"Furniture in Roman Times" is written for the general reader, but draws conveniently together for the student a mass of otherwise widely scattered material. Inevitably the amount of Roman furniture actually surviving in Britain is small: it would be even smaller were it not for the use that was made of Kimmeridge shale, a material only less perishable than timber. It is interesting to observe how the long-established Kimmeridge industry adapted itself to the imported classical style as yet another element in the uniform upper crust of material culture beneath which, at least in some parts of the Empire, a native non-Roman element often persisted.

Contemporary sculptures, on tomb-monuments particularly, augment and elucidate the fragments: sometimes conventionally as in the Chester series, sometimes more vividly as in the Simpelveld sarcophagus or the Toilet Scene from Trier. The final impression is that, technical skill and ingenuity apart, Roman furniture was not particularly beautiful and only a liberal use of soft furnishings could have made it comfortable. But as Prof. J. M. C. Toynbee has pointed out in her introduction, studies of this sort make the past live—and that not only for the general reader. For archaeology not merely extends knowledge of man backwards in time; it also deepens and enriches understanding by the light that it sheds on aspects of his life that 'history' may fail to touch.

W. F. GRIMES

HEAT AND MASS TRANSFER IN COMBUSTION THEORY

Some Fundamentals of Combustion

By Dr. D. B. Spalding. (Gas Turbine Series—Vol. 2.) Pp. x+250. (London: Butterworths Scientific Publications; New York: Academic Press, Ltd., 1955.) 40s. net.

THE first of a series of volumes, edited by J. Hodge, of Power Jets, and describing various features of the gas turbine has already been published. The volume under review is the second of the series, and its author, Dr. D. B. Spalding, is reader in applied heat at the Imperial College of Science and Technology, London. The science, though not the subject, of combustion is a relatively new one. Prior to 1939 work had been concentrated on a limited field, concerned with the combustion of premixed gases in the petrol engine, and especially with the phenomenon of detonation, the principal obstacle to progress in the prime mover then of supreme importance in military and commercial applications. A stage had been reached when it appeared that further advances must be made by the chemist rather than by the engineer.

With the increased use of the diesel engine, the rise in cost of fuel and the advent of the gas turbine, the field of combustion research has greatly widened, while detonation has ceased to be of much importance compared with, for example, the necessity for producing high combustion intensity, or with flame stabilization and blow-out criteria. Consequently, a very large literature has grown up; but except to the specialist, difficulty is experienced in reading and interpreting results which the various kinds of authors—engineers, physicists and chemists—present with widely differing emphasis. In this book Dr. Spalding has set out to integrate the most important

results of recent research, including a substantial contribution from his own work accomplished while he was at the Department of Engineering, Cambridge, and has in fact succeeded in developing a theory which combines the many isolated fragments of combustion research into a unified whole.

The first two chapters serve as an introduction to thermodynamics and fluid flow, but a serious student of combustion will require a much fuller explanation than is here contained. However, the clearly described and elaborate compressible-flow chart must be of interest to all concerned with high-speed flow of gases, while the thermodynamic approach is clear and rigid. It is, however, in the presentation in the next two chapters of the subjects of heat and mass transfer that the greatest originality lies. Here are developed the differential equations governing heat and mass transfer in the most general cases, such as when chemical reaction is also present. The solution of these equations is not usually possible; but by modifying Fick's Law so that it may be expressed in terms of concentration gradients instead of partial pressures and, when necessary, by assuming that thermal and mass diffusivities are equal, considerable simplification is achieved, so that in some special cases the equations can be solved and in general the form of the solution be derived, in functions of dimensionless groups (just as in heat transfer the Nusselt number is expressed as a function of the Reynolds and Prandtl numbers). It is shown that, with such simplifications, in all cases of mass transfer the results can be expressed in terms of the Reynolds, Schmidt and a new dimensionless number called the transfer number, which may have various simple forms according to the specific problem. The use of the transfer number is fundamental since it shows the different applications considered (for example, vaporization at liquid surfaces, combustion in gas jets and from solid and liquid fuels) to be special cases of a unified whole. The approximations involved are bold, but the quantitative results achieved are well within the usual limits of error associated with problems involving a multiplicity of variables, and lead to a clear conception of the controlling factors of each problem.

Chapter 5 is devoted to combustion processes in which the time-rate is important. There are excellent discussions of the propagation of flames in premixed gases, the conditions for flame extinction, flame stabilization and the criteria for blow-out conditions. The chapter is entitled "Chemical Effects in Combustion", somewhat misleadingly, as the properties discussed are much more physical than chemical. Conclusions developed from the theory are drawn in the short last chapter where there is some interesting criticism of the design of combustion chamber elements. There is no description of practical applications, as a further volume entitled "Combustion Practice" is scheduled to appear in the series.

All in all, this is an excellent book for every worker in combustion research, though its appeal to the practising engineer is much less. The style is crisp and authoritative, the references full, and the author is to be congratulated upon the lucid manner in which he interprets the rather bewildering array of non-dimensional numbers that confronts the student in this subject. He makes their use seem apparent and inevitable, and by their aid brings a hitherto not apparent coherence to a rather untidy subject.

F. D. ROBINSON