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 in a similar category. Of course it is not for this type of information that a reader turns to such a treatise, and the author might well have felt that revision was not worthwhile. But why include it in the first place, thereby adding to the length and cost of the book?

These are trivial criticisms of a work which will certainly become a classic and which future writers on the subject will ignore at their peril.

G. F. C. ROGERS

Turbulent Shear Flows: Selected Papers from the First International Symposium on Turbulent Shear Flows, edited by F. DURST, B. E. LAUNDER, F. W. SCHMIDT and J. H. WHITELAW. Springer-Verlag, Berlin, Heidelberg, New York, 1979.

THE NOTION that one might be able to predict the main features of turbulent flows by solving transport-type equations for a few statistical properties of turbulence occurred independently to many scientists (e.g. Kolmogorov, Prandtl, Emmons); but it was not until the development of the computer, and of adequate numerical methods for solving the equations, that the validity of the notion could be put to the test. Much of the testing has been done by present or former colleagues, students and friends at Imperial College (Mechanical Engineering Department; not Mechanics and Engineering Department, as a misprint on p. 3 would have it!); and it is they who have taken the lead in bringing the subject to international attention. The publication of this work is therefore a welcome opportunity to review the extent to which the high hopes with which we began the work have been realised. Ten years ago, we thought that increasing the number of transport equations would permit the universality of the turbulence models to be steadily improved. Has this happened? Further, we quickly discovered the difficulty of predicting the 'round-jet' data with the same constants as were valid for other free flows; and the handling of low-Reynolds-number turbulence, and of flows with strong body forces, were soon found to present problems. Have these difficulties been subsequently resolved?

The workman-like paper by McGuirk and Rodi on 3D turbulent jets, in Part 1 of the book, indicates that the Harlow–Nakayama $k \sim \varepsilon$ model with only minor 'tweaking', fits measurements well in major respects; but, where it does not, the authors express the usual hope that a higher-level model will be found which does do so. Other papers comparing predictions with experiments contain similar findings and suggestions. However, what is to be found in Part IV of the book, concerned with 'Developments in Reynolds-Stress Closures', gives little encouragement. Launder and Morse have solved the numerical problems; but they conclude with commendable and unusual honesty: 'the present work has not produced any general proposals'. Nor do other workers in this area appear to be more successful. There are encouraging comparisons between predictions and experiments in Part V, on sub-grid-scale modelling; but the methods of prediction used are enormously expensive, even for flow systems much simpler than that of the round jet; so there is no help to be expected from this quarter for a long time.

As to low-Reynolds-number turbulence, which occurs close to a wall and vitally affects the heat-transfer process, there is an interesting experimental report by Kutateladze, Khabakhpasheva and others; but the theoreticians have steered well clear of the area, with the exception of Durst, whose introductory remarks to Part II report some success, with a version of the $k \sim \varepsilon$ model, in predicting the velocity and energy profiles near a wall.

To judge from the papers in this volume, therefore, one must conclude that the 'high hopes' have not yet been realised; indeed, one might now begin to doubt whether they ever will be. However, despair would be premature for very few of the accessible avenues have so far been explored; and, now that the Reynolds-Stress route has been recognised as arduous, some researchers may return to one- and two-equation models, and find that greater universality can be achieved if other variables are considered than k and ε.

Whether their implications are pleasing or not, this volume does contain facts that users of, and researchers into, turbulence models must take into account. The editors and publisher are to be congratulated on making available, in attractively printed form, a valuable compilation of research results.

D. B. SPALDING

J. G. PEACEY and W. G. DAVENPORT, **The Iron Blast Furnace.** Pergamon Press, Oxford (1979). 258 pp.

THE STATED objective of the authors of this text is to help improve the readers understanding of the blast furnace process. The medium used to achieve this objective is a heat and mass balance mathematical model. Straightforward equations are developed to describe each of the main aspects of the process and then assembled to produce a complete blast furnace model. The development of the model is well presented and should be clearly comprehensible by both practising and aspiring process metallurgists.

After a brief summary of the blast furnace process and some preliminaries on thermodynamics and stoichiometry, the model framework and its development are discussed in some detail. Second order effects such as heat losses, reduction of Si and Mn and the calculation of tuyere flame temperatures are all dealt with succinctly. Model validation is discussed in two chapters. In one the model is shown to behave in a reasonable fashion (i.e. obey all physical constraints), whilst in the second some direct comparisons with furnace operating data are made. The effects of various tuyere injectants on furnace performance are discussed and the text is concluded with a chapter on process optimization using the model.

The text is both well written and well structured – clearly a benefit from the use of this approach in the teaching of young metallurgists for over a decade. It should certainly prove a useful text for students and others who wish to increase their understanding of the blast furnace process. Its reasonable price, about £6 for the softback version, makes this book good value.

Bearing in mind the above comments, I do have some reservations:

(i) Although there are problems at the end of most chapters, many of them require the reader to do a reasonable amount of computer programming; in the latter chapters this requirement becomes extensive. The book would find much greater utility in the classroom and elsewhere if a well documented listing of their computer program was included as an appendix.

(ii) The philosophical approach adopted in the text follows closely the work of Rist as reported in the mid-sixties. Since that time a number of comprehensive zonal heat and mass balance models have been developed within the large steel producing organizations. These models have been used fairly extensively both to help increase process understanding and in the assessment of blast furnace performance. Their predictive capabilities, though, are usually confined to parameter variation on a furnace to which it has just been matched with existing input and output data. From the lack of pertinent references it would appear that the authors are unaware of this substantial body of work. Thus, whilst I agree that this model should provide a useful means to help students understand the blast furnace process, I doubt whether it will be any more successful at optimising commercial operations than existing in-house models.