BOOK REVIEWS


REVIEWED BY D. D. JOSEPH

Rheological fluid mechanics is an intellectually interesting and technologically important subject. The reason that this subject has not come into a more central place in fluid mechanics is because of uncertainty about the correct form for the governing equations. Constitutive relations which are general enough to describe the tremendously varied responses open to a rheologically complex fluid are too general to solve many problems. And specific constitutive equations, developed from models, suitable for problem solving, are at best guided guesses which leave open the ultimate question about whether the constitutive relation you give is the right one for the fluid you get. Authors have had to decide between a good treatment of principles, without much problem solving, and a good treatment of fluid models, emphasizing problem solving. In the first category the treatise by Truesdell and Noll (The Nonlinear Field Theories of Mechanics, Springer, 1965) is without peer; in the second category are the books of Lodge (Elastic Liquids, Academic Press, 1964), and Middleman (The Flow of High Polymers, 1968).

The book by Astarita and Marrucci follows the line of thought developed by Truesdell and Noll, but from their own more pragmatic point of view and with some attention in the last two of seven chapters, to methods of approach toward solving important problems in the fluid mechanics of non-Newtonian fluids. The book is simply and clearly written. The arrangement of material is good and the book may be read, cover to cover. The technical arrangements for printing text, equations, and notes is outstanding and, in this, the authors and McGraw-Hill have produced an excellent work.

Non-Newtonian Fluid Mechanics cannot, of course, be compared to the Nonlinear Field Theories in breadth, rigor, and depth of scholarship. But the Truesdell and Noll book is full of new concepts, notations, and modes of thought and to say the least, demands more than some ordinary folk can give and more than less-ordinary folk will give. Since understanding is always incomplete, it is just a matter of degree, and a more gentle introduction to the theory of nonlinear continuum fluid mechanics developed by Coleman, Ericksen, Noll, Rivlin, Truesdell, and others is most welcome. The Astarita and Marrucci book gives this more gentle introduction. It achieves this greater simplicity in presentation by deleting materials which are not directly related to fluids, by sacrificing completeness and by omitting difficult mathematical demonstrations.

Astarita and Marrucci use their own experience to explain the basic concepts but are always faithful to the Truesdell-Noll point of view. Invariance of the stress to rigid body transformations is explained in terms of Noll’s concept of frame indifference; tensors are regarded as linear mappings rather than as sets of numbers with assigned properties under orthogonal transformations; fading memory is framed according to the Coleman-Noll concept of norms defined with weight functions that wipe out the distant past; thermodynamics follows the formulation of Coleman, etc.

Chapter 1 is mainly concerned with vectors and tensors. The authors approach relies heavily on the direct use of reciprocal base vector systems. This method is good; it allows one to generate formulas for transformations between contravariant, covariant, and physical components from first principles. The authors adhere rigorously to the concept of a tensor as a bounded linear mapping (a continuous transformation). They should have said more about the relation of this concept to the more conventional definition of tensors using Cartesian components and orthogonal transformations.

Chapter 2 gives an introduction to the theory of nonlinear continuum fluid mechanics in the context of one of its simplest exam-
Anelastic relaxation measurements were performed in a Nb-46wt%Ti alloy, in the temperature range of 300 to 700 K, using a torsion pendulum operating at an oscillating frequency near 2.0 Hz. The samples were measured in different conditions: cold worked, annealed in ultra-high vacuum and doped with several quantities of nitrogen. A.S. Nowick, B.S. Berry, Anelastic Relaxation in Crystalline Solids, Academic Press, New York, (1972).