J. Fluid Mech. (1977), *vol.* 83, *part* 1, *pp.* 207–208
Printed in Great Britain

REVIEW

The Thermodynamics of Fluid Systems. By L. C. Woods. Clarendon Press (Oxford University Press), 1975. 359 pp. £15.00.

This book is superb. In my view it has no equal; and, in preference to any other work on the subject, it should be read by anyone who wants to understand what thermodynamics – regarded as a branch of *physics* – is all about. The author at all times maintains a close contact with reality which is consistent with his 'growing aversion to axiomatic thermodynamics, with its *penchant* for substituting deductive mathematical constructions in place of physics', and with the opinion expressed in a footnote on page 168: 'Axiomatic treatments of continuum mechanics, sometimes misnamed "rational" treatments, have the virtue of setting the subject in a logical deductive frame and of eliminating relevant, if not vital, physical concepts drawn from wider fields. The net effect is to stifle intuitive reasoning – the frame becomes a straitjacket – and mathematical clarity is won at the expense of physical understanding.' It is a positive relief to find that, wherever appropriate, mathematical niceties give way to physical insight, so avoiding the absurdities exemplified by a recent paper, the author of which purports to deal with some fundamental problems of phenomenological thermodynamics in an axiomatic framework; in which, however, we are informed in several different contexts that 'it is not easy to frame a suitable rule of interpretation'.

We must be grateful to Professor Woods for resolutely eschewing all such non-physics by explicitly recognizing that thermodynamics is an approximating science. From the outset he therefore greatly emphasizes the need to introduce various characteristic times, indeed a whole hierarchy of such time scales. Without them one cannot even sensibly define the ubiquitous concept of 'equilibrium'; nor can one meaningfully subdivide the subject into its component parts: engineering (i.e. classical) thermodynamics, chemical thermodynamics, kinetic thermodynamics and statistical thermodynamics, each of which is characterized by its own time scale. Part I of this book deals with each of these in turn. There is a mastery inherent in this treatment which makes it a delight to read.

Chapter 1 introduces some basic concepts and conceptions, and here one meets for the first time uncommon notions like that of the irreversible equilibrium process, or slightly idiosyncratic terms like 'macroscopic infinitesimal time interval'. However, their use is characteristic of the fact that this is no mere slightly transformed regurgitation of what has been written so many times before. Chapters 2 and 3 then take us through basic 'classical thermodynamics' though §§16, 19 and 20 in particular are non-standard. In §16 one is brought face to face with the fact that the more detailed the description of the state the smaller the associated entropy. (Such a proposition must not be taken out of its context: the 'associated entropy' means 'the value of that particular entropy function which goes with such and such a definition of "state"'. As good operationists we ought to speak of 'entropy a', 'entropy b', etc., *qua* distinct physical quantities.) Then, in §§19 and 20, apart from a careful, short and hard-hitting discussion of the role of the time variable following upon the introduction of a set of relaxation times and of the notion of local thermodynamic equilibrium, there is a most refreshing, succinct discourse on irreversibility. As one might expect in this book, the term 'time reversal' is translated as motion (and spin) reversal. (If only people would stop reversing the time!) The paradoxes of Loschmidt and Zermelo are given short shrift in a convincing manner. Chapter 4 is a concise introduction to the formalism underlying kinetic thermodynamics, the observer's time scale now having been further reduced to be of the order of the time between successive collisions of a particle in a gas. A further ultimate reduction of the time scale then leads to a survey of statistical mechanics in chapter 5 which includes not only more or less standard ensemble theory, fluctuation theory, the effects of quantum degeneracy, etc., but also two delightful sections on 'the analogy between uncertainty and entropy' on the one hand and on 'life and entropy fluctuations' on the other. As one would expect, they are racy in style and free of that often pretentious waffle which surrounds these topics.

The whole of part I may be regarded as an introduction to part II, which deals with process thermodynamics. This is the subject which is often known as 'non-equilibrium thermodynamics', a term which is somewhat confusing and would be out of keeping with the author's careful presentation described above. Process thermodynamics is the theoretical framework for the description of the irreversible processes of macroscopic physics; and this work is mainly concerned with applications to fluid systems. Enough has been said of the spirit and flavour of this exposition to make further detailed description superfluous. To keep this review to a reasonable length I therefore content myself in the main with quoting the chapter headings: 6. General principles; 7. The reciprocal relations; 8. Material invariance and viscosity; 9. Fluid mixtures; 10. Magneto-plasmas and super-fluids; 11. Internal processes; 12. The fluctuation–dissipation theorem; 13. Kinetic processes. The treatment is remarkably detailed and complete; and it is coherent with part I, in particular with its continued emphasis on time scales.

I imagine every reviewer is entitled to one small gripe. Mine – perhaps just a personal one – concerns polyads. As a tensor analyst I find the use of polyads (in the context of tensors of valence greater than two) mnemonically most confusing; and in the present context I cannot readily envisage a counter to the points made by Schouten on page 59 of his treatise on the Ricci Calculus against the use of such a direct calculus.

The book seems to be remarkably free from misprints. The few that I have noticed are too trivial to be worth mentioning.

To conclude, no one concerned with thermodynamics, and not merely that of fluid systems, can afford to be without this book, be he undergraduate student, graduate student or research worker.

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