REVIEWS

Units, Dimensions, and Dimensionless Numbers. By D. C. Ipsen. New York: McGraw-Hill Book Co., 1960. 236 pp. 50*s*. 6*d*.

The techniques of dimensional analysis have played an important part in the development of fluid mechanics, and, together with the underlying ideas of unit and dimension, are of basic importance in all branches of physics and engineering science. Many of these subjects grew experimentally, some in isolation, and this led to an overlapping of units. Also the degree of arbitrariness in the choice of dimensions was often overlooked. And so, in spite of the powerful use of dimensional arguments during last century, notably by Rayleigh, a good deal of confusion remained and indeed some survives.

Today, many researchers in fluid dynamics are likely to have absorbed their ideas on dimensions by the way and to be interested primarily in applications; probably only few of those who know of Bridgman's *Dimensional Analysis* have actually read it. Students commonly learn about units and dimensional theory in a piecemeal manner, and often have unnecessary difficulty in first handling the ideas; some, bemused by the variety of systems, learn to protect themselves by writing 'c.g.s. units' at the end of every line. Dr Ipsen has written a thorough account of the subject, which he claims will serve both these groups. He has chosen to give a direct exposition of the normal usage of the subject, and he has obviously taken considerable trouble to produce a clear, readable and consistent development of dimensional theory. Starting from the simplest ideas of counting, with the traditional oranges and pies, he goes on to consider the character of physical variables, physical relationships, and finally similitude and the uses of dimensionless variables. Carefully selected problems are set at the end of each chapter; admittedly their effectiveness depends on the enthusiasm of the reader, but where he considers a problem specially important he gives a fully worked solution. Moreover, a feature of the book for readers of this *Journal* is that it is written essentially in terms of fluid dynamics, with just enough electromagnetism for current needs.

It is doubtful whether a single book could satisfy fully the needs of both researcher and student, and the fact that he limits himself on the whole to what he considers the prevailing point of view and uses only such mathematics as is strictly necessary for his argument suggests that he has in mind primarily the needs of a good engineering or physics student. The result has been to produce a smoothly and in the main well-written book, although he uses some colloquialisms without purpose and there are some rather odd patches near the start; the book is also well produced and has few misprints, though vectors pass unsung, presumably by an oversight. While this approach may benefit the student by avoiding the legacy of confusion in the subject, it has the real disadvantage of ignoring most of the classic arguments, successes and mistakes of the past, and indeed there are no references of any kind. This is surely a pity, for although it may be unkind to dwell on other people's mistakes, this is a case where mistaken ideas from the literature can be very revealing and worth a great deal of formal discussion of the pitfalls. Besides, there is a considerable amount of literature on this subject, and there still exist conflicts of viewpoint which some readers will wish to consider. It should in fairness be pointed out that Dr Ipsen does refer to conflicting viewpoints in his preface, but dismisses them as outside the field of his book, and also that he incorporates some applications from the literature into his examples.

The material of the book falls naturally into two parts, the first of which deals with the units and dimensions of physical quantities, and the second with their significance in physical relationships. Physical variables are introduced as physical concepts described mathematically and classified as substantial or natural, and a careful discussion is given of the physical and mathematical character of units. The author takes some pains to bring out the degree to which the division into fundamental and derived units is arbitrary and a matter of convention. He uses numerical equations to introduce the idea of physical equations, and first brings in dimensions as generalized units. Statements such as 'At this point it is not possible to reveal the full significance of dimensions' contain too much of the mysterious, but are not too frequent. Conversion is described clearly and briefly. The problems cover a wide range of subject and should be useful to the student; the few worked solutions are valuable, but it would be an improvement if answers were to be given to at least some of the other problems and if a table of conversion factors and one of the dimensions of physical variables were to be included. It would also help if there were more illustrations of the misuse of the methods, taken where possible from the literature. This part of the book is completed by chapters on the units and dimensions of mechanics, thermodynamics and heat transfer, and electricity; these are clear and reasonably wide-ranging although in places it would help if the reasons were to be given for particular choices (e.g. why should *three* fundamental units be the particular convention in mechanics?) and systems (e.g. what is the point of introducing the m.k.s. system?).

In the remaining parts of the book Dr Ipsen deals first with the proper (and improper) formulation of fundamental laws, including a discussion of Newton's law of motion, and he extends the ideas of dimensional consistency in physical relations to finding the possible forms which experimental relationships may take. This leads on to a careful study of similitude (or similarity) based on the differential equations which represent the behaviour of the system under consideration, which he develops in terms of the two-dimensional flow past a circular cylinder. (In this he illustrates nicely the decisions that must be made on which of the possible dimensionless (i.e. natural) variables are significant in any particular case.) Provided that dimensional analysis is applied systematically, he shows that the more formal approaches as of Buckingham's Pi theorem are not needed in practice. This is certainly true within the framework of this book, although it does not diminish the interest of the formal theory, and it may be observed that he has shown the forms of equation arising from dimensional analysis as plausible but not necessary. Finally he gives a brief and interesting discussion of each of the dimensionless variables that may arise in problems of fluid dynamics, in each case commenting on physical significance. It is surprising that the parameters of magnetohydrodynamics are omitted here, as he includes the Knudsen number for rarefied flows, for example; it is also a pity that in discussing heat transfer he uses the Grashof number rather than the more significant Rayleigh number (which is symmetrical in thermal and viscous diffusivity) and that he does not identify the Richardson number which is in fact widely used for the characterization of stratified turbulent flows, especially as both Rayleigh and Richardson numbers arise naturally from his analysis. These may be small points, but they are important in a book that may be widely used. He also considers the effect of relaxing the requirement of geometrical similarity.

This is basically a well-written account of dimensional theory which will provide a useful introduction for students, and they will certainly benefit from reading it. The picture it draws is a little too neat and isolated from the large body of literature on the subject to be final, and it is to be hoped that many readers will want to go further. In Focken's *Dimensional Methods*, to take a modern example, they will find a more extensive investigation and one which because of its wider range of subject may excite the imagination more successfully, but they will certainly not find so clearly written a book.

B. R. MORTON