REVIEWS

Theory of Jets in Ideal Fluids. By M. I. GUREVICH. (Translated from the 1961 Moscow edition by R. L. Street and K. Zagustin.) Academic Press, 1965. 585 pp. £6. 0*s*.

Despite the dominant position of well-known scientists like Zhukovsky, Chaplygin and Sedov in the development of fluid dynamics, it must be admitted that the language barrier has impeded for too long a full appreciation in the West of the extensive contributions of Soviet workers to all branches of the subject. In the application of the complex variable to the boundary value problems of subsonic gas dynamics, hydrodynamics and elasticity, Soviet scientists have long been dominant, a fact made increasingly clear with the publication in English of Muskhelishvihi's two books (*Singular Integral Equations* and *Some Basic Problems of the Mathematical Theory of Elasticity*), Sedov's books (*The Theory of the Plane Flow of an Ideal Liquid* and *Two-dimensional problems in Hydrodynamics and Aerodynamics*), and Vekua's work on *Generalized Analytic Functions*. The addition of Gurevich's book to this list will be welcomed by those hydrodynamicists who have not yet mastered the Cyrillic script. A good survey of the contributions of the Moscow School of aerodynamicists to applied complex variable theory is provided by the article by Keldysh and Sedov in the Proceeding of the I.U.T.A.M. Symposium at Tbilisi, September 1963.

The first eight chapters of Gurevich's text are concerned with steady, two-dimensional (planar) flows of an inviscid, incompressible fluid, the flow being such that free streamlines occur over parts of the fluid boundary. The word 'jet' in the title is a little misleading, for cavitating flows with internal free surfaces of finite length are included in the account. Complex variable methods are used throughout. Chapters 9 to 12 deal in turn with unsteady flow, subsonic compressible flows, axisymmetric flows and flows in which the effects of gravity and surface tension are important.

Chapter 1 is an introductory account in which the basic assumptions are set out and the methods of Kirchhoff, Zhukovsky and Chaplygin are described. This part of the text would have been improved by the inclusion of more discussion on the range of validity of ideal flows, and some account of the interaction of boundary layers with these flows. Chapter 2 deals with the flow from vessels or channels, having a variety of rectilinearly shaped orifices. The method employed—due to Von Mises—is that of mapping the flow domain into a semi-circular region, such that the free surfaces map into the circumference, and the wetted surfaces on to the diameter.

Cavitating flows past obstacles are considered in chapters 3 to 5, of which chapters 3 and 4 deal with cavities of finite length—the so-called 'Helmholtz flows'—and chapter 5 with cavities of finite extent. Methods of finding the Helmholtz flow about rectilinear (chapter 3) and curvilinear (chapter 4) obstacles are described in much detail, particular attention being paid to the contributions of Levi-Civita, Villat, Brillouin, Brodetsky, Nekrasov, Weinstein, Leray, Laurentiev, Keldysh and Sedov. On p. 156 the discrepancy between the positions of the separation points for ideal Helmholtz flow and experimental laminar boundary layer flow, past a circular cylinder, is attributed to viscosity. But surely a more important feature is that in the first case the cavity is assumed to contain a gas of negligible density, whereas in the second there is no cavity but simply a 'dead-water' region filled with fluid of the same density as the main stream.

In chapter 5 the re-entrant jet model of Efros and Gilbarg, and the Riabouchinsky 'mirror-image' model are discussed in detail. The much simpler method of closing the cavity by singularity is unfortunately omitted. For long cavities it makes little difference which method of closure is used, and in this case the use of a singularity has a clear advantage. Gurevich includes in this chapter an account of his own valuable work on the cavitating flow past a circular cylinder, using the re-entrant jet model. An account of T. Wu's theory of the cavitating flow about hydrofoils closes the chapter. The following chapter contains a variety of generalizations of the flows considered in chapter 5, notably the effect of the presence of one or two walls on the cavitating flow about wedges and cylinders, and cascade flow of the Helmholtz type. There is also an account of some work, initiated by Sedov, on the application of the re-entrant jet model to a cascade of hydrofoils.

Chapter 7 is on planing surfaces, and hydrofoils beneath a free surface, while chapter 8 contains solutions to miscellaneous topics, e.g. collision of jets and jets containing sources and vortices in the flow field.

In chapter 9 the author turns his attention to the rather more difficult problems of unsteady flows. After mentioning the work of Von Kármán and Gilbarg, he gives the theory of determining the virtual masses of various shapes in separated flows. This is followed by an account of the reviewer's work on slightly perturbed Helmholtz flows and that of Curle on jet formation. Full details are not provided, but this results in a very lucid presentation and makes quite clear the difference between the assumptions adopted by these authors. The chapter is concluded by an excellent review of that famous and difficult problem, surface impact of a wedge.

Compressibility is introduced into the theory in chapter 10, starting with Chaplygin's work on gas jets and various developments of this, especially those due to Falkovich. Following this is an account of Chaplygin's approximate method (equivalent to the use of the Kármán–Tsien 'tangent gas'), which immediately extends the whole of the incompressible flow theory discussed in the earlier chapters to subsonic compressible flow. Chapter 12 deals with the effects of gravity and surface tension on free surface flows. The early work of Zhukovsky and Richardson in finding exact solutions is followed by an account of the approximate methods of several authors, notably Woronetz and Mark.

Chapter 11 is the only chapter in which the complex variable does not appear, except in a brief reference to Garabedian's work. This is understandable because the flows considered are not planar but axisymmetric. Trefftz's integral equation approach and some extensions of it are discussed. The finite difference method has been used by many authors, and a brief review of this 'last resort' technique is given. Gurevich's own contributions to the solution of this very difficult problem, using Legendre polynomial expansions, is also explained. It is clear that axisymmetric cavitating flows still offer challenging mathematical problems, especially if unsteady flow (not mentioned in the text) is considered.

To conclude, Professor Gurevich has made every attempt in his excellent account of this classical field of fluid mechanics to compare experiment with theory, but for most of the flow patterns considered no experimental results are available; perhaps this shortage is some measure of the practicality of much of the work. However it is a valuable addition to the literature, being a well presented, scholarly account (262 references) of a subject Professor Gurevich has studied for over 30 years.

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Turbulent Boundary Layers in Compressible Gases. By S. S. KUTATELADZE and A. I. LEONT'EV. (Translated by D. B. Spalding.) London: Edward Arnold. 1964. 170 pp. 60*s*.

The development of an adequate theory of the development of incompressible turbulent boundary layers in the presence of pressure gradients is a formidable undertaking, and extension to compressible flow with heat and mass transfer might seem just foolhardy. If the systematic treatment given by Kutateladze and Leont'ev does not give the final answers to the very complex problems, it is a remarkable achievement to have produced such an internally consistent account. Their basic assumptions are that stress and velocity gradient are related by a Prandtl mixing-length, that the shape of the stress profile is a 'cubic parabola' containing the parameters, $\delta/\tau_s \, dp/dx$ (δ is total thickness and τ_s surface stress) and $(2/c_f)\,(\rho_s u_s/\rho_G u_G)$ ($\rho_s u_s$ is mass-flow through the surface and $\rho_G u_G$ is the mean-flow in the free stream), and that the Prandtl number for turbulent transport is near one. In effect, the relations between the turbulent fluxes and mean gradients of momentum, heat and matter are assumed to depend only on the local conditions and not on the past history of the flow upstream of the particular section. In certain circumstances, this kind of assumption leads to quite wrong predictions of boundary-layer behaviour—for example, development after a change of roughness or after emergence from a region of adverse pressure gradient—but it is possible to use them for a wide variety of 'ordinary' boundary-layer flows. The application of the assumptions depends on the establishment of the properties of the flow for very large Reynolds number, the relation of other flows to the limiting flow and the use of many approximations necessary for concrete results. It is a book for study rather than light reading, but the presentation is logical and the full comments by the translator are extremely helpful. The object is to give a coherent scheme to correlate existing measurements of boundary-layers and to predict behaviour in new situations. In general, the theoretical predictions agree with the observations to within the internal consistency of the measurements, and it is probably as successful as could be expected from a theory based on the simplified model of the turbulent flow. The book can be recommended to those seeking estimates of boundary-layer behaviour, but it is not directly concerned with the problem of the turbulent motion.

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