

Preface

Thermodynamics is the much abused slave of many masters • physicists who love the totally impractical Carnot process, • mechanical engineers who design power stations and refrigerators, • chemists who are successfully synthesizing ammonia and are puzzled by photosynthesis, • meteorologists who calculate cloud bases and predict föhn, boraccia and scirocco, • physico-chemists who vulcanize rubber and build fuel cells, • chemical engineers who rectify natural gas and distil fermented potato juice, • metallurgists who improve steels and harden surfaces, • nutrition counselors who recommend a proper intake of calories, • mechanics who adjust heat exchangers, • architects who construe – and often misconstrue – chimneys, • biologists who marvel at the height of trees, • air conditioning engineers who design saunas and the ventilation of air plane cabins, • rocket engineers who create supersonic flows, *et cetera*.

Not all of these professional groups need the full depth and breadth of thermodynamics. For some it is enough to consider a well-stirred tank, for others a stationary nozzle flow is essential, and yet others are well-served with the partial differential equation of heat conduction.

It is therefore natural that thermodynamics is prone to mutilation; different group-specific meta-thermodynamics' have emerged which serve the interest of the groups under most circumstances and leave out aspects that are not often needed in their fields. To stay with the metaphor of the abused slave we might say that in some fields his legs and an arm are cut off, because only one arm is needed; in other circumstances the brain of the slave has atrophied, because only his arms and legs are needed. Students love this reduction, because it enables them to avoid "nonessential" aspects of thermodynamics. But the practice is dangerous; it may backfire when a brain is needed.

In this book we attempt to exhibit the complete fundament of classical thermodynamics which consists of the equations of balance of mass, momentum and energy, and of constitutive equations which characterize the behavior of material bodies, mostly gases, vapors and liquids because, indeed, classical thermodynamics is often negligent of solids, – and so are we, although not entirely.

Many applications are treated in the book by specializing the basic equations; a brief look at the table of contents bears witness to that feature.

Modern thermodynamics is a lively field of research at extremely low and extremely high temperatures and for strongly rarefied gases and in nano-tubes, or nano-layers, where quantum effects occur. But such subjects are not treated in this book. Indeed, there is nothing here which is not at least 70 years old. We claim, however, that our presentation is systematic and we believe that classical thermodynamics should be taught as we present it. If it were, thermodynamics might shed the nimbus of a difficult subject which surrounds it among students.

Even classical thermodynamics is such a wide field that it cannot be fully described in all its ramifications in a relatively short book like this one. We had to

resign ourselves to that fact. And we have decided to omit all discussion of • empirical state functions, • temperature dependent specific heats of liquids and ideal gases, and • irreversible secondary effects in engines. Such phenomena affect the neat analytical structure of thermodynamic problems, and we have excluded them, although we know full well that they are close to the hearts and minds of engineers who may even, in fact, consider incalculable irreversibilities of technical processes as the essence of thermodynamics. We do not share that opinion.

In the second half of the 19th century and early in the 20th century thermodynamics was at the forefront of physics, and eminent physicists and chemists like Planck, Einstein and Haber were steeped in thermodynamics; actually the formula $E = m c^2$, which identifies energy as it were, is basically a contribution to thermodynamics. We have made an attempt to enliven the text by a great many mini-biographies and historical annotations which are somewhat relevant to the development of thermodynamics or, in other cases, they illustrate early misconceptions which may serve to highlight the difficult emergence of the basic concepts of the field. A prologue has been placed in front of the main chapters in order to avoid going into subjects which are by now so commonplace that they are taught in high schools.

Colleagues, co-workers, and students have contributed to this work, some significantly, others little, but all of them something:

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Ingo Müller & Wolfgang H. Müller