Thermometry, edited by T. D. BANSAL. National Physical Laboratory, New Delhi, India (1967). Price 35*s*.

IN FEBRUARY 1967 Dr. T. D. Bansal, Scientist-in-Charge of the Heat Division, N.P.L., India convened there a "Get-Together on Thermometry" which was attended by invited specialists as well as by Indian scientists, industrialists and users. These included several medical men, for half a section was devoted to clinical thermometry.

The meeting was inaugurated by J. A. Hall of the Bureau International des Poids et Mesures and formerly of the Temperature Measurement Section, N.P.L., England. The book contains the fifty-seven presented papers together with discussions and information on many associated problems, for instance: "How to pack thermometers", "How to measure skin temperature" and "Will quality control help the industry?" "Thermometry" differs from normal conference proceedings in the degree of attention it gives to the troubles India has met, and is overcoming, in the manufacture, standardization and use of various types of thermometry equipment. However, the more usual review papers are included, as well as accounts of recent research developments.

Hall reviews platinum-resistance thermometry and predicts that within three years a satisfactory reference table, continuous from —260° to 1063°C, should be available. Thomas (P.T.B.) details gas-thermometry measurements made since 1937 and shows that, at the gold point, the measurements of PTB and VNIIM differ from the IPTS (International Practical Temperature Scale, 1948) value of 1063°C by several times the accuracy now available. This Russian work is also described by Izrailov *et al.*; their value is 1064·38 ± 0·06°C, compared with the PTB value of 1064·48°C. Oishi *et al.* (NRLM) in 1956 obtained a lower value, namely 1063·69 ± 0·05°C, but Oyama's report indicates that further measurements from that laboratory are planned.

For low temperatures, another VNIIM paper by Brodsky *et al.* presents several modern methods. Nuclear quadrupole thermometry is one; the use of potassium chlorate as the thermometric substance allows the thermodynamic scale to be realised with an accuracy of 0·002 degK in the range 20°–273°K, and 0·01 degK from 273° to 473°K. This technique requires neither repeated calibrations nor skilled operators; it is already being used as a secondary standard for the IPTS.

Bansal describes the calibration equipment and methods of NPL India, and reveals how a satisfactory system can be developed without the high-precision equipment considered essential by wealthier laboratories. An ice-point apparatus, described by Bansal and Wasan, successfully overcomes difficulties associated with environmental temperatures as high as 43°C, and allows a temperature constant to less than 0·01 deg to be maintained with minimal attention for days.

Papers on liquid-in-glass thermometers, thermocouples and optical pyrometers as well as such diverse subjects as dew-point and molten-steel temperature measurement are also included.

These few selected topics should serve to show that NPL India has made available a volume that can be recommended to those concerned with thermometry and its applications in both developing and developed countries.

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ALFRED WALZ, **Strömungs und Temperaturgrenzschichten.** 260 pp., 122 Figs., 3 Tables. G. Braun, Karlsruhe (1966).

PROFESSOR WALZ's monograph is the outcome of the author's many years of fruitful research on the theory of the boundary layer, both laminar and turbulent. Its purpose is to describe the method of calculation which Walz and his co-workers have developed, and to illustrate its use by example. There is a scholarly historical introduction, and a sufficiently elementary explanation of the important physcial ideas; but the aim of the book is a narrow one; and it is successfully attained.

The value of the book depends inevitably on the value of the method; and this will take time to determine. My personal view is that the method will not prevail; its merit is computational simplicity; but, now that digital computers are so widely available, this feature cannot compensate for limitations of accuracy and application. For laminar boundary layers, the point is particularly easy to see: the exact differential equations are not in doubt; so, since general computer programmes exist for solving them numerically, there is little incentive to bother with integral methods, employing frequently invalid assumptions about the profile shapes. Walz uses at most two ordinary differential equations, those governing the momentum and the kinetic-energy integrals; the enthalpy distribution is taken to be linked with that of velocity. The complexity of practically interesting boundary layers cannot be comprehended in so narrow a frame.

It might be argued (and Walz gives some support to the view) that integral methods can provide exact solutions to the differential equations, when the number of free parameters in the profiles is made large enough. About this there are several things to be said. First, we must choose the weighting functions carefully; in disproof of the relevant statements in the book, it is possible to show that, if the velocity profile exhibits a maximum, an infinite set of profiles can be found, all of which possess the same values of $\int_0^\infty \{1 - (u/u_\infty)^n\}\,dy$, for all positive values of n. [Here u stands for velocity, y for distance from the wall, and u_∞ for u where $y = \infty$.] Secondly, even when satisfactory weighting functions are employed, matrix singularity interrupts the integration with increasing frequency when the family or allowable profiles is enlarged. Thirdly, if, as in Walz's procedure for turbulent flow, matrix inversion is replaced by the appeal to empirical information, even a modest increase in the number of free parameters makes demands for experimental data that are disproportionately and unattainably large.

Yet, even if few people find it profitable to adopt Walz's method of calculating boundary layers, there are many who could copy with advantage his method of writing books. He has set himself a clear objective, and resisted the temptation to display his knowledge of topics which are irrelevant to it; the argument is marshalled logically and with full consideration for the reader's interests; and the auxiliary material, such as examples, nomenclature, diagrams, and references, is organized impeccably. Finally, the publishers have given the book a handsome appearance, uniform with that of the latest edition of H. Schlichting's *Grenzschicht-theorie.*

D. B. SPALDING

The Proceedings of the 1967 Heat Transfer and Fluid Mechanics Institute, 468 pp. Stanford University Press, Stanford, Calif. (1967).

THE PROCEEDINGS of the Heat Transfer and Fluid Mechanics Institute can generally be relied upon to contain a number of papers of fundamental as well as of specialist interest and this volume presenting the papers of the 20th annual meeting is no exception. The host institution was the University of California at San Diego, and in consequence the main fields of interest there, namely post-Apollo re-entry phenomena and propulsion fluid mechanics and heat transfer figure prominently in the fields discussed. However, in addition a selection of papers were presented covering vortices, wakes and boundary layers.

Two general invited lectures, one on atmospheric entry in the post-Apollo Era by L. Roberts and one on analytical studies of two-phase flow in propulsion systems by F. E. Marble are presented in abstract only; the remaining papers are given in full.

A paper on the aerothermodynamic problems of the Apolo by R. B. Erb, D. B. Lee, K. C. Weston and D. H. Greenshields discusses the theoretical and experimental techniques that have been adopted to investigate and solve these problems and the flight tests that have so far shown encouraging agreement with the predicted results. The practical importance of heat transfer in the region of the stagnation point and the effects of radiation are reflected in all the six papers that follow. S. Y. Chen, J. Baron and R. Mobley examine theoretically the effectiveness of transpiration cooling in that region in hypersonic flight, and P. R. Nachtsheim examines multi-component diffusion in chemically reacting laminar boundary layers with particular reference to the flow at the stagnation point of an axi-symmetric body. D. B. Olfe and R. J. Cavalleri are concerned with shock structure as affected by non-grey radiative transfer, N. A. Macken and J. P. Hartnett discuss the interaction of convection and radiation in stagnation point flow and include the effects of suction and blowing. R. B. Dirling, W. S. Rigdon and M. Thomas develop an approximate technique for determining the flow field and heat transfer in the radiating shock layer under conditions where atomic-line radiation is important and requires detailed spectral calculations, and much the same problem is considered by G. T. Chapman who includes the effect of mass transfer.

The section on propulsion fluid mechanics and heat transfer displays a strong interest in the effects of acoustic fields and other forms of vibration on fluid jet-flows. One of the problems which gives rise to such studies is the need to understand high frequency combustion instability in liquid-propellant rocket motors. F. G. Buffam and F. A. Williams describe investigations of the response of a turbulent liquid jet to transverse acoustic fields and show that the coupling can be large; R. J. Schoenhals, E. R. F. Winter and E. I. Griggs present results showing that longitudinal structural vibrations can produce a flow retardation effect; H. G. Keith and K. R. Purdy investigate analytically the effects of an intense longitudinal acoustic field on forced convection heat transfer and show that these effects can be important. Other papers in this section include a study of convective heat transfer in the base region of large space boosters with clustered engines by R. A. Taylor and P. P. Tou, an interesting optical technique of measuring turbulence in a supersonic jet by M. J. Fisher, D. W. Prosser and J. M. Clinch, and a parametric solution of the one-dimensional flow equations with heat addition by S. S. Penner and W. Davidor.

The final group of eight miscellaneous papers include an interesting paper on vortex breakdown by M. G. Hall, a simple model by F. Fendell and D. Coats to describe the structure of a rotatory flow associated with a heat source of relevance to geophysical phenomena (e.g. tornadoes), a basic paper on the application of heated films to the measurement of skin friction by G. L. Brown, an analysis of the effects of free stream acceleration on base flows at supersonic speeds by A. F. Charwat, G. H. Burghait and W. H. Nurick, a theoretical and experimental investigation by Y. T. Chin, J. Hulsebos and G. H. Hunnicutt of the effects of lateral curvature on a turbulent boundary layer in air, including the effects of helium injection, an important investigation of the effects of free stream acceleration on flow and heat transfer in a turbulent boundary layer by L. H. Back and R. A. Seban, valuable shock tunnel measurements of heat transfer and skin friction in the turbulent boundary layer on a flat plate over a useful range of the main parameters by J. E. Wallace, and finally an investigation of non-equilibrium air dissociation and ionization in the merged layer regime in the region of the stagnation point of a blunt body.

It is clear that any active worker in the fields of heat transfer and fluid mechanics will find much of long term value to him in these Proceedings, even if the applications with which he may be concerned are well remote from the Apollo and post-Appolo programmes that have evidently inspired many of the papers.

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