Introduction

The National Bureau of Standards was established by Congress on March 3, 1901, with a charge to take custody of the standards of physical measurement in the United States and to solve "problems which arise in connection with standards." Although minor (and transient) variations occurred in the name of the institution, it was known for most of the century as NBS until Congress mandated a major name change, accompanied by new responsibilities, in 1988. Thus the "Bureau" completed its first century as the National Institute of Standards and Technology, or NIST. This volume commemorates the centennial by presenting brief accounts of selected classic publications of NBS/NIST which illustrate at the same time the rich history of its scientific and technical accomplishments and the broad scope of its contributions to the Nation.

If asked to select one word that best describes the work of the institution, most people familiar with NBS/NIST would choose "measurement." Indeed, the theme of precise, accurate measurements runs through the first century's history. Seventeen years before the founding of NBS, Lord Kelvin wrote [1],

> "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science."

His statement captures very elegantly the philosophy and culture of NBS/NIST. The measurement methodology described in this volume runs the gamut from cutting-edge research in atomic physics to new ways of measuring the heat released in building fires; from measuring the response of the human eye to different colors to selecting the best sets of data for improving rocket engine performance; and from automating manufacturing processes to advising consumers on how to buy tires for their cars. These publications illustrate the support NBS/NIST has given to U.S. industry and to other Federal agencies in solving specific measurement problems, as well as the impact of Bureau work on the scientific community at large and on the general public.

With so many diverse audiences to serve, communication of the results of its work has been a major concern since the founding of NBS. In a remarkably prescient article published in *Science* in 1905, Edward B. Rosa, one of the 11 initial NBS staff members (the only one with the title of "Physicist") outlined his vision of the future of the Bureau [2]. In addition to its mission to maintain the standards of measure of the United States and to advance the art of precise measurements, he added a third mandate, "To distribute information regarding instruments and standards to manufacturers, state and city sealers of weights and measures, scientific and technical laboratories, and to any and every one applying for such information"—a daunting challenge which the Bureau has taken very seriously. Rosa went on to stress the interdependence of the three functions and to explain that the distribution of information would be "accomplished through correspondence and the circulars and bulletins issued by the bureau," thereby setting the stage for the broad publication program illustrated in this book.

There are, of course, other mechanisms by which the Bureau has disseminated its information. Staff members have described their work through lectures at academic and industrial establishments and to foreign audiences. Participation in national and international standards committees has been a very significant transfer mechanism. Thousands of guest workers from industry, academia, and other national laboratories have spent time working in Bureau laboratories, taking new technology and new ideas back to their home institutions (as envisioned by Rosa in his 1905 article). Unique facilities—the research reactor, synchrotron radiation source, and automated manufacturing research facility, to name only a few—have drawn scientists and engineers to NBS/NIST where they could carry out measurements that would be difficult or impossible elsewhere. Nevertheless, formal publications have arguably been the most influential single mechanism for the institution to reach its diverse audience over the century. It is the intention of this book to give the flavor of those publications.

The book consists of short accounts describing 102 representative publications that had a significant impact during NBS/NIST's first century. These 102 were chosen, out of tens of thousands that have appeared in print, to illustrate the range of activities covered by the publication program. Many others are equally deserving of mention and, in fact, some of these are listed in the bibliographies accompanying each account. The final selection was made by a committee of representatives of the major units in the current NIST organizational structure plus the Standards Alumni Association, which looked especially at candidate publications from the early days of NBS. This committee considered over 400 nominations from NIST staff and alumni in arriving at the final 102. An effort was made to cover the most significant NIST/NBS programs, including those in which formal publications are not the dominant communication mechanism.

The selected publications are arranged in the book by time periods. Those from the first half of the century are grouped into two periods, 1901-1930 and 1931-1950. The publications from the second half are listed by decade. Within each decade certain papers on related topics have been grouped together. An index of subjects and individuals appears at the end.

Certain important works were not considered for this book, even though they had significant input from staff members, because they were not, strictly speaking, NBS/NIST publications. Among these is the *International Critical Tables* [3], a seven-volume series prepared in the 1920s whose contributors included hundreds of scientists from all parts of the world, in addition to many NBS staff members. The Editor-in-Chief was E. W. Washburn, Chief of the NBS Chemistry Division, and the Editorial Board included G. K. Burgess, Director of NBS. The preface, written on behalf of the National Research Council (the official publisher), gives special acknowledgment to NBS for its leadership. The *International Critical Tables* was the definitive source for accurate data for the next 30 to 40 years, used at every level of science and technology, from undergraduate teaching to engineering design. It remained in print until about 1980, and it is still found (and still used as a reference) in every major library of the physical and engineering sciences. Also in this category are countless standards documents in which NBS/NIST staff played a major role but which were published by ASTM, ANSI, ASHRAE, and other national standards organizations as well as by international groups such as ISO, CODATA, IUPAC, and the various committees of the International Bureau of Weights and Measures (BIPM). Such documents tend to be anonymous in the sense of bibliographic citations, but Bureau representatives are frequently among the prime movers in the committees that prepare them. As a particular example, NBS/NIST has made strong input to the Consultative Committee on Units (CCU), the group responsible for promulgation of the International System of Units (SI), the "modern metric system" [4]. Special mention should also be given to the Fundamental Physical Constants, a continuing project in which Barry N. Taylor and other NIST physicists have played the dominant role over the last quarter of the century. Their set of *CODATA Recommended Values of the Fundamental Physical Constants* [5] has been universally adopted for worldwide use.

For those interested in the full history of NIST, several publications are available. The 1905 paper by Rosa [2], which summarizes the work during the first few years, has already been mentioned. Three official histories have been written. *Measures for Progress,* by Rexmond Cochrane, covers the first 50 years [6]. Elio Passaglia's *A Unique Institution* follows with coverage of the 1950-1969 period [7]. James Schooley rounded out the history of the first century with *Responding to National Needs: The National Bureau of Standards Becomes the National Institute of Standards and Technology (1969-1993)* [8]. These books give extensive administrative, financial, and personnel details, as well as summaries of the technical work during each period.

The contributions of NBS during the two world wars, which could not be published at the time the work was done, is very well documented in two reports which make fascinating reading. The book *War Work of the Bureau of Standards* [9] describes about 200 projects undertaken during World War I; these range from studies of shoe leather and metal for military identification tags to utilization of the Bureau's expertise in spectroscopy to improve methods of aerial photography. Bureau metallurgists were particularly active in helping the military develop specifications and testing methods for items ranging from armor plate and steel helmets to horseshoe nails. The story for the second world war is given in *NBS War Research. The National Bureau of Standards in World War II* [10], edited by former Director Lyman J. Briggs. While the best known NBS contribution was the proximity fuze (described in more detail in one of the accounts in this book), almost every part of the organization became involved in war work of some kind. Director Briggs was appointed by President Roosevelt in 1939 as chairman of the first committee to investigate the feasibility of building an atomic bomb; ultimately, about 60 NBS staff members worked on the bomb project. NBS made a major contribution in developing methods to purify uranium and graphite, which was used as a moderator in the reactors that produced plutonium, and the first experiments on separating uranium isotopes by thermal diffusion were done in a Bureau laboratory.

The publications described in this book appeared in a variety of media, which is characteristic of NBS/NIST publications as a whole. Many appeared in scholarly journals of scientific and engineering societies; a few came out as books through commercial publishers. The rest appeared in one or another of the Bureau's own publication series. It may be useful to describe these briefly. The *Journal of Research of the National Institute of Standards and Technology,* which traces its origin to 1928, publishes research papers by staff members in all fields covered by NIST. Larger works of long term-interest have appeared in the *Monograph* and *Handbook* series, and the *Special Publication* series is available for works that do not conveniently fit into other categories. Interim or transient reports appear as *Technical Notes* or *NISTIRs* (where "I" can mean either Internal or Interagency). Some NIST programs have their own series, e.g., the *Building Science Series,* the *National Standard Reference Data Series* (NSRDS-NBS), the *Applied Mathematics Series* (AMS), and the *Federal Information Processing Standards* (FIPS). The Bureau has also joined outside organizations in certain publication series, for example, the *Journal of Physical and Chemical Reference Data,* started in 1972 as a joint endeavor of NBS, the American Institute of Physics, and the American Chemical Society. This journal has published almost 600 critically evaluated data compilations, submitted both by NIST scientists and outside authors, as well as 21 supplementary hard-cover monographs.

The classic documents described in this book are traditional publications on paper. The last decade of NBS/NIST's first century saw the start of a major revolution in communications with the emergence of electronic publishing. NIST scientists are already making heavy use of this medium, and the bibliographies in this book show many references to Internet sites. A number of NIST Laboratories and Programs have established World Wide Web sites which receive heavy use by the scientific community. This form of publication is developing too fast to give a comprehensive list of sites, but the following examples convey the flavor of NIST's current efforts:

- Physical Reference Data <http://physics.nist.gov/PhysRefData/>—fundamental constants, atomic and molecular spectra, x-ray attenuation, and radiation dosimetry data.
- Chemistry WebBook <http://webbook.nist.gov>—evaluated data on thermal properties and spectra of thousands of chemical compounds, including the heavily used NIST/EPA/NIH Mass Spectral Library.
- Digital Library of Mathematical Functions <http://dlmf.nist.gov>—under development as a modern version of the 1964 classic *Handbook of Mathematical Functions.*
- Fire Research Information Services < http://fris.nist.gov>—provides access to fire test data, publications, and fire modeling programs.
- MSEL Data on the Web <http://www.msel.nist.gov/dataontheweb.html>—mechanical, thermal, and chemical properties of ceramics, metals, and polymers.
- Protein Data Bank <http://nist.rcsb.org/pdb>—3-D crystal structure of proteins.

These and other NIST web sites are already accessed thousands of times each day, and use of the sites is growing rapidly. As it enters its second century, we can expect the National Institute of Standards and Technology to take full advantage of the new opportunities for disseminating the results of its work.

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