issues far earlier than the numerical analysts. For example, only recently have numerical analysts begun to appreciate that their customary pointwise error measures are inappropriate for problems with highly oscillatory solutions. In perturbation theory there are more natural definitions of a solution, and there are approaches with real promise for these extremely difficult problems. It is to be hoped that Miranker's seminal work can be generalized to less special problems, so that new software tools can be based on the ideas.

The author states that most of his material is drawn from the recent literature and that his treatment varies from formal to informal. This is accurate. The monograph might be described as a collection of papers by the author and his coworkers, supplemented with the necessary background material. More attention has been given to background material in numerical methods than in perturbation theory. Some mathematical sophistication is necessary for the more important sections of the book.

This is a stimulating book on the application of the methods of singular perturbation theory to the numerical solution of stiff ordinary differential equations. The numerical examples merely demonstrate feasibility, but numerical analysts should be reading this book for the possibilities of the approach, rather than for algorithms they can immediately implement. It is to be hoped that Miranker's success will encourage others to further develop the ideas to the point that they will provide new and powerful numerical algorithms.[1]

L. F. SHAMPINE

[1]This work was performed at Sandia National Laboratories and supported by the U.S. Department of Energy under contract number DE-AC04-76DP00789.

BULLETIN (New Series) OF THE
AMERICAN MATHEMATICAL SOCIETY
Volume 7, Number 3, November 1982

0273-0979/82/0000-0604/$01.75

The tragicomical history of thermodynamics 1822–1854, by C. Truesdell, Studies in the History of Mathematics and Physical Sciences, Volume 4, Springer-Verlag, New York, Heidelberg and Berlin, 1980, xiii + 372 pp., $48.00.

1. This volume carries the word 'history' in its title, and is published in a series of historical studies. The reader is thus doubly invited to expect an historical account, in which, therefore, past events and their contexts are described.

Truesdell's play is divided into five acts and an epilogue, with two named 'distracting interludes' (pp. 139–148, pp. 219–276) and an extra Act V to be played as an 'antiplot in a dark and empty theatre' (pp. 277–304). The action takes place mostly in the period between Fourier (1822) and Reech (1854), with major roles played also by Carnot, Kelvin, Clausius, Joule and Rankine, and minor parts and noises off coming from various other figures. Laplace, Biot, and Poisson perform a Prologue (pp. 29–46), without the help on p. 31 of Laplace [**1803**].

Virtually no scenery or lighting are indicated. Characters appear bereft of biography, even concerning the books and papers brought up for marking.

The production is naturally eccentric in several ways. Each act and interlude is prefaced by a quotation, in the original Italian, from Dante. Usually the *Purgatorio* or the *Inferno* (inferno—heat—thermodynamics; got it?) are used, but *Paradiso* is achieved when Reech is reached (p. 277). A race named as 'Historians of Science' is berated several times for various real or imagined sins. One of these, that 'they usually accept uncritically the party line of today's profession of physics as to what the various disciplines are and what must come out triumphant in the end' (p. 296), is so ridiculous that I presume that a typesetting error has crept in; in fact, many historians of science have no idea what today's position is in any science.

2. Historians of science are well used to finding opportunities missed, gaffes made, and so on, which are correctable without the use of devices of later periods. Thermodynamics may have been particularly prone to carelessness and stupidity, but the relentless catalogue of sins recorded here reduces the tragicomedy (a word repeated to the point of irritation) to a fool's *Paradiso*. Apparently, these historical figures should have developed their theories in pretty complete form, with ranges of generality clearly specified, and *all* known anomalies covered. Little sense of the *struggle with novelties* is conveyed in Truesdell's history; instead an extremely uncharitable impression comes over, to such an extent that the occasional paragraphs of praise seem out of place, even unargued.

Truesdell takes such a strong line because he checks out the original texts for validity of reasoning, presumption of premise, vagueness of generality, and reifiability of concepts, allegedly in terms of the concepts and methods of the time (compare p. 5). The task can now be undertaken 'since only in the last twenty years have the expressed aims of the creators of thermodynamics been achieved' (pp. 3–4)—by Truesdell alone, on the evidence of the bibliography (pp. 359–360). One wonders, therefore, what happened in thermodynamics *between* Reech (and his coprincipals of the mid 19th century) and the revivals of the 1960s. Was the subject in heat death all that time? The concluding 'Götterdämmerung' (pp. 336–339, with *Paradiso* appearing again) is too brief to answer the question, though there have been some supplementary remarks in some footnotes earlier (especially in praise of Gibbs).

In fact, Truesdell's account is somewhat more distant from the original texts than he allows. For example, although indeed 'line integrals were not commonly familiar in the early years of the nineteenth century' (p. 20), nevertheless 'Carnot is thoroughly familiar with...

$$L(\mathcal{P}) = \int_{t_1}^{t_2} \omega(V(t), \theta(t)) \dot{V}(t)\, dt = \int_{\mathcal{P}} \omega(V, \theta)\, dV\text{'} \qquad \text{(p. 85).}$$

An important distancing arises from Truesdell's preference for derivatives over differentials (p. 8), the use of which is castigated (especially on pp. 21 and 140); one criticism, eventually stated on p. 207, does not apply to all the works discussed. In a rather tragicomical passage on pp. 50–51, Biot's difficulty in forming differentials of the same order is quoted, but another explanation is given in terms of a distinction between differences and gradients which does not have to apply in a differential model, where the infinitesimal difference $dv \div dx$ is also a gradient, understood as evaluated *at* the appropriate values of the variables v and x (Grattan-Guinness [**1975**]).

3. As a conscious policy (p. 5), Truesdell has looked at little other secondary literature—to the detriment of the show. The appraisals, mercifully only summary, of Fourier's analytical procedures and achievements (pp. 54–55, and 77) are at best unfair and show ignorance of what was actually done. Lamé and Clapeyron allegedly combined only on a joint paper on elastic solids (p. 142), whereas in fact their deep friendship was moulded by common political ideals and a decade of joint service in the 1820s in Russia (Bradley [**1979**]). Laplace does indeed have a strange model of physical phenomena in terms of binary intermolecular forces (pp. 32–33, *etc.*), but the reader will have to find his own way to Fox [**1974**] to grasp its historical significance. *Etc., etc.*

While these points raise doubts concerning Truesdell's familiarity with the history, they are only peripheral to his concerns. More serious doubts attend the very interesting Act II, where Carnot performs. Truesdell takes him to have in mind steam engines ('machines à vapeur'), but it seems more likely that he was concentrating on heat engines ('machines à feu'). His contemporaries so read him (Redondi [**1980**], Chapter 3), and Truesdell himself implies this view in the title of his previous book on this subject (Truesdell and Bharatha [**1977**]). Further, while indeed 'Experience with steam engines was central to the creation of thermodynamics' (p. 271), no *coro d'ingegneri* is brought on stage to demonstrate this truth. Instead, apparently 'Little of any consequence regarding this subject was then known', with Biot's 1816 *Traité* on physics, rather than an item from the engineering literature of the time, cited as evidence (p. 79). The reason for this choice is presumably provided by Snob's Law on p. 174: '"practical engineers" are the last persons in the world from whom to expect searching questions!'.

4. The great strength of the book lies in its formal analyses of the various theories, especially in the logical relationships (entailment, contradiction, independence, or whatever) which hold between principles and assumptions. While details of interpretation may come to be questioned (note Hutchinson [**1979**] on Truesdell and Bharatha [**1977**]), there is sure to be *much* of lasting value here. In particular, the account will help justify puzzlement which newcomers to thermodynamics often take away from exposure to the subject. The book would have been very suitable for Springer's *Graduate Texts in Mathematics* series, with exercises added and some reorganisation of material, to attain a form something like that of Edwards [**1977**], for example, in that series.

But here it is in Springer's history series, a 'real history' of thermodynamics (p. 3), in contrast to the contemptible pranks of 'Historians of Science'. However, historiography cannot be swamped by a mere shower of sneers. As a 'real history' this book falls short enough to be tragicomical in several unintended respects. *La commedia non è finita.*

References

M. Bradley [**1981**], *Franco-Russian engineering links: the careers of Lamé and Clapeyron, 1820–1830*, Ann. of Sci., **38**, 291–312.

H. Edwards [**1977**], *Fermat's last theorem* · · · , Springer, Berlin.

R. Fox [**1974**], *The rise and fall of Laplacian physics*, Historical Studies in the Physical Sciences, **4**, 81–136.

I. Grattan-Guinness [**1975**], *On Joseph Fourier: the man, the mathematician and the physicist*, Ann. of Sci., **32**, 503–524.

K. Hutchison [**1979**], Review of Truesdell and Bharatha [**1977**], Ann. of Sci., **36**, 660–663.

P. S. Laplace [**1803**] (Two notes), in C. L. Berthollet, *Essai de statique chimique*, vol. 1, Paris, pp. 245–247, pp. 522–523; also in *Oeuvres complètes*, vol. 14, pp. 329–332.

P. Redondi [**1980**], *L'accueil des idées de Sadi Carnot. De la legende à l'histoire*, Vrin, Paris.

C. Truesdell and S. Bharatha [**1977**], *The concepts and logic of classical thermodynamics as a theory of heat engines rigorously constructed upon the foundations laid by S. Carnot and F. Reech*, Springer, Berlin.

I. GRATTAN-GUINNESS