85

capture on film. In this we recognize the traditional artistic selectivity exercised in an unorthodox medium.

To the entomologist, Mr. Scharf's insect-scapes may be familiar, factual portraits. But the uninitiated, delving like Alice into an unexpected Wonderland, may actually experience visceral horror at the sight of the monstrous hairiness of a jumping spider or feathery midge. The inverted perspective of a gladiola petal seen as a surrealistic sea of breasts or the growth steps on salt crystals compose a vivid essay on natural symmetry and the relativity of size.

Many scientists who use the SEM in their research often allow aesthetic principles to influence their search for meaning. And meaning — in science — is usually found in regularities, patterns, symmetries — the repetitive and reproducible motifs which appeal to the mind's eye.

Indeed, most of us who probe with an SEM to photographically encapsulate microstructural information will have trouble switching mental gears to view Mr. Scharf's work as art. It is difficult to evaluate this photographic essay by established standards — of either art or technology — simply because it purports to chart new territory in no man's land.

Perhaps the greatest value of this collection of microphotographs is its ability to arouse our sense of wonder and quench our thirst for symmetries. This is an area where art and science often interface and intersect. Mathematicians such as Hermann Weyl have analyzed with the tools of Group Theory the symmetry patterns in nature, amplified and reproduced in human culture: in architecture, art, and music. Artists such as M. C. Escher have intuited and almost exhausted all the possible color group symmetries which had mathematical and physical reality, but not always artistic power. Physicists like Eugene Wigner in his essays on "Symmetries and Reflections" have delved into the hidden power of symmetry principles, which engender conserved or invariant quantities in the physical world. The SEM may also blur the often artificial boundaries between science, technology, and art, by revealing the beauty of form and structure in the microscopic world and beyond.

Aviva Brecher teaches physics at Wellesley College and is a Visiting Scientist in the Laboratory for Paleomagnetism of M.I.T.'s Department of Earth and Planetary Sciences. She occasionally uses the scanning electron microscope in her research to reveal the magnetic structure of ancient meteorites and moon rocks. ☐

Meanings of Energy

Energy: Historical Development of the Concept
R. Bruce Lindsay, ed.
Stroudsburg, Penn.: Dowden, Hutchinson, & Ross, Inc., 1975, xiii + 369 pp.; no price

Reviewed by Elias P. Gyftopoulos

This volume is the first of a series of benchmark papers on energy. The book is intended "to trace the development of the concept from early times to the middle of the nineteenth century, when the concept had arrived essentially to its modern meaning . . ."

The editor begins by summarizing the significance of the field being covered. Important papers are translated or reproduced from some original source, and groups of papers are introduced by editorial comments that place the material in the proper context and perspective. The editor himself translated many of the articles. The volume includes 39 complete papers or excerpts from the works of Aristotle, Plato, Hero, DaVinci, Galileo, Newton, Leibniz, the Bernoullis, Carnot, Gassendi, Lavoisier, Hamilton, Mayer, Joule and other distinguished thinkers who contributed to the development of the concept of energy. They are an excellent collection of seminal ideas from which "the concept that has unified our understanding of experience" originated. And they compose a complete and representative series of the concept's history.

The editor has scrutinized and correlated these papers into a unified whole by using the criterion of "constancy in the midst of change," which he regards as the key idea that characterizes both the practical and the philosophical meanings of energy.

But "constancy in the midst of change" provides neither an explanation of the popular usage of the word energy nor a scientific definition of the concept of energy.

Constancy or Degradation?

The popular usage of the word energy refers to something that makes electric lights work, automobiles run, and factories produce consumer goods — that is, to the capacity of certain material bodies to perform useful tasks. This usage represents what scientists and engineers call availability, available energy, or available work — a concept related to both energy and another inherent property of matter called entropy. But availability can be easily lost: for example, when energy is transferred from one material to another (as in a heat transfer from hot gases to cold gases), or while matter changes from one condition to another (as in the change of a cold fuel-air mixture to hot products of combustion). In other words, availability is lost when the transfer of energy or change of condition involves irreversibility. Nevertheless, availability is an attribute of matter which provides us with the capability to do productive work. And to secure this capability we consume a relatively large fraction of our income both at home and abroad.

So, the popular usage of the word "energy" does not satisfy the criterion of "constancy in the midst of change" but rather that of degradation in the midst of our efforts to capture energy's usefulness.

On the other hand, the thermodynamic definition of energy differs from the popular meaning of the word: it is more general than the definition given in mechanics and it cannot be derived from the principle of invariance in the presence of change. The magnitude of this energy differs from that of the corresponding availability, the difference being determined by the value of the entropy.

A Critical Distinction

The editor introduced his criterion in response to the question: "Must you pursue a whole course of university physics with its awful array of mathematical symbolism in order to understand what energy means, how it is measured, and the reason for its overwhelmingly important role in human life?" Many teachers have shared Professor Lindsay's concern for a simple way to explain "energy," yet none have found a definition as inclusive and encompassing as that offered by the first law of thermodynamics. In essence, this law holds that "energy is a property of matter (a state function) which can be measured by doing work on that matter (by connecting that matter to weights that are lowered or raised between two fixed levels in a gravity field)." No doubt, this is a complicated definition, but without an understanding of the terms matter, system, state, property, and work the scientific meaning of energy cannot be expressed. These prerequisites are somewhat analogous to the prerequisites of other familiar terms (for example, instantaneous velocity or acceleration) for which a scientific definition cannot be given until other concepts, such as space, position, time, and derivative are understood. Although common-sense examples can explain availability, no obvious, intuitive, or everyday-life explanation exists for energy itself.

Because its operational definition involves work, energy is often misinterpreted as the capacity of matter to perform useful tasks. This interpretation can be easily dismissed, if we consider as an example the air around us. It has lots of energy and yet has no ability to heat our homes or feed our growth. More fundamentally, any amount of energy can be transferred to matter by doing work on it, but the availability of this energy depends on how the final condition or state of the matter in question is reached. If the final state is reached without irreversibility, the capacity to perform useful tasks — the adiabatic availability — will be equal to the energy transferred. However, if the final state is reached with irreversibility, this capacity will be smaller than the energy transferred, and may even be equal to zero.

Whereas the definition of energy as a state function that can be measured by work does imply "constancy in the midst of change," the idea of constancy or conservation neither defines nor implies the existence of energy as a property of matter. Money in a safe is conserved and yet is not energy. As extensively discussed in several papers in the book, momentum is conserved and yet is not energy. The work involved in the measurement of energy need not be related to a change of a quantity that is conserved and is a property of matter. In other words, the definition of energy is the essence of the first law and, to date, no one has been able to derive this law from other principles of physical science, including all the invariances resulting from the symmetry transformations of mechanics. The reason, of course, is that other principles cannot cope with entropy as a property of matter whereas the first law can.

The distinction between availability and energy — its scientific and philosophical implications aside — is of paramount importance to our concerns about exhaustible fuel resources. Several studies have disclosed that the U.S. economy uses only 8 per cent of the availability of all the fuels that it consumes. By making better use of availability, namely by increasing the efficiency of end-uses of fuels in our economy, we will be able to perform many more useful tasks in our society without diminishing the amount of energy that we can afford to buy.

The book is thorough and thought-provoking. But readers should be forewarned not to expect an elaborate explanation of either the popular usage of the word energy or the contemporary scientific definition of the term.

Elias P. Gyftopoulos is Ford Professor of Engineering at M.I.T. □

A Key to the Corporate Washroom

The Managerial Woman
Margaret Hennig, Anne Jardim
New York, N.Y.: Doubleday and Co., 1977, xvii + 221 pp.; $7.95

Reviewed by Melissa M. Weiksnar

There's a kind of survivor guilt we northeasterners feel living in Texas — we refugees, so branded each time we say "y'all" with a Boston accent. I'm a member of one of those 5,000 households who move to Houston each month. To state my motive in its crudest sense: I came here to make money.

First, there's the culture shock and compromise. If you live out by N.A.S.A. and work 20 miles yonder in one of Houston's three downtown districts, you've got to be on the freeway by 6 a.m. to avoid traffic jams (one year ago, it was 6:15). You watch all the cowboys in their pickup trucks, and come to crave the morning report from Port City Stockyards. You're condemned a heretic if you dislike beef. Your favorite yogurt is made in Miami; even if you find the brand in Houston, there's no prune whip. The *New York Times* takes three days to get here, but by then history is repeating itself anyway.

I work for a major oil company, developing and maintaining computer programs for our international production engineers. I'm the liberal, East-Coast-establishment, freeze-in-the-dark, renegade-Yankee, M.I.T.-women's libber.

One day at the office, I pulled my *Times Book Review* from its plain brown wrapper and noticed an ad for *The Managerial Woman*. Pining for intellectual stimulation, I bought it. I skimmed Chapter Four: the authors' Oedipal theory appears as if only to prove that someone passed Psych 100 at Wellesley. And remembering that the authors deal only with the milieu of middle management, I extrapolated carefully. I haven't been able to keep a straight face in the conference room since.

The book's appearance coincided with a series of irksome meetings I'd been attending. It bothered me to encounter international corporate managers who didn't even appear competent, and I needed an explanation. I'd heard "good old boys" rumors. And I suspected from the way these men talk to one another that a certain bond comes only with the mud, sweat, and years they've invested in boring the earth for petroleum.

Mss. Hennig and Jardim tell me that the big boys work like the little boys play. Even if everybody hates Sonny, it takes 11 kids to make a team. Years later, off in the sands of Libya, Sonny becomes your 11th-hour teammate and drinking buddy — just as you tolerated him as a brat on your football squad. Another hangnail: maybe Simon is simply your friend; he doesn't make you win, but at least he doesn't make you lose. Because he's your friend, you always find a place for him on your team.

Now for us girls (sic). Our childhood play tends to be intimate, so likes and dislikes can dominate in the absence of a higher goal: "You don't like my doll's hair color so you're not my friend any more." This play trait emerges as personal pettiness in big girls, and supposedly dooms us in big business.

The Managerial Woman alerts us that a young man entering business doesn't study the personalities of those around him, but rather the personal ties: is this environment supportive? He sees his work as a step in a career, and will transcend personal likes and dislikes. He is much more concerned about the buoyancy surrounding him than his ability to sail with technical competence: the result of team sports, we're told. Further, little boys expect from an early age that "someday" they will have to earn a living. Little girls, even now, still perceive a scapegoat: they figure, for better or for worse, they can always find a male to support them.

We're told that the women who enter business are too uptight about their personal qualifications. But how else do we make an impact? After all, males are naturally accepted in business: they essentially have to prove they can fail before being thrown overboard. Females must prove success to come on board in the first place. But, alas, it's not our credentials but our risk-taking that will help us succeed. And again, we're victims of breeding. Risk for little boys means adventure and excitement; risk for little girls means you'll get your dress dirty, or you'll fall and hurt yourself. Therefore, the authors feel, women have been taught to view risk as a potential for loss, not a possibility for gain.

Further coupled with risk-aversion is a