

BOOK REVIEWS

Feature Reviews

M. Norton Wise (Editor). *The Values of Precision*. viii + 372 pp., illus., index. Princeton, N.J.: Princeton University Press, 1995. \$49.50, £35.

When did nature acquire sharp edges? Fastidious experimenter though he was, Robert Hooke was not persuaded of the utility of precision measurement, “for we find that Nature it self does not so exactly determine its operations, but allows a Latitude almost to all its Workings, though as I said before, it seems to be restrained within certain Limits” (“A General Scheme of the Present State of Natural Philosophy, and How Its Defects May Be Remedied by a Methodical Proceeding in Making Experiments and Collecting Observations,” in *The Posthumous Works of Robert Hooke* [1705], ed. Richard Waller [Johnson, 1969], p. 38). In her essay on Old Regime demography in the volume under review, Andrea Rusnock reports that mid-eighteenth-century French debates over depopulation were still largely couched in qualitative terms (p. 25). But, as Jan Golinski notes in his essay on late eighteenth-century chemical measurements, by the 1780s Antoine Lavoisier was reporting weights to the nicety of, for example, 0.13133727 pounds of inflammable air (p. 78). This volume of essays, originally delivered as papers to the Princeton Workshop in the History of Science in 1991/1992, addresses the questions of when, why, and how it began to make sense to scientists, bureaucrats, merchants, and manufacturers to strive for ever more decimal places, ever more exact and exacting measurements, in the conviction that the mills of nature “grind exceeding small.”

The thirteen essays (ten topical pieces, plus three synthetic chapters by the editor) span the period from the mid-eighteenth to the late nineteenth century, crisscross the Rhine, the Channel, and the Atlantic between France, Germany, Britain, and the United States, and range over the disciplines of demography, astronomy, physiology, chemistry, physics, and mathematics, as

well as over state, industrial, and commercial involvement in measurement and calculation. The essays are arranged in roughly chronological order, grouped under three headings that also suggest a thematic periodization: “Enlightenment Origins,” “Industrial Cultures,” and “Mass Distribution.” For almost all of the authors, precision, even within the most circumscribed scientific or industrial context, is more than a technical achievement—although it is certainly that, and the techniques are here presented in considerable detail. Precision is further depicted in these pages as both a reflection of a culture that would invest sizable resources of time, money, and labor to extend decimal places and shrink error bars, and also as a culture in its own right, one that endows its hard-won numbers with meanings and values. Hence the volume’s punning title, which plays on both senses of *values*. Taken singly, each of the essays is of unusually high quality; taken together, they are the best introduction available in English to the diverse practices, applications, and morals of precision.

But these tales of how the sharp edges of nature were honed in the censuses and standards of French administrators, in the laboratories of chemists, physicists, and physiologists, and in the tables of actuaries and human computers are oddly blurry about the motivations and functions of precision. Having admirably refused to accept either the inevitability or the desirability of precision in science, commerce, and government, the authors offer no consistent alternative answer to its whys and wherefores. As M. Norton Wise points out, “precision is expensive” (p. 225). Other authors in this volume add that it is also controversial—witness the skeptical British reception of Lavoisier’s eight-decimal-place weights documented by Golinski; and trouble-

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some—Simon Schaffer's account of James Clerk Maxwell's nerve-racking attempts to establish the ratio between electrostatic and electromagnetic units is enough to trigger a vicarious migraine; and even reversible—Frederic L. Holmes and Kathryn M. Olesko show that Hermann von Helmholtz retreated from his earlier, more precise measurements of the transmission speed of nervous impulses to more easily communicated graphic methods. Given these inconveniences, why did precision nonetheless advance with the hurtling momentum of the gleaming black locomotive so wonderfully featured on the book's cover?

A number of possible answers parade through the essays. The first might be called bureaucratic determinism (the dust jacket locomotive bears the name "ETAT"): precision originates in the needs and aspirations of the modern, centralized state. It is no accident (so runs the story) that the first attempts at precise quantification of the population, of weights and measures, of chemical components, and of much else began in late eighteenth-century France. Rationalizing administrators (recall that Lavoisier was a tax farmer as well as a savant) required a network of exact information and uniform standards in order to "organize, plan, defend, and tax with efficiency" (p. 93). There are several objections to this thesis to be found in the essays themselves. As Ken Alder shows in his witty essay on the French metric system, the vaunted precision of *mètres*, *litres*, and *décades* was in no way correlated with efficiency in either government or commerce—*au contraire*. Similarly, Olesko notes that the precise measures commissioned in 1816 by the Prussian government from the Berlin Akademie der Wissenschaften had negligible influence on trade (p. 122). As in the French case, the German scientists pushed for more precise determinations of weights and measures than their respective governments either needed or wanted. Theodore M. Porter, writing about the resistance of Victorian actuaries to government surveillance, shrewdly observes that it is only the weak and defensive bureaucrat who takes refuge in precision. Secure elites, presumably including Old Regime administrators, prefer the exercise of judgment and discretion to tiresome computations and enumerations. As Porter remarks of the highly numerate but fiercely antiprecision actuaries, "There's no need for precision if you have a profession" (p. 191)—or simply prestige, to continue the alliteration.

A second and related answer to the why and wherefore of precision is standardization: networks of markets, industry, legislation, and lab-

oratories require precision in order to coordinate, calibrate, and translate their ever more far-flung activities. On this account, precision is the offspring of globalization. The principal difficulty here is portability: on the testimony of most of the essays, precision travels badly. Far from disseminating uniformity, it tends to multiply variability. Joseph Priestley objected to Lavoisier's refined measurements "because such methods curtailed the possibilities for replicated experiments" (p. 82). Lord Rayleigh, whom Schaffer describes as "the guru of late Victorian precision measurement," surveyed "the highly various endeavours of Weber, Kohlrausch, Thomson, Maxwell, and Rowland" to determine the absolute resistance unit (p. 164). George Sweetnam quotes a British authority on the "notoriously temperamental" ruling engines that marked precision gratings (p. 297). As Schaffer remarks, "robust systems"—the kind that move easily from place to place—"may well demand imprecision" (p. 137). The authority of precision—represented by the platinum meter stick in Paris (p. 39), or the imprimatur of *Hofrath* Carl Friedrich Gauss on measurements of the Hanoverian *Landesnormalgewicht* (p. 120), or the "sub department of standards" established by Henry Rowland at Johns Hopkins University (p. 289)—may radiate outward from center to periphery, but authority alone cannot solve the myriad practical problems of transporting the finicky apparatus and delicate skills needed to standardize precision.

To focus on the authority rather than the function of precision does, however, reorient the perspective from which to explore the allure of sharp edges. These essays trace, at least implicitly, how the sources of that authority shift from the time of the French Revolution to the turn of the twentieth century. Proponents of the extravagantly expensive meridian measurement and cadastre tables that were supposed to underpin the French metric system anchored the new conventions in the universal and disinterested authority of nature (p. 49); Lavoisier claimed that his precision measurements partook of mathematical certainty (p. 81); Prussian officials bent on reforming weights and measures understood justice to be at stake (p. 115). Universal nature, mathematical certainty, justice—here precision draws its force from the abstract ideals it allegedly serves. By the 1830s, however, the warrant for precision had become the moral fiber of the individual making the measurement or computation. Olesko identifies Friedrich Wilhelm Bessel's personal integrity as the guarantee of the Prussian foot (p. 125); Porter's actuaries talk

endlessly of judgment and caution (p. 184); Graeme J. N. Gooday vividly portrays the indignation of British physicists who condemned the ammeter and voltmeter as threats to the moral responsibility and self-sufficiency of the measurer (pp. 265, 271). Andrew Warwick records similarly outraged responses among some makers of mathematical tables to the introduction of calculating machines like the arithmometer, which allegedly diluted the self-discipline and self-reliance of the human calculator (p. 330). At some point circa 1900, the prepackaged precision of the ammeter, the voltmeter, and the arithmometer carried the day (Wise emphasizes the key role of commercial instrument makers [pp. 353–355]), and reliability and uniformity became the indexes (as opposed to the inverse correlates) of precision. But the transition was evidently not a smooth one, and several of these essays document the intensity of the struggle to preserve a distinctive morality as the substance and symbol of the authority of precision.

At the heart of the morality of precision was hard work. Schaffer contends that “the immense labor required to set up such unalterable standards was always accompanied by a deliberate effort to efface this labor” (p. 136), and his essay is a remarkably detailed and poignant reconstruction of the sweat and tears poured into a measurement that precision only rendered more elusive. But many of the acolytes of precision quoted in the pages of this volume seem not only candid about but proud of their “infinite pains” (p. 243) and “courage to face the labour” of vast calculations (p. 318). A forked, Weberian logic

seems to underlie the tension between the “data,” which, like divine grace, can only be freely “given,” and precision measurement and calculation, which constitute the scientific equivalent of a doctrine of works. Labor contaminates the one but validates the other.

The labor of precision must be seen as first and foremost labor for its own sake. One of the most important contributions of these essays is to lay to rest some of the platitudes about the function of precision, which could not be relied upon to settle controversies, test theoretical predictions, or diffuse uniform standards. The cult of precision was at least as much a matter of symbolism as of function, particularly the symbolism of meticulous, disciplined work. Whose work? Schaffer remarks on Maxwell’s difficulties in bridging the social gap between student experimenters and hired workmen at the Cavendish (p. 155); Sweetnam quotes A. A. Michelson’s advertisement for an assistant “handy with his fingers and a good observer—who will do just what he is told—and is not too ambitious” (p. 296); Warwick mentions in passing that the computation of tables of frequency distribution curves was done by “five women using a Brunsviga calculator” (p. 326). The identity of the laborer underwrites the value of the labor. Before precision could be entrusted to machines, it must first have become the work of rude mechanicals. Behind the history of laborious precision lies a barely begun history of the scientific laborer, and of the moral authority that grounds and emanates from nice work.

LORRAINE DASTON

Theodore M. Porter. *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life.* xiv + 310 pp., bibl., index. Princeton, N.J.: Princeton University Press, 1995. \$24.95, £19.95.

“The demonstrated conclusions touching the things of heaven,” wrote Galileo defensively, “cannot be changed with the same facility as opinions about what is legal or not.”

In the following centuries, one of the most persistent ambitions of Western society has been to make the conclusions touching the “things” of society, law, and politics appear as compelling and impervious to the fluctuations of mere opinions as conclusions touching the operation of heaven and earth. The faith that natural scientists

are bound by the “plain” language of numbers to speak with authority that cannot be corrupted by fragile human judgment was gradually extended to the fields of engineering and the social sciences. The notion that experts who are disciplined by respect for objective facts are a symbol of integrity and can, therefore, serve as guardians of public virtues against the villains of politics and business was widely interpreted to include, beyond natural scientists, other categories of experts who speak the language of numbers. It is