J. CHANG (Editor), **Methods in Computational Physics, Vol. 17, General Circulation Models of the Atmosphere.** Series Editors: B. ALDER, S. FERNBACH and M. ROTENBERG; Academic Press (1977).

NUMERICAL weather forecasting and climatology do not normally come within the working range of the general worker in heat and mass transfer. Although the major influences on the equations describing the large scale motions are caused by the effects of the earth's rotation, the physical processes of interest are familiar. Condensation of water vapour, a turbulent boundary layer, radiation, convection and conduction, all have to be accounted for in these forecasts of velocities and pressures at advanced time. The presentation of the present volume is clear and self-contained, so that it can be understood by workers performing calculations with three dimensional models of other complex physical systems. It can therefore be read either as a good introduction to the subject and its present state-of-the-art or as a work of general interest which may suggest new approaches to one's own work.

The book contains five independent articles. The first is a survey that describes the various options in modelling physical processes and in computational procedures. The remaining articles describe particular circulation models which have been implemented at Meteorology Centres in England, U.S.A., and Australia; three of these are finite-difference methods and one is a spectral method. As suggested in the first article, the capability of the spectral approach implies that the finite-element method may offer an interesting alternative approach.

Any attempt to list the aspects of this work which may interest the general reader is bound to be a personal choice. However, the problems caused by limitations of computer storage and their resolution must be included. As an example, a six-layer atmosphere model with a 2.5° longitude-latitude grid is quoted for global circulation calculations. A grid of this size is considered small but still suffers from problems caused by non-linear aliasing, subgrid-scale eddy activity and incomplete representation of topographical details. The execution time for a 1 model-day calculation is two hours on a CDC 7600, and doubling the horizontal resolution would increase this eightfold. It is no wonder that meteorologists have been at the forefront of demands for bigger and faster computers. One consequence of storage limitations is that explicit time difference schemes predominate in this field, with leap-frog schemes extended to control mode separation being the most popular. The alternative of a semi-implicit method, with the components associated with the rapid gravity waves being calculated implicitly and other terms, associated with slower characteristic velocities, explicitly, is of interest.

Another aspect of general interest is the question of the quality of the initial data. In the meteorological context, these are available at random off-gridpoint positions and frequently at different times and of variable accuracies. Inaccuracies in the data initialization can cause large amplitude oscillations to develop during the numerical integration, which particularly in the tropics, may be difficult to distinguish from meteorologically significant motions. The techniques for blending observed and predicted data during the course of a calculation has interesting analogies in more general engineering practice.

The book is clearly presented and well illustrated. I enjoyed reading it while holidaying on a farm near the sea. The benefits to mankind that would be created by accurate weather forecasting were therefore obvious. Improvements in forecasting over the past twenty years have been substantial, but there is still a long way to go before consistently accurate predictions can be made even for a period of 36 h. This book may help by encouraging an interplay of ideas with computer modellers in other fields.

P. L. BETTS

HERMAN BRANOVER, **Magnetohydrodynamic Flows in Ducts.** Wiley, New York (1978).

BY FAR the greatest amount of funding for work on MHD is in Soviet Russia, where interest is centred on power generation prospects. Sonic streams of very high temperature combustion products above 3000 K flow in large 400 MW MHD ducts with sophisticated wall materials in heavily water-cooled constructions all inside enormous superconducting magnets (supplied by the Americans under a collaborative agreement).

To avoid the obvious difficulties involved, fundamental studies are most easily carried out using liquid metal loops. These studies of *incompressible* MHD flows in ducts are important for basic science but their practical relevance is at present limited to liquid metal pumps and flowmeters (and indeed to flowmeters in many other types of liquid and of pipe, including blood in arteries!). There are other direct applications in view, such as stirring of weld pools and other metallurgical prospects, but these have yet to be widely developed.

Thus the field of liquid metal (or electrolyte) loops is a rather specialized corner of magnetohydrodynamics with a distinctive set of problems all its own and that is the field covered by this volume. It has little to do with MHD Power Generation. The Magnetic Reynolds numbers, Hartmann numbers and interaction parameters it deals with go a lot higher (not to mention densities and conductivities) while its Mach numbers are much lower (flows are incompressible) and the practical difficulties of handling fast-moving, high temperature gases are replaced by a different set of problems that are well described in this book.

Some MHD purists feel that the combustion-driven MHD generators that attract so large a proportion of the research funds hardly involve any truly MHD effects at all and they will welcome this book. On the other hand, those interested in the MHD of astrophysics will feel that this book is not for them since the whole concept of a physical duct around the flow renders it essentially earth-bound. So the scope of this volume is restricted.

It is inevitable that such a specialized field has its internationally recognized leader and the studies carried out by Herman Branover at the Physics Institute in Riga throughout the sixties – the peak period for MHD as a whole – must surely be considered as without equal (except perhaps by disciples of Peter Lykoudis or Arthur Shercliff!). Unfortunately, Branover's many publications were entirely in Russian and, even more unfortunately, they ceased completely and abruptly, in 1970. (His bibliography records a single set of "measurements of the spatial correlation of velocity pulsations in an MHD channel" after then, in June 1971 but these measurements remained unpublished. It is not difficult to guess when Branover set about emigrating.) The English-speaking world is fortunate that the considerable volume of Russian literature from that peak period is now summarized and analysed in English along with much of the earlier English literature and such more recent work as is available. It is even more fortunate that Branover is now back in business again. After a gap of five years (apart from a single paper in the Proceedings of the Tennessee Symposium on Engineering Aspects of MHD in 1974) he found his way to Beersheva, Israel where he has established a centre of MHD activity and from where he has been actively publishing at something like his old rate.

This volume is firmly based upon his earlier Russian books with some up-dating and re-interpretation. The style is rather formal, even ponderous at times, but still readable and indeed the formality is probably essential in many places where fairly complex mathematical arguments have to be followed carefully. The large amount of direct translation involved has been very well done since it is reasonably transparent to the reader.

The emphasis of the book is very much experimental and the theories are examined critically to see to what extent they agree with practice. This is refreshing as far as books in English are concerned since there has been a tendency for theory and experiment to develop far too much in parallel – both going on to infinity but never meeting! This has been a particular danger in the field of turbulence and Branover's personal contributions to the experimental study of MHD turbulence make him an especially appropriate author for such a text; this particular topic is examined at length.

Little attention is devoted to problems of heat (and none to mass) transfer to the duct walls. The various boundary layers (Hartmann or shear) are studied in great experimental and theoretical detail (rectangular vs circular ducts, conducting vs insulating walls, smooth then rough boundaries, flows along and across the field, onset and suppression of turbulence, etc., etc.) but almost invariably to establish flow geometry (velocity variations, boundary layer thicknesses, etc.) and momentum transfer in terms of the friction factor or drag coefficient (which are interchangeable as far as Branover is concerned).

Only about seven pages out of 290 are concerned with heat transfer. This would not perhaps matter, if the Reynold's analogy applied since heat transfer rates would then follow the friction factors that are so fully discussed. Unfortunately, at low Prandtl numbers, e.g. in liquid metals, the situation is distorted by metallic thermal conduction. (Branover calls it "molecular", but he must mean "electronic") and the discussion becomes more qualitative. Only the principal features of heat transfer in the presence of a magnetic field are mentioned (the importance of Joule heating with an external circuit or conducting walls, the equally important generation of heat in thin shear layers at high Hartmann numbers). The amount of experimental data is limited – and indeed experimenters usually put a great deal of effort into maintaining temperatures constant to within one or two degrees around the entire loop. So not much here for the heat and mass transfer man.

All in all, this is a book only for the specialist, despite its claim to be "also for engineers and students, who may well be encountering magnetohydrodynamics for the first time". To avoid misunderstanding, "Incompressible" should be included in the title. But for anyone in the business of liquid metal loops or incompressible MHD duct flows this book will undoubtedly be required reading.

D. T. SWIFT-HOOK

E. F. NOGOTOV, **Applications of Numerical Heat Transfer,** McGraw-Hill, New York. 142 pp.

THIS book originally published by UNESCO, is based on a series of lectures given by the author in the U.S.S.R. in 1974. It deals with applications of finite-difference methods to problems in conduction and convection.

There are three main sections. Firstly, basic concepts are covered, including the topics of convergence, stability, stability analysis and alternative finite difference approximation formulae. Then problems in heat conduction are analysed ranging from simple one-dimensional cases, through boundary condition approximations to three-dimensional and variable property cases. Finally, the approach to a limited range of convection cases is specified.

The book has a number of attractive features, which unfortunately are counterbalanced by more prominent drawbacks. Thus the material has the pleasing quality of requiring about the same level of understanding all the way through, rather than over-explaining the simple and vice versa. But the layout comprises long sections uniformly presented (for example, the six-page section introducing stability and convergence), so that the beginner would have difficulty discerning the more important "trees" in a given "wood".

The author's experience and expertise, and the research material to which reference is made, are all evident; expressions such as "may be recommended" are common, and there are a number of practical hints in the Conclusion. It seems a pity, therefore, that this expertise is not reflected in some judiciously selected results, tables or graphs, which in fact are completely lacking; they could readily have been included for the simpler conduction problems.

Finally, the convection section is substantially deficient for "engineers working in the energy field" for whom the book is written. The words laminar and turbulent appear to be totally missing! This is because applications are biased to free convection with a maximum specified Reynolds number of 100 (p. 110), although there is a vague reference to "approximated viscosity effect" (p. 117) for high-rate processes. Hence there is no discussion of turbulence modelling.

To sum up, the book does not appear to satisfy the claim in the Preface to be a "complete ... treatment of the subject". However, despite the above criticisms, the book has definite attractions which make it worthwhile as, perhaps, a second textbook on the subject.

M. W. COLLINS

J. KESTIN, **A Course in Thermodynamics.** Vols. I and II. McGraw-Hill, New York. 725 pp. and 617 pp.

TEACHERS of thermodynamics will be pleased that it is again possible to obtain copies of Professor Kestin's erudite two-volume treatise. It is a work of substantial scholarship to which teachers and advanced students of science and engineering can turn for a rigorous exposition. In it they will find a discussion of all those logical difficulties which are glossed over in introductions to the subject. Furthermore, as befits a treatise rather than a textbook, adequate reference is made to the historical development of the subject. In the preface to the second printing, the author acknowledges that it is too abstract an approach for the stomach of most undergraduates, and certainly it uses mathematical tools likely to be in the hands only of postgraduates. Nevertheless, the exposition follows in the mainstream of current approaches to the subject, and no great reorientations of the mind are necessary to follow the argument.

Volume I deals with units and concepts, equations of state, First and Second Laws, and the behaviour of a comprehensive range of thermodynamic systems including electrical and magnetic systems. That it takes over 700 pages to cover this basic material is sufficient indication of the depth of treatment.

Volume II treats of more advanced topics, beginning with a full discussion of equilibrium including its use as a unifying principle by Hatsopoulos and Keenan. This is followed by an introduction to statistical thermodynamics and quantum mechanics and their application to the properties of perfect gases and perfect crystals. It goes on to deal with the behaviour of a pure substance in a single phase, and chemical equilibria in a single phase and in heterogeneous systems; and ends with a full treatment of the Third Law and irreversible processes in continuous systems. Designers of courses in advanced thermodynamics will have no need to look further than this volume for adequate material.

Whether it is a criticism of the author or the publisher, it is sad that the opportunity has been missed to shorten the section on units by introducing SI. The old definition of the mole and the unit symbol °K are still in evidence. The author may have regretted quoting the, by now, obsolete IPTS-48 in full; surely an easily up-dated reference would have been sufficient. Similarly it might be argued that the section on practical temperature measurement is superfluous because there are adequate specialised texts on the subject. Tables of properties, which occupy 90 pages at the end of Volume II, are