An Album of Fluid Motion

Milton Van Dyke

Flow visualisation has from early times played an important part in the study of fluid mechanics. Scattered through the literature is a multiplicity of often beautiful and revealing photographs which represent a valuable source of information for teaching and research. In this album over two hundred such photographs have been collected from ten different countries and assembled with descriptive captions, together with a comprehensive list of references.

It would be extremely difficult to present such a vast subject as fluid mechanics in any linear fashion. Here the progression is generally from low to high speed flow; thus the earlier sections on creeping flow, laminar flow and separation are followed by sections on vortex motion and instability leading up to turbulence. Two further sections cover free surface flow and natural convection and the volume concludes with material on subsonic flow, shock waves and supersonic flow.

In order to be able to publish the album at a modest price only black-and-white photographs are included; although perhaps less striking than colour prints, the superb quality of reproduction renders them unusually informative. One photographic sequence likely to be particularly appreciated is a modern repetition using Osborne Reynolds' original apparatus of his celebrated 1883 investigation of flow stability in a tube, which was originally documented only by sketches. Another sequence well illustrates the characteristic arrowhead shape of Emmons' turbulent spot and its development with increasing Reynolds number. For shear beauty, however, the photographs of the hexagonal convection pattern of cells produced by Bénard convection are difficult to surpass. One such photograph is reproduced below (about 40% smaller than in the Album) together with its original caption.

Of interest to many will be the wide variety of techniques used for flow visualisation, particularly low speed flow. In addition to smoke, dye and coloured water, a large number of illustrations are based on aluminium and magnesium dust, powder and cuttings, plastic particles and glass beads in water, silicone oil and glycerine, together with air bubbles in water, moisture condensation, benzene vapour and titanium tetrachloride gas. Electrolysis, electrolytic precipitation and various other electrochemical techniques also find a place. Especially novel is the use of condensed milk as a coating which melts around a cylinder moving through water. Fish scales, though familiar to me, do not find a place, and more surprisingly neither to any significant extent does the well-established hydrogen-bubble technique. As might be expected, illustrations of high speed flow are based exclusively on shadowgraph, schlieren and interferometry (some of it holographic), though these techniques are also used in certain photographs of turbulence, free surface flow and natural convection.

This storehouse of flow visualisation techniques and their suitability would well repay study by any intending researcher in fluid mechanics. In fact the album cannot be too highly commended also for teaching purposes, especially if the photographs can be displayed by overhead projector. My only (minor) criticism is that Dr Van Dyke's inability to locate the originals of the photographs used by Ludwig Prandtl to illustrate his work might have been partially repaired by reproducing Figure 79 of Shapiro's book, 'Shape and Flow'*. This shows stills from a moving picture by Prandtl of boundary-layer separation past an object with a severe adverse pressure gradient; the stills are of comparable quality to those in the album.

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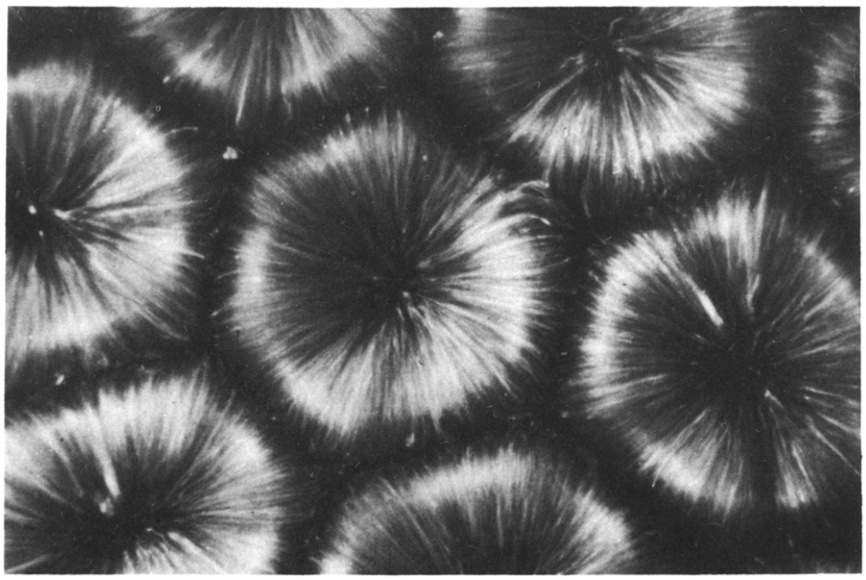

***Surface-tension-driven (Bénard) convection.** A top view, magnified some 25 times, shows the hexagonal convection pattern in a layer of silicone oil 1 mm deep that is heated uniformly below and exposed to ambient air above. With the upper surface free, the flow is driven mainly by inhomogeneities in surface tension, rather than by buoyancy as on the previous page. Light reflected from aluminum flakes shows fluid rising at the center of each cell and descending at the edges. The exposure time is 10 s whereas fluid moves across the cell from the center to the edge in 2 s. Photograph by M. G. Velarde, M. Yuste and J. Salan*