J. Fluid Mech. (1998), *vol.* 357, *pp.* 380–381 Printed in the United Kingdom

BOOK REVIEW

Air Bubble Entrainment in Free-Surface Turbulent Shear Flows. By H. CHANSON. Academic Press, 1996. 348 pp. ISBN 0-12-168110-6. £80.00 or $129.95.

A succinct phrase to describe the topic of this book is 'white water'. The entrainment of air gives a high visibility to water that we appreciate in waterfalls, fountains, white-water rapids, and breaking waves. These all involve relatively strong interactions between water and air leading both to the formation of drops and bubbles and a less easily described intimate mixture of air and water. The author, a hydraulic engineer, does not attempt to cover the whole range of these topics. The book is primarily about steady flows of the type that arise in connection with civil engineering works such as dams and water distribution with occasional references to natural flows and to industrial applications.

Apart from the introduction and concluding summary there are three main parts of the book:

(i) Plunging jet entrainment: as well as falling jets this includes hydraulic jumps that correspond to a horizontal jet meeting a body of water.

(ii) Self-aerated channel flows: this mostly concerns flow down steep slopes and includes partially-filled conduits.

(iii) High-velocity water jets and related air–water flows.

In addition there is a substantial amount of ancillary matter leaving only 238 pages out of 401 pages for the primary text.

A good background of fluid mechanics or hydraulics is assumed since there is no discussion of equations of motion or continuity for these two-phase flows. For each type of flow there is a description of the fluid flow pattern followed by a summary of the available measurements. These are mostly from laboratory experiments with occasional prototype values. The author is concerned in ensuring readers are aware of the difficulties associated with the extrapolation of data from experiment to prototype. In many cases the author includes results from his own experiments and data from numerous sources, such as PhD theses, that are not readily available.

Theory is not neglected but, at best, is at the level of simple models using constant eddy viscosities and diffusivities. Otherwise empirical equations are quoted. Interesting results appear in the comparisons with experiments and with the corresponding single-phase shear flows. For example in the downward plunging jet, bubbles diffuse more rapidly than momentum which in turn spreads more rapidly than in the single-phase case. Eddy coefficients deduced from the experiments are discussed.

Considering the subject by different types of flow leads to a certain amount of repetition which is probably of value when the book is used for reference. On the other hand it partially obscures the two basic types of air entrainment. One comes from the impact of one body of water on another. At low relative velocities there might be no air entrainment but this book concentrates on high-speed flows which implies that at least one of the water bodies is turbulent with surface fluctuations enhancing air entrainment. The other mechanism of air entrainment is the turbulence itself if it is strong enough to disrupt the surface. Both these types are discussed but only in so far as to indicate that much basic research is still required in this area. In this respect it would have been valuable to have had more complete dimensional measurements reported to facilitate further analysis of the results. The discussions of bubble diffusion

would have benefited from more attention to the effects of buoyancy and to bubble equations of motion, e.g. do lift forces on bubbles help enhance their dispersion? Similarly, an estimate of the turbulent intensity needed to entrain air would have value.

The author has served a useful purpose in bringing so much material together on this topic. The design engineer might find much of it useful as long as the warnings on scaling are heeded and some ambiguities can be clarified. In particular equation (E-5) from the appendix on air bubble diffusion in jets has two variants, (E-5a) and (E-5c) which are not later distinguished and is given a different form on page 63, so it is not clear which form gives the curves in figures E-2 and 6-7. Appendix D, which the text claims 'derives' the velocity of sound in an air–water mixture does little more than state an expression for the velocity.

Overall this is a book with a very practical base but one that should also interest researchers since, unlike most textbooks which present that which is known and understood, this book presents many flow features that are worthy of further study.

D. H. PEREGRINE