. The flow is evidently laminar and appears to be unseparated, though one might anticipate a small separated region near the trailing edge. ONERA photograph, Werlé 1974

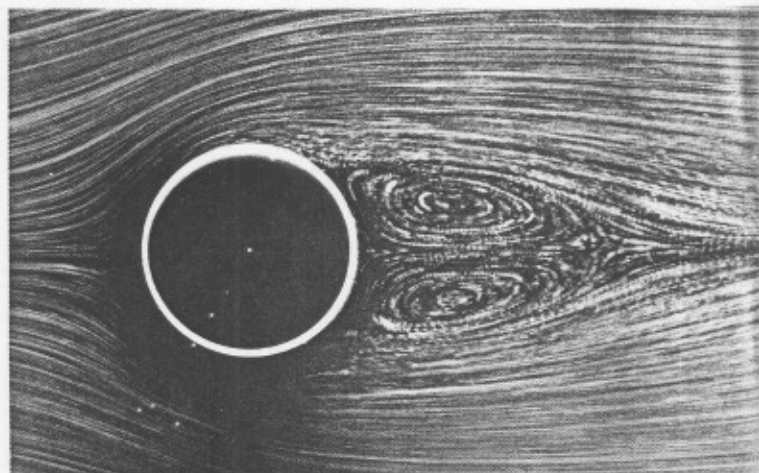


40. Circular cylinder at $R=9.6$. Here, in contrast to figure 24, the flow has clearly separated to form a pair of recirculating eddies. The cylinder is moving through a tank of water containing aluminum powder, and is illuminated

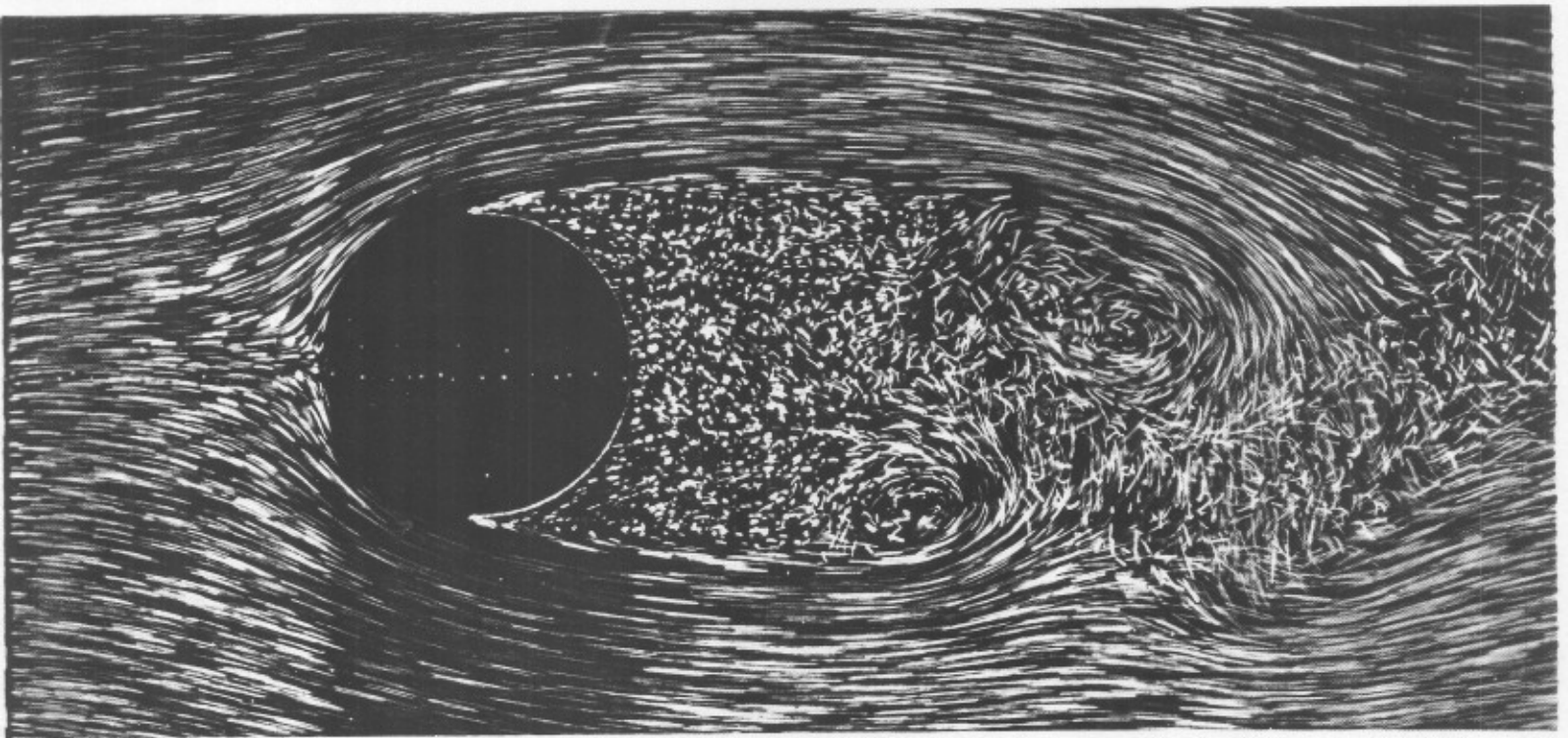
by a sheet of light below the free surface. Extrapolation of such experiments to unbounded flow suggests separation at $R=4$ or 5, whereas most numerical computations give $R=5$ to 7. Photograph by Sadatoshi Taneda



41. Circular cylinder at $R=13.1$. The standing eddies become elongated in the flow direction as the speed increases. Their length is found to increase linearly with Reynolds number until the flow becomes unstable above $R=40$. Taneda 1956a

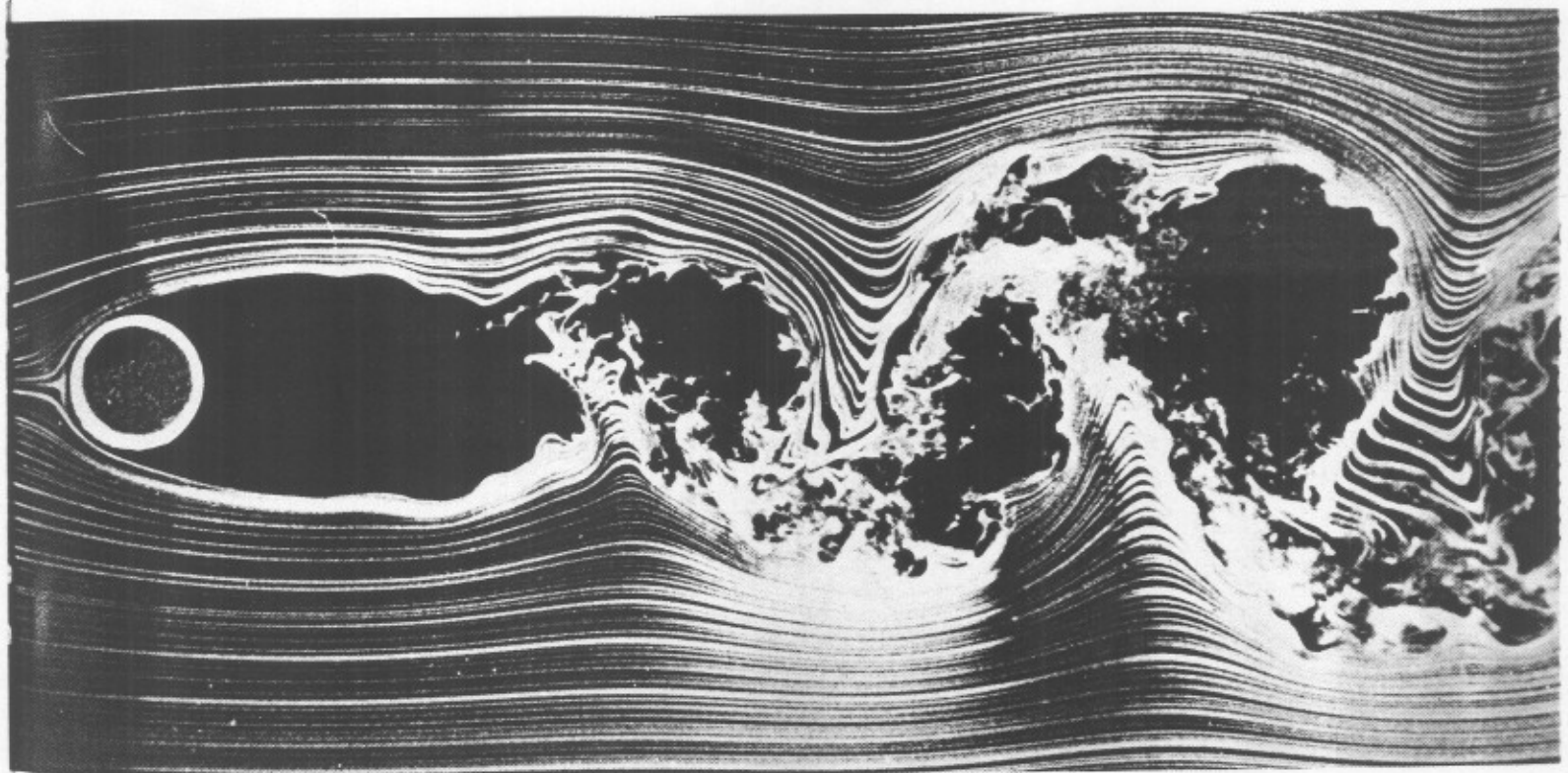


42. Circular cylinder at $R=26$. The downstream distance to the cores of the eddies also increases linearly with Reynolds number. However, the lateral distance between the cores appears to grow more nearly as the square root. Photograph by Sadatoshi Taneda



47. Circular cylinder at $R=2000$. At this Reynolds number one may properly speak of a boundary layer. It is laminar over the front, separates, and breaks up into a turbulent wake. The separation points, moving forward as

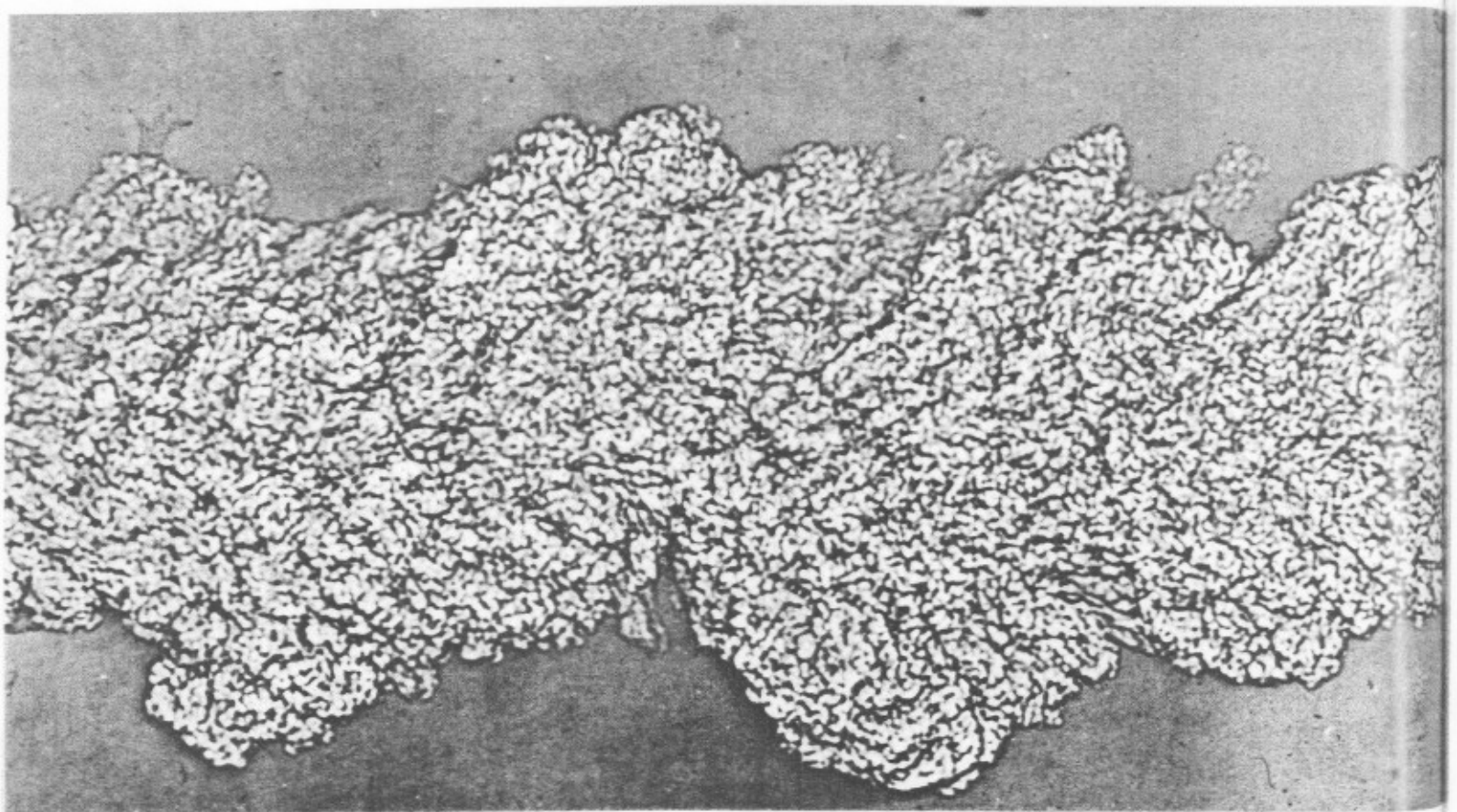
the Reynolds number is increased, have now attained their upstream limit, ahead of maximum thickness. Visualization is by air bubbles in water. ONERA photograph, Werlé & Gallon 1972



48. Circular cylinder at $R=10,000$. At five times the speed of the photograph at the top of the page, the flow pattern is scarcely changed. The drag coefficient consequently remains almost constant in the range of Reynolds

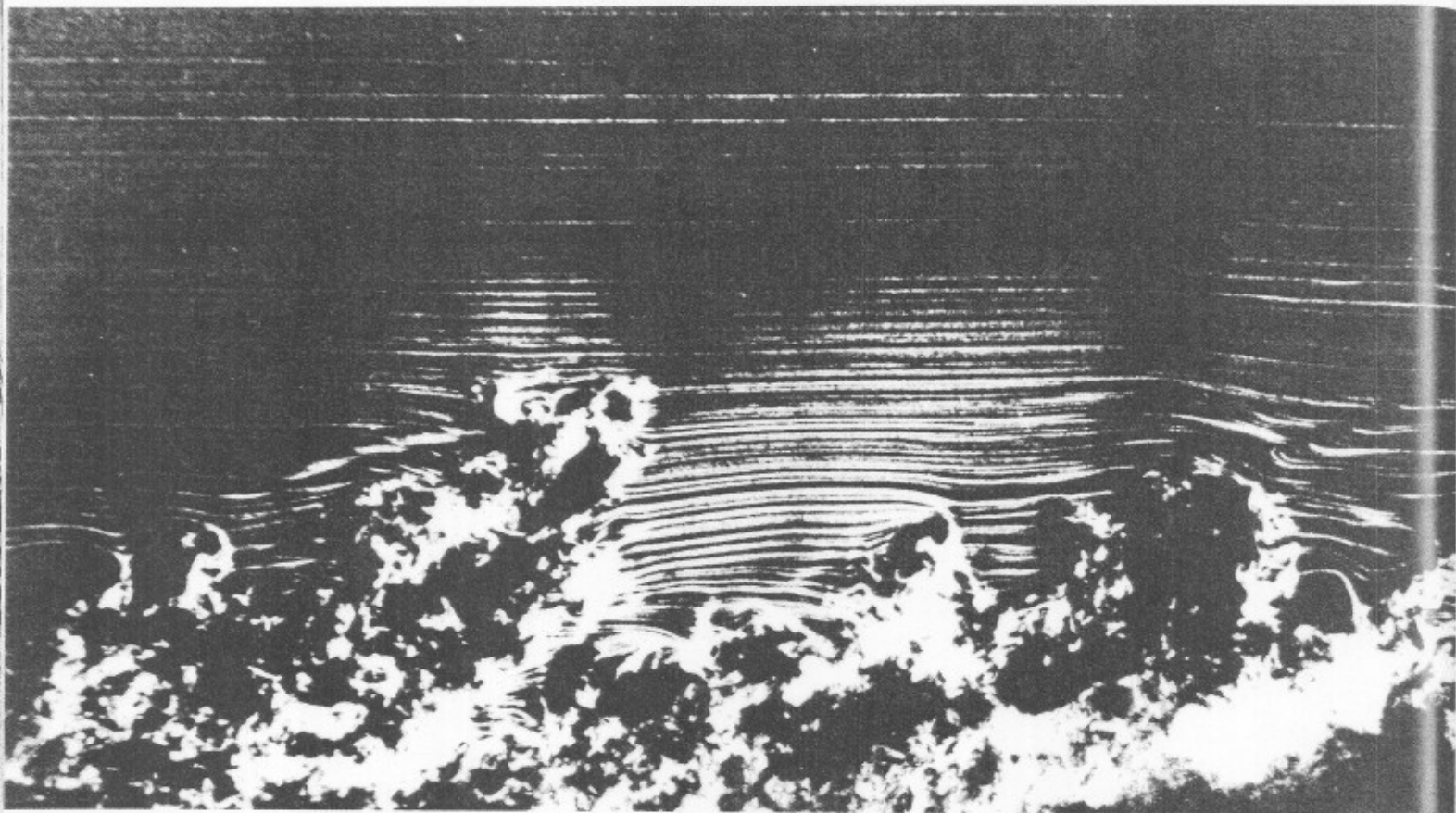
number spanned by these two photographs. It drops later when, as in figure 57, the boundary layer becomes turbulent at separation. Photograph by Thomas Corke and Hassan Nagib

6. Turbulence



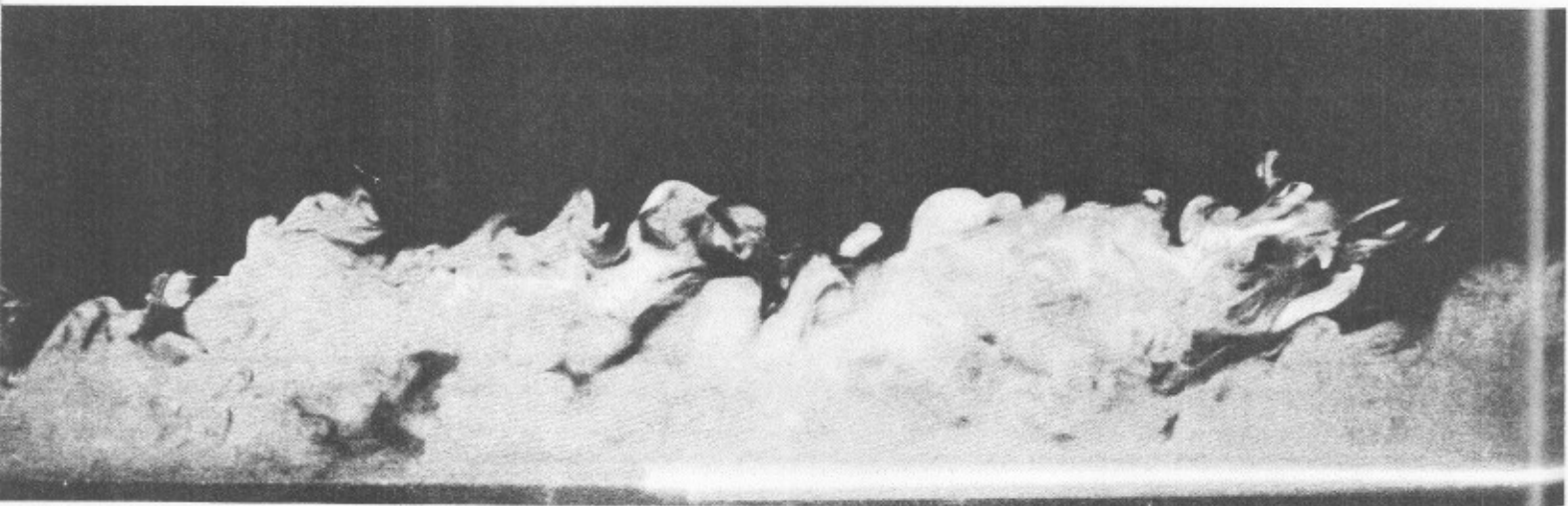
151. **Turbulent wake far behind a projectile.** A bullet has been shot through the atmosphere at supersonic speed, and is now several hundred wake diameters to the left. This short-duration shadowgraph shows the remarkable sharpness of the irregular boundary between the

highly turbulent wake produced by the bullet and the almost quiescent air in irrotational motion outside. *Photograph made at Ballistic Research Laboratories, Aberdeen Proving Ground, in Corrsin & Kistler 1954*



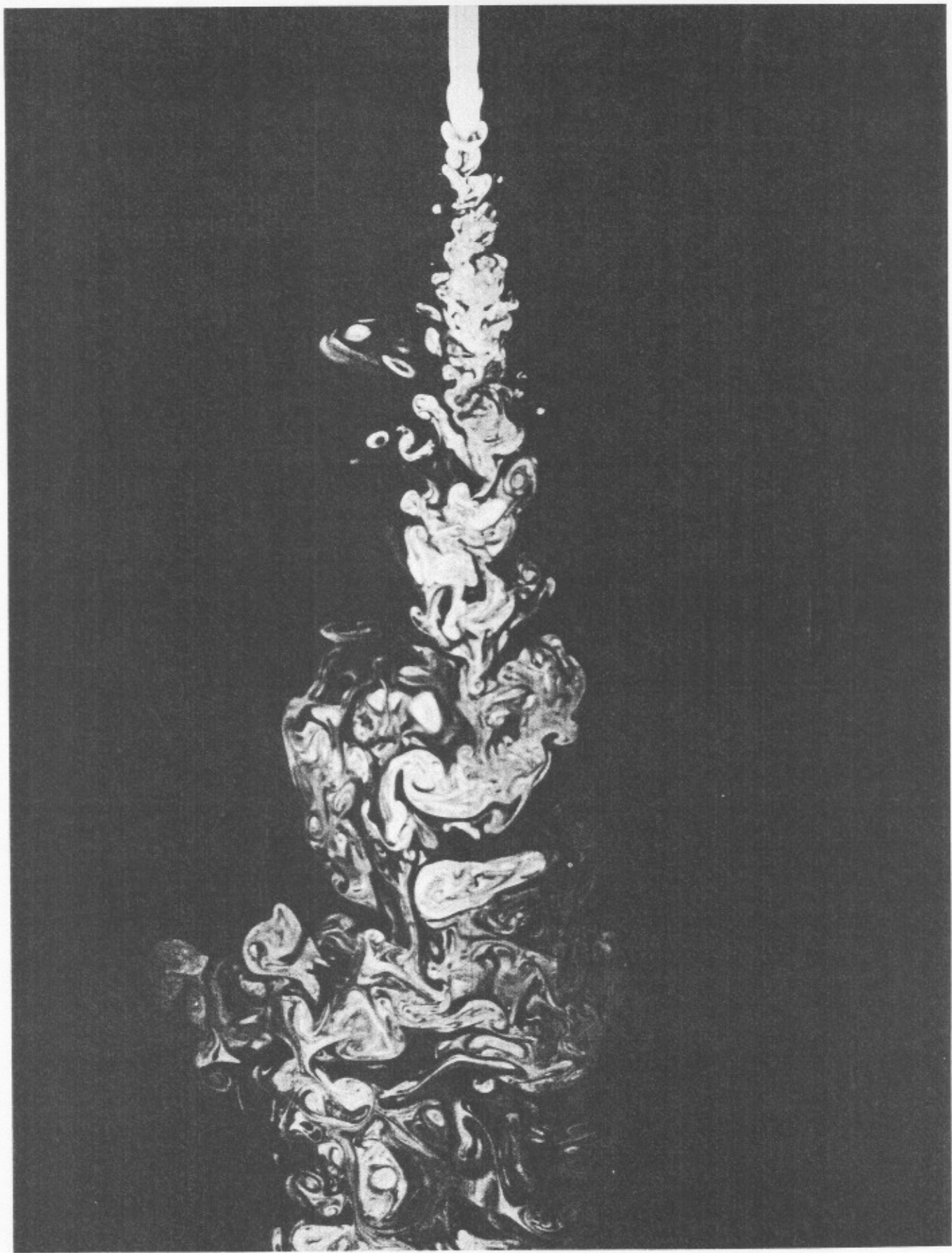
157. Side view of a turbulent boundary layer. Here a turbulent boundary layer develops naturally on a flat plate 3.3 m long suspended in a wind tunnel. Streaklines from a smoke wire near the sharp leading edge are illuminated by

a vertical slice of light. The Reynolds number is 3500 based on the momentum thickness. The intermittent nature of the outer part of the layer is evident. *Photograph by Thomas Corke, Y. Guezennec, and Hassan Nagib.*



158. Turbulent boundary layer on a wall. A fog of tiny oil droplets is introduced into the laminar boundary layer on the test-section floor of a wind tunnel, and the layer then tripped to become turbulent. A vertical sheet of light

shows the flow pattern 5.8 m downstream, where the Reynolds number based on momentum thickness is about 4000. *Falco 1977*



166. **Turbulent water jet.** Laser-induced fluorescence shows the concentration of jet fluid in the plane of symmetry of an axisymmetric jet of water directed downward into water. The Reynolds number is approximately 2300.

The spatial resolution is adequate to resolve the Kolmogorov scale in the downstream half of the photograph. *Dimotakis, Lye & Papantoniou 1981*