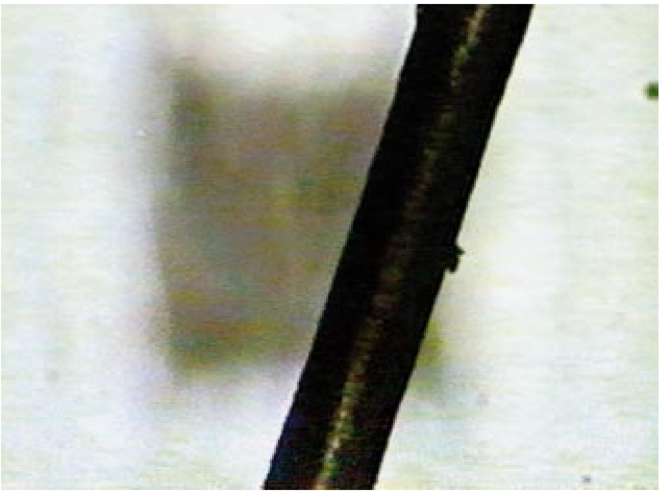

FIG. 1.

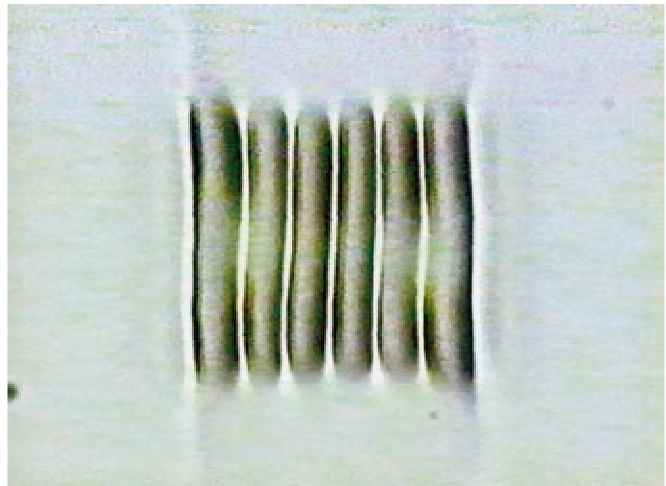

FIG. 2.

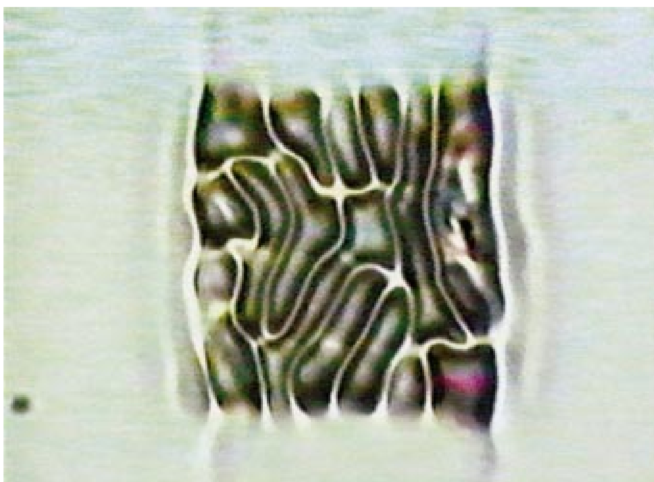

FIG. 3.

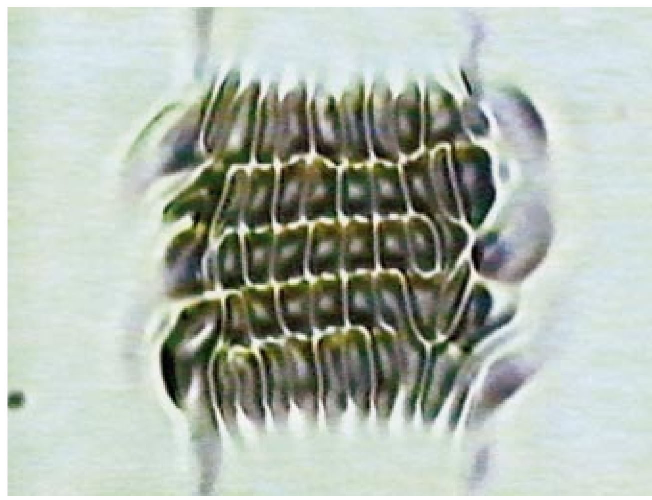

FIG. 4.

The Transition to Turbulence in a Microscopic Fluid Flow

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The experiment comprised a 46 μm thick layer of nematic liquid crystal sandwiched between two optically flat glass plates. A line electrode of thickness 185 μm was etched onto the inner surface of each plate. The arrangement was such that when viewed from above the lines overlapped at right angles. This created an active region of aspect ratio 4 : 4 :1 to which an electric field could be applied. An image of the active region is shown in Fig. 1, in which a human hair has been included for scale.

As the electric field strength was smoothly increased a six roll flow developed, and this is shown in Fig. 2. Associated with the convection is a spatially varying refractive index. This enables the flow to be observed directly as an intensity pattern formed by the focusing and defocusing of transmitted light. Upon further increasing the field strength this system underwent a sequence of transitions to turbulence (Peacock, Binks, and Mullin[1]). Two flows respectively realized in this sequence are presented in Figs. 3 and 4. The former shows a weakly turbulent state and the latter shows an array of square convection cells, both of which are found in the parameter regime between ''chaos'' and ''turbulence.''

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[1]T. Peacock, D. J. Binks, and T. Mullin, ''From low- to high-dimensional dynamics in a microscopic fluid flow,'' Phys. Rev. Lett. **82**, 1446 (1999).

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