under the X-Y, P-V, and T-S curves. Each area corresponds to some kind of work.

There are an infinite number of integrating factors for d'Q. Each one would lead to an exact differential with a new X and Y. As an example, v^{k-1} where $k = c_p/c_v$ is an integrating factor for the case of an ideal gas. Thus

$$v^{k-1}\, d'Q = dY \qquad (20)$$

or

$$d'Q = v^{1-k}\, dY \qquad (21)$$

There is no special value attached to this XY combination. Further, 1/T has general application to all processes, although the present development has been restricted to ideal gases. There may be some useful integrating factors other than 1/T, but we shall not search for them.

WHAT DO WE HAVE?

WE HAVE FOUND a function, entropy, which is a property of the system. We shall be able to show that entropy plays a very useful role in thermodynamics. But that comes later. We now ask, what do we have? Usually when a physical quantity is defined, there is some material concept involved which appeals to our senses. In the case of the other generalized displacements in Table 1, it is simple to visualize distance, area, and volume. The concept of electric charge is not difficult to imagine. In the case of magnetic quantities, we have to use a little more imagination. The generalized forces can be understood in terms of measuring instruments. Everyone thinks of a mercury column in glass as signifying temperature. A dial on a voltmeter gives a direct reading of voltage.

If we went deeply into measurement in a sophisticated manner, we would find the simple concepts must be examined with much more care. We would discover temperature is difficult to define precisely. In the end, we would be asking how can we measure the variables and how can we assure reproducibility and comparative accuracy.

Entropy suffers in comparison with other physical quantities, because we have no *entropometer* from which we can read values of entropy. However, if we can show how to measure entropy, that should enable us to form an intellectual if not a physical notion of what it is.

Returning to the equation for an ideal gas, we have on a unit mass basis

$$ds = d'q/T = C_v \frac{dT}{T} + R\,\frac{dv}{V} \qquad (22)$$

This equation can be integrated to give

$$s = C_v \ln T + R \ln v + s_o \qquad (23)$$

or

$$\Delta s = C_v \ln T/T_o + R \ln v/v_o \qquad (24)$$

These equations tell us how to measure s or Δs for an ideal gas. However, we must make measurements of T and v and then *calculate* s. We could develop an instrument which would translate (24) into something which could be visibly seen. Such an instrument would not be very useful.

We must be satisfied with a mathematical and intellectural rather than a familiar physical concept of entropy. □

ChE book reviews

INTRODUCTION TO PROCESS ECONOMICS

F. A. Holland, F. A. Watson and J. K. Wilkinson, John Wiley & Sons, 290 pages.

Reviewed by James H. Black, University of Alabama, University, Alabama

This book is intended as an undergraduate text for the process engineering disciplines, such as chemical, metallurgical, and mineral engineering. It would also give an excellent introduction to process economics for the practicing engineer or serve him as an excellent reference book. It is, as the title states, a book covering process economics; but some wider aspects, such as some of the management sciences, are also presented.

The organization of the book is excellent. It is divided, logically, into two parts: the elements of profitability assessment and the elements of decision making. Thus, the reader first gets a complete treatment of time value of money calculations, followed by chapters on profitability estimates, uncertainties in profitability estimates, capital cost estimates, and manufacturing cost estimates. The second part of the book covers such decision making tools and techniques as statistical analysis, curve fitting and trend analysis, linear programming, financial and cost accounting, price and cost trends, value engineering, marketing, and some material on risk and insurance.

This is a good book, well worth the cost. It would be of particular interest and value to those who found use in the recent series of articles on engineering economics, by the same authors, in *Chemical Engineering* magazine.