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FILM REVIEWS

Modes of Vibration. By L. J. POLDERVAART, A. P. J. WIJNANDS, I. H. A. M. VAN MOLL and E. J. VAN VOORTHUISEN. 1974. 16 mm, silent, black and white, 10 min. 180 Hfl. In English.

Sound Pulse–Boundary Layer Interaction Studies. By L. J. POLDERVAART, A. P. J. WIJNANDS and I. BRONKHORST. 1974. 16 mm, optical sound, black and white, 20 min. 375 Hfl. In English.

Both available from the A.V. Centre, Technische Hogeschool, Den Dolech 2, Postbus 513, Eindhoven, The Netherlands.

These films are the latest in a remarkable series on visualization and control of high-speed jet flow. *Modes of Vibration* is a superb stroboscopic visualization of instability waves growing on a two-dimensional supersonic jet. The waves are excited by sound that is shown to be generated by the coherent motion of the cellular boundaries of the underexpanded basic jet flow. In the film this secondary acoustic motion is directed with appropriately positioned reflectors and screens to induce the jet into various vibrational modes, or modes of eddy formation. Plate 1 shows a typical sequence from the film. In the first picture the reflected excitation pulse arrives at the nozzle lip and 4 μs later an embryonic shear-layer eddy is already visible. The eddy grows as it moves downstream and quickly spans the entire flow; the jet is then a series of large eddying motions. This cycle is repeated every 55 μs. The effective visualization of this motion is an outstanding piece of work and demonstrates that the large eddies can be adjusted at will through the use of acoustic reflectors and absorbers.

The second film demonstrates clearly that the eddies previously analysed in the 'screech' cycle of a supersonic jet are a general feature of unsteady jet motions. This time a two-dimensional (40×3 mm) jet is excited by a collimated acoustic N-wave driven by an electric spark. The film shows beautiful pictures of the jet response to this external forcing at various subsonic and supersonic jet speeds. The photographs on plate 2 are typical examples. That response starts immediately downstream of the nozzle lip, where embryonic eddies form on the shear layer. These eddies travel downstream, growing rapidly until they completely determine the jet structure. At this point the eddies seem fully deterministic and are typically twice the nozzle scale in size.

The form of the eddies is insensitive to details of the acoustic excitation, a continuous variation of the incidence angle over a 150° arc having no observable effect on the jet structure. Neither is the eddy structure velocity dependent. The downstream growth of the eddy length scale is not obviously identifiable as a 'vortex pairing'; it is more a merging of two eddies and is completed before the two vorticity concentrations have rolled around once.

The film commentary is concerned with details of the phase relationships of the eddies and their acoustic triggers, but the eddies seem much the same

however triggered. This vortex structure is probably highly significant to the sound-generating motions of a jet. The sound seems to originate from those regions where the deterministic eddy structure breaks down into chaos.

These are splendid films in which is demonstrated an experimental technique that allows a unique view of some definite unsteady jet motion; those motions are likely to be a characteristic of the noisy propulsive jets that power high-speed aircraft.

J. E. Ffowcs Williams

Shorter Notices

Studies in Fluid Mechanics and Applied Mathematics. Edited by H. Hasimoto and T. Tatsumi. 1975

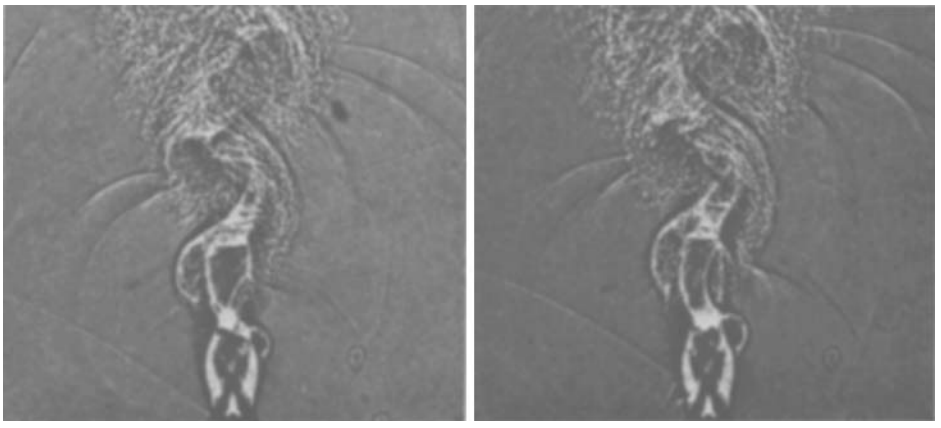
This privately published volume is a collection of 44 papers (in English) dedicated to Professor Isao Imai in celebration of his 60th birthday. All the papers have been published elsewhere, mostly in *Journal of the Physical Society of Japan*, and are here reproduced photographically. They are all by former students and associates of Professor Imai and illustrate well the range and character of his influence on the development of fluid mechanics in Japan. A short biography and a list of Professor Imai's publications are included.

Elementary Fluid Mechanics, 5th edition. By J. K. Vennard and R. L. Street. Wiley, 1975. 740 pp. £9.50 or $17.95

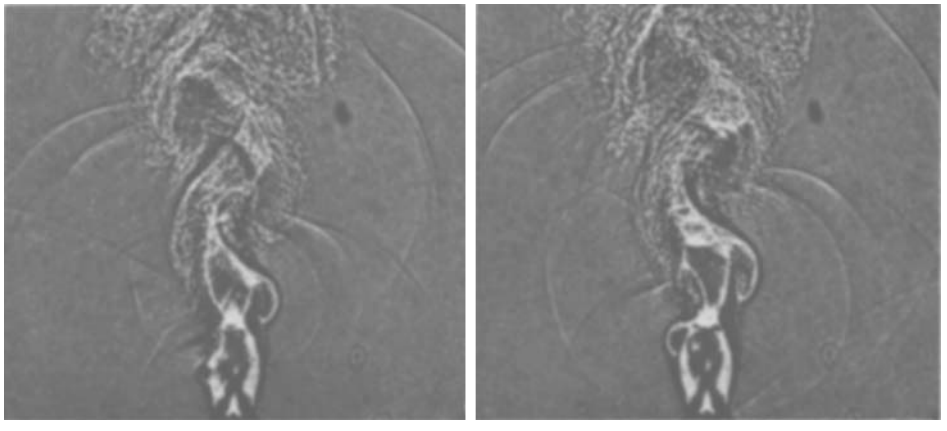
This well-known text for engineering students, first written by the late Professor Vennard in 1940, has been revised further in this 5th edition by Professor R. L. Street without any changes of structure or style. And before the ink on this notice was dry, there arrived on the editorial desk an alternative version of the 5th edition in SI units, dated 1976, intended for readers in metric countries. By implication the ordinary 5th edition is primarily for American readers who use the FSS system of units, called by Americans the English system although not all English practitioners would know what the second S stands for.

The Dynamic Properties of Supercooled Liquids. By G. Harrison. Academic Press, 1976. 199 pp. £6.20

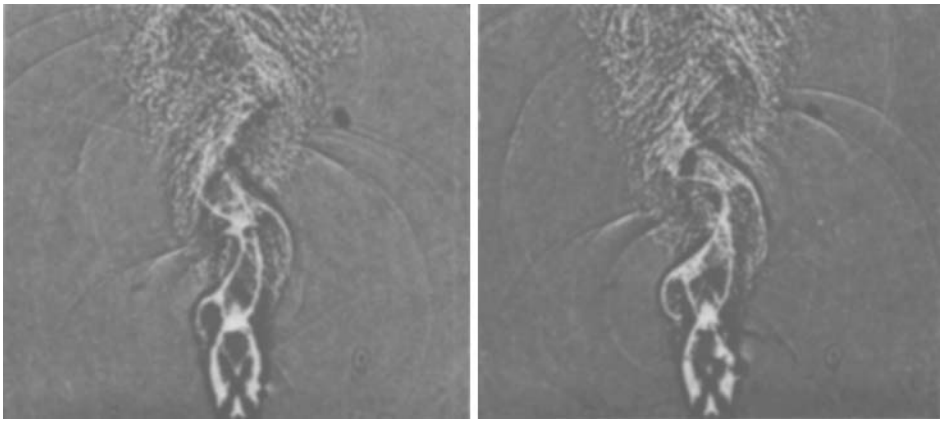
This is a book for physicists or physical chemists but it may have some interest for fluid mechanicists interested in the fundamental properties of simple liquids. Current interest in polymeric fluids has made viscoelasticity a subject of some importance. Harrison examines circumstances under which simple liquids display viscoelasticity, namely at very high pressures, very low temperatures, very high rates of deformation, or some combination of all three. The supercooling mentioned in the title refers to the low temperatures necessary for simple fluids to be viscous enough to show some elastic behaviour at accessible 'frequencies' of deformation. The book is straightforward. The introduction forms a well written self-contained essay that can be recommended to all.



$t=0$ $t=4\ \mu s$



$t=16\ \mu s$ $t=28\ \mu s$



$t=41\ \mu s$ $t=49\ \mu s$

PLATE 1. Modes of vibration.

(*Facing p.* 860)

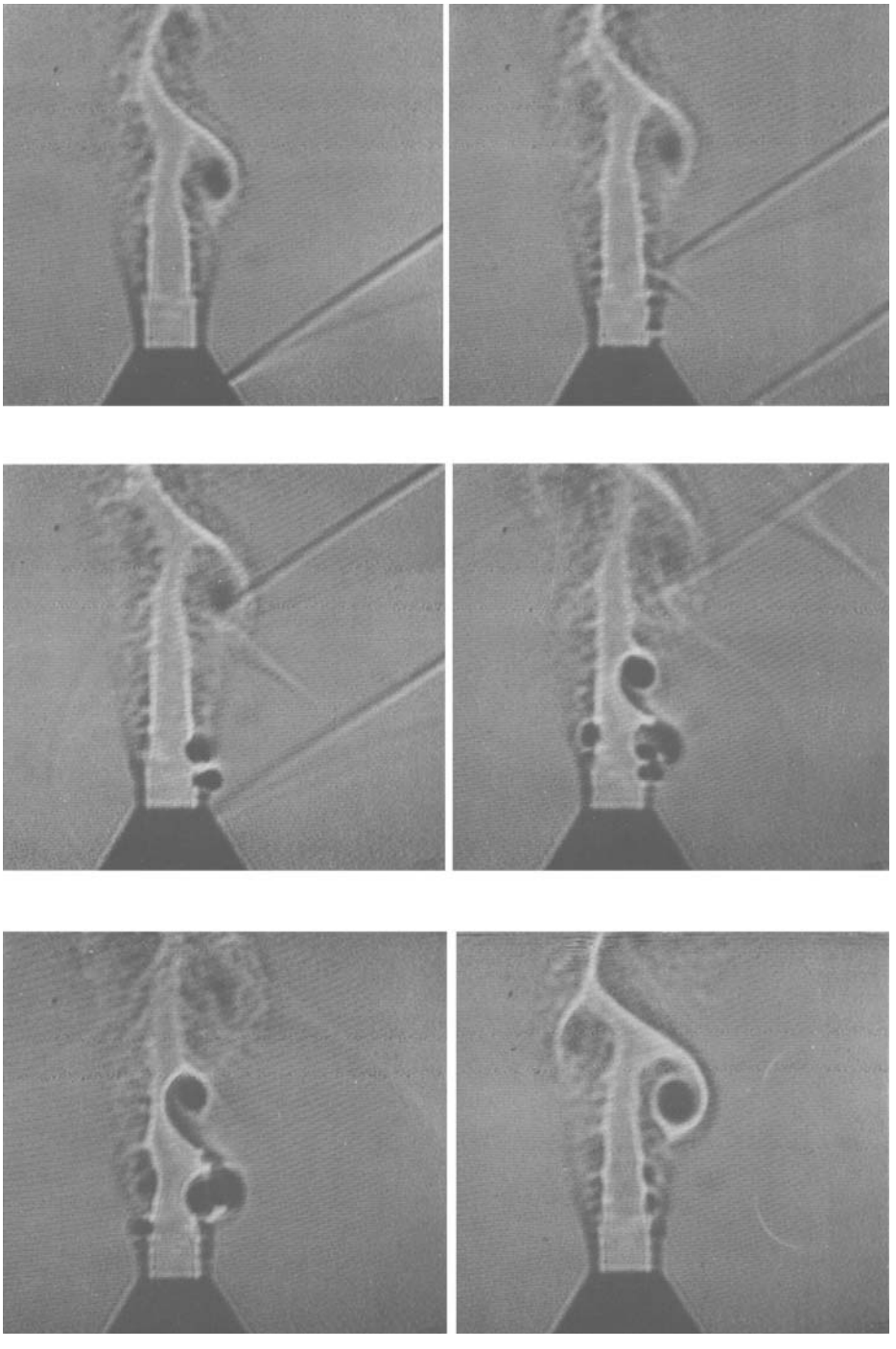


PLATE 2. Video recordings showing the interaction of two successive pulses with the shear layer as a function of time. Time interval between pulses is 25 μs.

Later chapters deal in a relatively simple (unprofound) fashion with the liquid state, linear viscoelasticity, high frequency methods for measuring the mechanical properties of liquids, the viscoelastic properties of supercooled liquids and structural and dielectric relaxation. The origins of the book lie in the extensive research contributions of Professor John Lamb and his co-workers at Glasgow.

IUTAM Symposium Transsonicum II. Edited by K. OSWATITSCH and D. RUESS. Springer, 1976. 574 pp. DM 88.

The second Symposium Transsonicum was held in September 1975, thirteen years after the first symposium. In that period there were considerable advances in the study of transonic flow. In particular the last few years have seen a revolution in numerical calculation methods. All this activity is fully reflected in the papers contained in this volume, and, in general, the papers contain sufficient detail to allow useful comparisons of the various methods. In addition to the numerical work there are a number of papers on experimental work, particularly for internal flows, and contributions on basic theory and unsteady flow. The volume provides a very good survey of the current state of transonic flow although it is unfortunate that the editors were unable to include details of the discussion periods.

Proceedings of the Fifth Conference on Fluid Machinery. Edited by L. KISBOCSKÓI and Á. SZABO. Akadémiai Kiadó, Budapest, 1975. 1261 pp. £29.40.

This collection of papers is a good reminder of the range of applications for fluid machinery. For example, the first volume contains a paper on irrigation water wheels of the type operated by oxen and another on the dynamic performance of full cavitating pumps, where one motivation for the research is the 'POGO' instability of liquid-fueled rockets. In fact many of the papers are concerned with cavitation – either the effect on performance or the resulting damage to solid surfaces – whereas compressible fluid machines are hardly mentioned at all. Not all the papers are directly concerned with machinery, but with boundary layers and flows in bends, for example. The papers are all in English by authors from a very wide range of countries. An omission is that there are very few authors from within commercial companies. Yet within the West, at least, this is where much of the knowledge and expertise connected with fluid machinery resides.

Equilibrium Properties of Fluid Mixtures. A Bibliography of Data on Fluids of Cryogenic Interest. By M. J. HIZA, A. J. KIDNAY and R. C. MILLER. Plenum, 1975. 160 pp. $29.50.

Taken together, the title and subtitle give a good idea of the contents of this book. The fluids covered, 26 in all, are ones with low boiling points, such as hydrogen, xenon and butane; the experimental data covered range from phase equilibria to calorimetric measurements, 10 categories in all if the phase-equilibria data for each system (solid–liquid, solid–vapour, etc.) are counted

separately. For each category, a table is presented of references arranged according to the mixture of fluids studied; a separate bibliography is presented for each category. The references are presented without assessment of their quality.

Liquid Thermal Conductivity. A Data Survey to 1973. By D. T. JAMIESON, J. B. IRVING and J. S. TUDHOPE. Her Majesty's Stationary Office, 1975. 221 pp. £9.40.

As well as converting all thermal-conductivity data to a standard format, the authors of this book have added their own estimates of the likely accuracy of many of the measurements. The result is 16 tables of thermal conductivities (and temperature coefficients for about half the cases) covering a wide range of liquids. The most comprehensive table is that for organic liquids, which takes up 90 pages. Smaller tables extend the compilation to silicon compounds, binary mixtures, water, etc.

Viscosity. By Y. S. TOULOKIAN, S. C. SAXENA and P. HESTERMANS. Plenum, 1975. 643 pp.

This book contains compilations of both theoretical and experimental results. The section on theory paints the theoretical picture with broad brushstrokes and gives large numbers of references in a way probably adequate for non-theoreticians. Similarly a section on experimental methods runs quickly through the viscosimeters used for Newtonian fluids. The experimental data compiled are on a much larger scale: 1803 sets of data according to the introduction. The presentation is good; for those fluids for which there are several data sources, recommended values are given together with a graphical representation of the departures of other data from the recommended values, thus allowing the reader an opportunity to form his own opinion on the accuracy. For less common fluids the authors quote available results together with an accuracy estimate (but do not make it clear whether this estimate is theirs or the original workers').