REVIEWS

Introduction to Hypersonic Flow. By G. G. CHERNYI (translated and edited by R. F. Probstein). Academic Press, 1961. 261 pp. £3. 4*s*.

The great interest in Russian work over the past few years has brought forth a considerable number of translations of books and original papers which were hitherto inaccessible to most Western readers. In a subject which has developed rapidly over a period of a little more than ten years, the delay between the appearance of the original volume and its translation can influence considerably the value of the work to the research worker. In this case, two years of intensive effort has thrown new light on much of the field considered in the book.

This book is an excellent translation of the work originally entitled *Gas Flows at High Supersonic Speeds* written by G. G. Chernyi. The change in title of the English edition may give us some clue about the status of the book in Professor Probstein's mind. An introduction to hypersonic flow does not demand a complete review or rigorous statement of hypersonic flow theory. The book is derived from lectures given at Moscow State University and caters for the undergraduate as well as the research worker in the field. Whether a book can satisfactorily meet both these needs is doubtful, although some attempt has been made to reconcile the two. It is more debatable whether a teacher and writer can construct an acceptable book from 'only those parts of the theory of hypersonic ideal gas flows in the development of which the author took part in some way or other'. However wide his interests may lie, the work must be incomplete. The immediate consequence of this is the complete omission from this book of what could be considered the most important part of the field. The 'blunt body' problem in hypersonic flow, which has consumed so much research effort, is not considered at all. This omission has not gone unnoticed by the author but stating that there is a skeleton in the cupboard does not expose it. It had been intended to introduce a chapter on this subject in the Western edition but owing to lack of time this was not undertaken. It is regrettable that such a decision had to be taken, since the book would have gained immeasurably by it.

At the time this book was first published there appeared the now classical volume *Hypersonic Flow Theory* by W. D. Hayes and R. F. Probstein. A very comprehensive review of Russian work was included within it. The scope of Professor Chernyi's book is very limited by comparison, even when the seven chapters of *Hypersonic Flow Theory* concerned with inviscid flow alone are taken. *Hypersonic Flow Theory* did much to map out and define the field in a more or less rigorous approach to the problem. Professor Chernyi, using a more simplified approach, selects his subjects in a way which more often appears to be decided by his own interests than that of the general theory. In sacrificing many of the mathematical niceties of the problem and relying purely on physical 'reasonableness' he is able to make an easier book to read. It is unfortunate that some of the simplification appears to have been achieved by omission.

The book deals entirely with inviscid hypersonic flow theory of an ideal gas except for a brief discussion in the first chapter of 'real' gas effects which are in practice associated with the realization of hypersonic speed. The subject is therefore essentially the extension and adaptation of compressible flow theory to high Mach number flows. This is done by the introduction of hypersonic similarity and the consequent equivalence principle in the conventional way as a small perturbation theory. The well known similarity solutions are given, together with tabulated values of pressure, density, etc. Considerable coverage is given to the derivation of minimum drag bodies starting with that obtained by using Newton's law of resistance which was originally derived by Newton himself. This is extended to the case of the Busemann drag relation which includes a centrifugal pressure gradient. The work of Hayes is here included. Two optimizing procedures are possible. One in which the limiting flow direction is determined by the body direction and the other by inserting a 'thrust' or 'turning' cowl (originally suggested by Hayes) to change the flow direction at the base of the body. The Newtonian theory of hypersonic flow is developed as a boundary-layer method. Several not very representative examples are given.

The familiar method of characteristics is not described and the tangent cone and wedge approximations are dealt with only briefly. Considerable coverage is given to the derivation of an approximate analytic solution to the flow past a cone for use in the tangent cone approximation. Although a comparison of results with experiments is shown to give reasonable agreement, no attempt is made to enumerate or criticize the assumptions implicit in such approximations. Several methods of solution to the flow past slender bodies where the flow is completely supersonic are described. Although much of the chapter is concerned with methods which are more satisfactory for supersonic flows, this introduction may prove useful to the student in understanding the basic interaction of the flow field and the shock wave which underlies the more truly hypersonic shock expansion theory. This again is treated only briefly.

The final chapter of the book is perhaps the most important since one of the major contributions of the Russian work is contained within it. This concerns the 'blunted body' problem. The effect of nose blunting on various body shapes is considered using approximate methods to simplify the integral equations of motion. Although the approximations and simplifications are numerous a qualitative description of the flow in such cases is given. It must be admitted, however, that the derivation of these results leaves much to be desired. A more satisfactory approach to the problem has been given by H. K. Cheng whose work reveals some surprising results not evident in Professor Chernyi's theory. Considerable work remains to be done on investigating the successive approximation procedures required to deduce these results. The limiting processes involved and the consequent accuracy of the method are by no means clear. The recent criticism of blast-wave analogy of hypersonic flow has shown the uncertainty of the foundations on which this branch of hypersonic theory is based. The importance of the entropy layer in these problems was obviously not appreciated by the author, and an editor's footnote warns us of this difficulty. A final section, which is perhaps the most important of the book, extends hyper-

sonic similarity to the blunted body. It would have seemed more logical to have inserted this at the beginning of the final chapter since it really forms the basis of it.

Finally, the editor must be commended for translating and presenting this book to the English-speaking reader. It must have required considerable patience on his part not to have smothered the whole book with footnotes and comments. Those that have been added are differentiated from the text, restrained, and occur only where necessary. The references, so valuable in a book of this kind, have been further improved by the inclusion of English translations of the foreign literature wherever possible.

The value of the translation must rest, however, largely on the amount of scientific literature which it renders accessible to the English-speaking reader. It is unfortunate that it is not an independent evaluation of the work in this field.

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