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Osborne Reynolds pipe flow: direct numerical simulation from laminar to fully-developed turbulence R.J. ADRIAN, Arizona State Univ., X. WU, Canadian Royal Military College, P. MOIN, Stanford Univ., J.R. BALTZER, Los Alamos National Lab. — Osborne Reynolds' pipe experiment marked the onset of modern viscous flow research, yet the detailed mechanism carrying the laminar state to fully-developed turbulence has been quite elusive, despite notable progress related to dynamic edge-state theory. Here, we continue our direct numerical simulation study on this problem using a 250R long, spatially-developing pipe configuration with various Reynolds numbers, inflow disturbances, and inlet base flow states. For the inlet base flow, both fully-developed laminar profile and the uniform plug profile are considered. Inlet disturbances consist of rings of turbulence of different width and radial location. In all the six cases examined so far, energy norms show exponential growth with axial distance until transition after an initial decay near the inlet. Skin-friction overshoots the Moody's correlation in most, but not all, the cases. Another common theme is that lambda vortices amplified out of susceptible elements in the inlet disturbances trigger rapidly growing hairpin packets at random locations and times, after which infant turbulent spots appear. Mature turbulent spots in the pipe transition are actually tight concentrations of hairpin packets looking like a hairpin forest. The plug flow inlet profile requires much stronger disturbances to transition than the parabolic profile.

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