

THE CRUCIAL DECADE— AN ENVOI

AN AD HOC COMMITTEE REPORTS

In April 1953, in the midst of the impasse raised by the controversy over AD-X2, Secretary of Commerce Weeks asked the National Academy of Sciences to convene an ad hoc committee to evaluate the functions and operations of the National Bureau of Standards in relation to the current national needs. At stake was not only the reputation but the purpose and direction of the Bureau. It was recognized that they were threatened not so much by the controversy over AD-X2 as by the impact on Bureau research of the Korean war.

As in the two World Wars, the staff, facilities, and programs of the Bureau were mobilized for the new conflict across the Pacific. A year after that war began, prolonged negotiations for its end commenced. As in the case of industry, commerce, and science, the Bureau was on a war footing beyond its control. In March 1953, anticipating Secretary Weeks' own request by almost a month, the Director of the Bureau had written him to seek the counsel of the National Academy of Sciences on the current program and operations of the Bureau.

The ad hoc committee appointed by the Academy submitted its initial findings in late July and its formal report on October 15. Under the direction of Dr. Marvin J. Kelly, director of the Bell Telephone Laboratories and a member of the Visiting Committee, the 10 members of the committee thoroughly explored the place of the Bureau in the Federal structure, its organization, programs, technical operations, administration, and funds and financing.

There was no question, the 109-page report declared, of the vital importance of the Bureau to the Nation or of the quality of its professional staff. The heart of the report dealt with certain of the Bureau programs. The years following World War II witnessed an unprecedented growth in the science and technology of the Nation, and the Bureau's basic research programs expanded in aid of them until 1950. Then basic research began to lose ground "at a tragic rate," as the Committee expressed it, to the weaponry

development work proffered through transferred funds by the Department of Defense and the Atomic Energy Commission.

The principal recommendation of the ad hoc committee called for the transfer of these weapons programs to the Department of Defense. Except in wartime, such work did not belong in the Bureau. On the other hand, its nonweaponry research, testing and calibration, and evaluation projects for the Department of Defense and the Atomic Energy Commission should continue, as valuable to the basic programs of the Bureau.¹ To redress the imbalance that had occurred, the committee recommended greatly increased direct appropriations for the basic programs of the Bureau and for such fundamental research as the determination of physical constants, properties of materials, standards and standard practices, and testing and evaluation procedures. The committee further recommended that the Bureau decrease many of its remaining repetitive test operations as costly in time, effort, and funds. And it urged the Bureau to seek greater use by other agencies of the Government of its scientific and technical facilities.

The imbalance in the basic programs of the Bureau occasioned by the military demands of the Korean war could be reversed, said the committee, and, with adequate appropriations, the staff and research level of 1950 achieved again within 2 years. Within 4 years "the Bureau should be in a position to perform its authorized functions in balance at the minimum level for the nation's needs."²

The Nation was confronted with a permanent industrial revolution, a continuing technological revolution. The objective of the committee study and its recommendations was to restore to the Bureau its "essential services for our industrial society." For the translation of new scientific knowledge into industrial products, the Bureau must maintain balanced programs in those areas of science and technology requiring new measurements and standards. To that end the committee urged that advisory groups from the scientific and technical societies represented on the ad hoc committee be formed to aid the Director in achieving balance in the current program and in instituting new programs.³

¹ Ad Hoc Committee, NAS, "A Report to the Secretary of Commerce," Oct. 15, 1953, pp. 19-20 (NBS Historical File); NBS Annual Report 1953-54, preface and p. 10.

Only recently had it become true, as the committee said (p. 12), that "the work of the Bureau for the Atomic Energy Commission, which has a dollar value of almost \$2,900,000 in 1953, is not of a weapons development nature."

² *Ibid.*, pp. 14, 20-21; NBS Annual Report 1953-54, pp. 11, 126. For the procedure by which the Bureau's budget is presented to Congress, and the "need for a new philosophy [in] the appropriation of funds," see pp. 80-81.

³ *Ibid.*, pp. 18, 95. The 10 technical advisory committees to the Bureau represent the American Institute of Electrical Engineers, Institute of Radio Engineers, American Institute of Physics, NAS Policy Committee for Mathematics, American Institute of Mining

Secretary Weeks accepted the recommendations of the committee in their entirety and promptly began issuing the directives to carry them out. On September 27, 1953, at one stroke, the Bureau lost four of its divisions, comprising the whole of the proximity fuze and guided missile programs. Three of them, the ordnance electronics, electromechanical, and ordnance development divisions, working on fuzes and related materials, centered around the new electronics laboratory erected in 1946 by the Army Engineers on the Bureau grounds across Van Ness Street. This complex became the Harry Diamond Ordnance Laboratories in 1949, honoring the inventive prodigy who came to the Bureau in 1927 and presided over ordnance development from 1940 until his death in 1948. With the staff of almost 1,600 members, the laboratories were transferred to Army Ordnance.⁴ At Corona, Calif., the Bureau's missile development division, with a staff of over 400, that same month became the Naval Ordnance Laboratories (Corona).⁵

The transfer of the two major weapons programs involved a loss of over one-third of the Bureau staff and more than half its \$50 million budget for the fiscal year 1952-53. A year later the Institute for Numerical Analysis in the applied mathematics division, supported by the Office of Naval Research and the Air Force at the University of California at Los Angeles, was formally transferred to the University. By the end of 1954 the Bureau had been reduced from almost 4,600 to 2,800 members, of which approximately 400 were out at Boulder, Colo.⁶

The curtailment of weapons development was quick. More time was required to implement three other recommendations of the committee: the insuring of quality and incentive in the Bureau staff; adjustment in the testing and calibration program, to reduce the burden of massive routine testing; and the modernization of facilities, with increased space provided for basic programs.

The high quality of the professional staff had become imperiled by the contraction in basic programs in recent years, with consequent reduction in staff as large numbers of the junior staff were siphoned into the Bureau's military programs. The future of the staff was threatened by the challenge of

and Metallurgical Engineers, American Chemical Society, American Ceramic Society, American Society of Mechanical Engineers, National Conference on Weights and Measures, and American Society of Civil Engineers (NBS Annual Report 1953-54, p. 127).

⁴ NBS BuMemo 49-45 (July 25, 1949). Upon its transfer, the complex was renamed the Diamond Ordnance Fuze Laboratories (DOFL). See AdminBul 53-57 (Sept. 30, 1953). It is now the Harry Diamond Laboratories.

⁵ Hearings * * * 1953 (Jan. 11, 1954), pp. 6, 66, 77-82.

⁶ NBS Annual Report 1953-54, pp. 12-13.

supply and demand posed by the postwar surge in employment opportunities for young scientists and engineers.⁷

Although not mentioned by the committee, there was also an element of discontent among the staff, particularly in the upper echelons, induced in part by clashing personalities introduced during the previous administration.⁸ The postwar reorganization of the Bureau, with its attendant changes in research assignments and work loads, staff changes, and increase in administrative duties and paper work, had been carried out largely by new administrative assistants brought in for that purpose. Some confusion and concern naturally resulted.

In order to hear out the staff, both professional and nonprofessional, and to discover and strengthen the factors making for a good research environment, the Director in November 1953 invited an advisory service, Social Research, Inc., of Chicago, to conduct a survey or inventory of staff attitudes towards the Bureau, Bureau policies, and working relationships. It was an altogether unique experience in the history of the Bureau.⁹

The two reports of Social Research made to all members of the staff 8 months later disclosed that, on the whole, most of the professional staff believed the Bureau compared favorably with the best universities and best industrial laboratories as a place to work, and that it provided many of the amenities of university life with the financial and equipment advantages of industry. Still, a significant group seemed to feel that the Bureau offered less in the way of individual freedom and opportunity to build a scientific reputation than elsewhere, and some apparently considered the pressure to publish or perish a unique requirement for promotion at the Bureau. The morale among the nonprofessional staff was about average, compared with that in similar groups in business and industry—an encouraging finding considering the late highly publicized unpleasanties.

The sheer size of the Bureau and its high degree of specialization, particularly since World War II, had dissipated to some extent the strong sense of community that since its founding had been the special quality of the Bureau. Yet the survey found identification high among the staff, both with their working unit and with the Bureau as a symbol representing a

⁷ Ad Hoc Committee report, p. 13. Reduction of funds for basic programs resulted in a loss of 328 members of the research, operations, and testing staff between 1949 and 1952, bringing it down from 1,728 to 1,400 members. Report of the Visiting Committee, July 1, 1952 (in the Office of the Director).

⁸ As Bernard L. Gladioux, Executive Assistant to the Secretary of Commerce, told the House Appropriations Subcommittee, "There is an underlying problem [of personalities] out there." It was discussed off the record. Hearings * * * 1951 (Feb. 6, 1950), p. 1361.

⁹ Announced in NBS AdminBul 53-66, Nov. 25, 1953.

particular way of scientific life. The professional group almost without exception, and most of the nonprofessionals, agreed with the ad hoc committee report on the importance of the basic research programs to the Bureau and with the fact of their recent serious attenuation. The task of the administration, to recover the basic programs and enhance and promote the Bureau symbol, was evident.¹⁰

The ad hoc committee had urged some modification in the testing program of the Bureau. The program in 1953, comprising calibration, quality control, acceptance, qualification, regulatory, and referee testing, preparation of standard samples, and product testing, had funds amounting to \$2.6 million. Both the committee and the Bureau were especially concerned over the relative efforts expended on product or acceptance testing and calibration testing, and the vital need of the latter as the way in which the Bureau disseminated its standards. Yet calibration testing, perhaps the most important end product of the Bureau's basic programs, was to a degree vitiated by the large amounts of repetitive testing, far more than the high level of technology in industry really required. Where such testing could not be dispensed with, said the committee, it should be turned over to commercial laboratories.

While the committee agreed that the Bureau must continue to make evaluation tests on commercial products at the request of other agencies of the Government, such testing was the area that most frequently brought the Bureau to the unfavorable attention of the general public—as had happened with AD-X2. The committee had no solution. The Bureau must make the tests but leave “the policies and activities of a nontechnical nature” connected with such tests to the Secretary of Commerce.¹¹

The first postwar Director, Dr. Condon, had for a time resented the effort expended by the Bureau on routine and repetitive testing, but he came to argue more persuasively than any Director for the routine work on Federal purchases, as representing “one of the most fertile fields for Government economy,” than any Director ever had before. Contrary to general opinion,

¹⁰ NBS AdminBul 54-49, Aug. 2, 1954; AdminBul 54-68, Sept. 27, 1954.

The “attitude survey” conducted by social scientists has become an accepted adjunct of administration. In 1957 the Bureau joined with eight other Federal agencies and eight private laboratories in a questionnaire designed to find ways “to attract and hold scientists and engineers in the Government.” Apart from the predictable responses (low salary scales, Civil Service examining techniques and processes, inadequate incentive, uncertain fringe benefits), the principal finding of the survey was that a permanent group be created in the Civil Service Commission to work with agencies making such attitude surveys (NBS AdminBul 57-39, July 29, 1957; AdminBul 58-1, Jan. 16, 1958).

¹¹ Ad Hoc Committee report, pp. 15-16.

the Bureau had never been given responsibility for laboratory surveillance over the quality of Government purchases. There never had been any legislation authority for this activity. Such surveillance as existed offered "only a very spotty check," except in the purchase of cement and of electric lamps. Bureau testing controlled the acceptance of some 4 million light bulbs bought for the Government each year, assuring a consistent quality product; the same was true of Government cement purchases.¹²

Not less but much more routine testing was required in other Government purchases, and Dr. Condon pointed to the \$100 million spent by Federal agencies for paint each year and the \$500 million for labor to apply it. Yet the Bureau in fact tested very little of the paint that the Government bought, although it knew there was abundant reason for more testing. It had neither the funds nor authorization from other agencies to do that testing. The Government spent \$12 million annually for automobile tires and \$5 million for tires on Air Force planes, without any check on their quality. A preliminary study made at the Bureau on truck tires for the Post Office suggested that \$150,000 spent on testing tires offered to the Government might well save between \$3 and \$4 million annually.¹³

Acting with the support of recommendations of the ad hoc committee, however, the Bureau sought to transfer to nongovernmental organizations a number of its other testing services. Efforts to decrease routine calibration work met with little satisfaction or success. The U.S. Testing Co. of Hoboken, N.J., set up a calibration service for thermometers but met little demand and abandoned it. Urged by the ad hoc committee report, the Bureau approached other commercial testing companies to take over routine calibration not only of thermometers but of volumetric glassware. Following the

¹² E. U. Condon, "Developing purchase specifications," *Pacific Purchaser*, February 1949, p. 13; Hearings * * * 1951 (Feb. 23, 1950), p. 2288; Hearings * * * 1952 (Apr. 10, 1951), p. 473.

¹³ Hearings * * * 1951, p. 2288; Hearings * * * 1952, pp. 464-465.

Dr. Stratton was chairman of the committee that drew up the act establishing the Federal Supply Commission (later the Federal Supply Service), responsible for Federal supplies and making purchase contracts. (See Stratton's account of Bureau relations with the Commission, in Hearings * * * 1921, Jan. 2, 1920, pp. 1569-1570.) In 1949 the FSS was transferred from the Treasury Department to a new independent agency, the General Services Administration (GSA). Except for the maintenance of Federal Specifications, the Bureau has been called on to provide little more quality control over Federal purchases under GSA than under the Treasury, despite the interest of GSA and a "memorandum of understanding" between GSA and the Bureau in 1953 (Hearings * * * 1951 Feb. 23, 1950, p. 2288; NBS Annual Report 1953-54, p. 131).

The necessity for the testing is beyond question. In Annual Report 1953-54, p. 99, the Bureau noted that of 280 samples of building materials submitted to the Government in that period and tested by the Bureau, 137 failed to meet specifications.

unfavorable response ("the work does not appear attractive as a commercial venture"), the Bureau began to promote reference standards laboratories¹⁴ in both Government and industry to handle calibrations whose accuracy did not necessitate comparison with the national standards.¹⁵

Further unburdening itself of routine efforts, in 1953-54 the Bureau turned over three of its service publications requiring periodic revision to the American Society for Testing Materials and the American Standards Association, with considerable success except for necessary price increases.¹⁶ At the same time, commercial firms were given two classes of standard samples to prepare and distribute, the Bureau's short-lived radioisotopes and its viscosity oil standards.¹⁷

As foreseen, the rapid advances in technology in the decade after the war made relentless demands on the Bureau for more and more testing, calibration, and greater precision measurements. Even with the reduction in repetitive testing and standard samples, restriction of calibration to basic standards, and the institution of statistical engineering procedures and semi-automatic methods of calibration, the number of tests and calibrations continued to rise. With an authorized increase in the charges made for these services, fees rose from \$2.9 million in 1953 to more than \$5.4 million just a decade later.

Even though increasingly confined to serving the regulatory, purchasing, or functional responsibilities of other Government agencies, the Bureau's testing program and especially its calibration services, grew with the expansion of the Nation's research program. To augment cement testing, for example, a Cement Reference Laboratory was set up at the Bureau under the joint support of NBS, the Bureau of Public Roads, the Army Engineers, and the American Society for Testing Materials. The Bureau also initiated a

¹⁴ "Reference standards" are defined in ch. II, p. 76.

¹⁵ Memo, A. T. McPherson, "Experience in turning over activities of NBS to non-government organizations," Mar. 19, 1960 (NBS Historical File); NBS Annual Report 1953-54, pp. 96-97. For an earlier attempt to shift cement testing to commercial laboratories, without success, see letter, P. H. Bates to N. T. Stadfeld, Dec. 11, 1942 (NBS Blue Folder Box 72).

¹⁶ The publications were M187, "Directory of commercial and college testing laboratories" (1947; issued since 1927); M178, "National directory of commodity specifications" (1945; issued since 1925); and C410, "National petroleum oil tables" (1936; issued since 1916).

¹⁷ Memo, A. T. McPherson, Mar. 19, 1960. Another service discontinued as no longer necessary was the performance testing of dry cells, which began in 1924 and cost \$10,000 annually. Memo, Director NBS for Assistant Secretary of Commerce, July 7, 1952 ("General Correspondence Files of the Director, 1945-1955").

mobile laboratory service, to make cement tests where time schedules precluded use of the Bureau's area laboratories.¹⁸

Calibration and standard samples programs were similarly augmented. In 1955 construction of a new calibration center began at the Boulder Laboratories, initially to calibrate for the Air Force and Navy Bureau of Aeronautics the vast quantity of radio, radar, and other electrical equipment making up more than half the cost of some of their new planes. Representing an investment of \$2 million, almost half that sum for interlaboratory standards and special equipment, the center would serve science, industry—particularly the new aerospace industries—as well as the military and other Government agencies.¹⁹

The new importance of Bureau testing was further recognized when on May 3, 1956, Public Law 940 authorized the Bureau, for the first time since its founding, to retain as working funds its fees charged for the calibration of standards and the sale of standard samples to commerce and industry.²⁰

Congress might let the Bureau retain its testing fees, but it could not be immediately persuaded to support the major ad hoc committee recommendation, the restoration of the level of basic research at the Bureau through increased appropriations. The chairman of the committee, appearing before the House Appropriations Subcommittee, informed it that the Bureau was not keeping up with the great growth in U.S. technology and was nowhere "big enough for its normal basic functions."²¹ The House members were not moved. Even with the severance of the fuze and missile programs and their funds, the remaining sums transferred to the Bureau by other Federal agencies still exceeded by more than three times the direct appropriations of Congress, and Congress was concerned about those funds beyond its control.

"It is the same old program that we are faced with every year," Congressman Prince H. Preston, Jr., of Georgia told his fellow members on the House subcommittee,

and that is, lack of control we have over the Bureau of Standards' appropriation by virtue of the fact you have so much transferred

¹⁸ NBS Annual Report 1957, p. 98.

The new facilities, and better test methods, resulted in more testing of cement but reduced the volume handled by the Bureau. By the 1960's, just two of the NBS cement laboratories were in operation, at Seattle and Denver, and those at Houston, Kansas City, San Francisco, Allentown, Pa., and Riverside and Permanente in California were closed down. Conversation with Martin R. Defore, Dec. 22, 1964.

¹⁹ NBS Annual Report 1955, p. 123. Wider dissemination of high precision laboratory standards, calibrations, and procedures was the objective of the first meeting of the National Conference of Standards Laboratories held in 1962, attended by over 600 representatives of 200 industrial laboratories and other organizations and reported in NBS M248 (1962).

²⁰ NBS Annual Report 1956, pp. 108, 140.

²¹ Hearings * * * 1955 (Jan. 11, 1954), p. 81.

money or reimbursable projects. * * * I do not know what the answer * * * is as long as [the Bureau] can get more money from other agencies than we appropriate * * *. As a matter of fact, if we were to try some economies * * * a 20 percent cut [for example] * * * there would be nothing in the world to prevent the Bureau of Standards from doing a little staff negotiation with the Navy, or somebody [and get more transferred funds. Thus the Bureau doesn't] have to put into effect any reduction by virtue of the appropriations we make. [It] would just be going to some other source to get the money we denied.²²

Apart from the presumed ease with which the Bureau obtained transferred funds was the fact that, while they supported research valuable to basic programs of the Bureau, little fundamental research was ever authorized by those funds. For that research, and for expansion, the Bureau looked to Congress. The predicament was to be resolved 3 years later, with the coming of the space age.

GAITHERSBURG

Second only to the importance of restoring the basic programs at the Bureau to their former high level was the ad hoc committee's recommendation for modernization of its facilities and increased space for those basic programs. Attention had been called to the condition of the Bureau plant a year after the war when a new plant division chief arrived. His initial survey disclosed that Bureau facilities were "in a sordid mess." The main buildings were 30 to 40 years old and looked it, since funds had never been made available for their periodical rehabilitation. Deterioration had accelerated with their great use, abuse, and meager care during the war. Just as alarming was "the almost total lack of basic records on what had been built at the Bureau, where power, steam, water, electrical and other lines ran, and what the ramifications of the facilities really were."²³

The Public Buildings Administration, responsible for the design, construction, and protection of all Federal buildings, was called to reconstruct

²² Ibid., pp. 90-91, and Hearings * * * 1957 (Mar. 20, 1956), p. 102.

The counterpart of this observation had been voiced three decades earlier in industry's complaint that the special appropriations of Congress to the Bureau expanded its sphere of operations, without controls and contrary to the intention of the organic act of the Bureau. See ch. V, p. 231n.

²³ Interview with William I. Ellenberger, Aug. 12, 1964. The condition of the buildings and the so-called excessive expenditures for their maintenance were particular targets of the House Appropriations Subcommittee survey made at the Bureau in 1949. See Hearings * * * 1951 (Feb. 23, 1950), pp. 2179 ff.

the records and survey the Bureau plant.²⁴ Its restoration of records, recommendations for rehabilitation of utilities, and for destruction of some of the temporary structures beyond repair were salutary. The modernization of electrical, plumbing, and heating facilities, accomplished in 1949–53 as a result of the survey, still left the Bureau plant a maze of over a hundred buildings, annexes, and minor structures. Most were antiquated and far short of modern laboratory standards, and all were so crowded that no expansion of activities was possible in them.²⁵

As a solution to the maze, the visiting PBA architects drew up splendid plans for a completely remodeled Bureau on its present site, reconstructing the entire interiors of the major buildings and replacing the scores of lesser buildings with a dozen new and architecturally satisfying modern structures.²⁶ The plans were subsequently described as “purely objective * * * on the presumption of unlimited resources,” a condition to which Congress was not likely to agree.²⁷

Less than a decade later, convinced of the need of new Bureau facilities and their importance to the national welfare, Congress approved relocation.²⁸ In May 1956 the Director selected a 550-acre plot of high-level ground near Gaithersburg, Md., approximately 19 air miles (45 minutes by

²⁴ The PBA reconstruction is the basis for the Bureau's plant data given in app. O.

²⁵ The request to the PBA, to survey the plant and determine the repairs and alterations necessary to put it in satisfactory condition, was made in January 1946. The report was made on May 21, 1947. The survey is discussed in Hearings * * * 1948 (Mar. 12, 1947), pp. 295, 308; Hearings * * * 1949 (Jan. 20, 1948), p. 537; Hearings * * * 1951 (Feb. 23, 1950), p. 2274; and NAS-NRC Report, “The role of the Department of Commerce in science and technology,” Mar. 2, 1960, p. 92.

²⁶ In a three-stage “redesign of the entire plant,” the prospectus called for retention and thorough modernization of 26 of the original buildings, demolition of 68, and erection of 12 new structures. “Redevelopment Program Survey, NBS,” Oct. 1, 1948 (PBA, Federal Works Agency, Project 49-118, in NBS Historical File). The estimated cost of the PBA modernization was subsequently reported as approximately \$40 million. [Senate] Hearings * * * 1958 (Apr. 11, 1957), p. 137.

²⁷ Interview with W. I. Ellenberger, Aug. 12, 1964.

²⁸ As late as the fall of 1957 the Visiting Committee to the Bureau wrote to Secretary Weeks that the immediate needs of the Bureau were so great that the committee would prefer modernization, new buildings, and expansion at the present site rather than reconstruction at a new site. Letter, M. J. Kelly, Chairman, Visiting Committee, to Secretary Weeks, Oct. 17, 1957 (Visiting Committee files in Office of the Director).

A year later the Visiting Committee approved the decision to build on a new site, but in the interest of haste recommended retention of the Washington site and construction only of new types of research facilities at Gaithersburg (Minutes of meeting of the Visiting Committee, June 19, 1958).

Ultimately, complete reconstruction was agreed on. A new plant could be more efficiently managed and, as had dictated the choice of the original Bureau site, relocation would remove the Bureau from a variety of mechanical, electric, and atmospheric disturbances to precise scientific measurement that now surrounded the Bureau in the city.

car) from downtown Washington, and available for an estimated \$750,000.²⁹ Four years later Congress appropriated approximately \$23.5 million as the first installment on a building program estimated to cost in the neighborhood of \$70 million for buildings and \$45 million for special facilities and equipment.

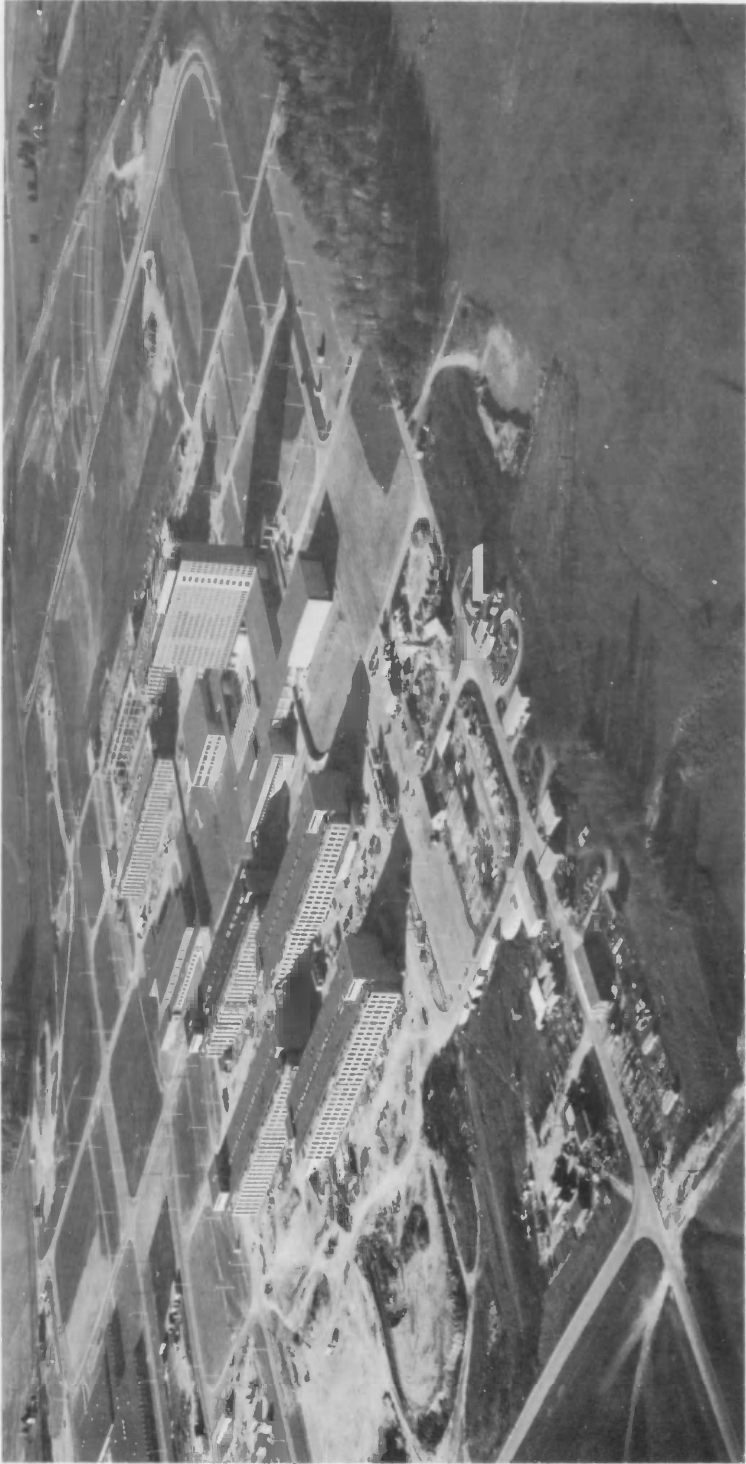
On June 14, 1961, ground was broken. The first contracts had been let for construction of the central boiler plant, to serve the complex planned, and for an engineering mechanics laboratory. That fall additional contracts were negotiated for a radiation physics laboratory, administration building, supply and plant structures, the shops, and a service building. The third phase called for construction of seven general purpose laboratories, each occupying an area larger than a football field. The fourth and final phase was to include several small special purpose laboratories and a reactor building. When completed the new Bureau complex would comprise over 20 structures.

The ad hoc committee report of 1953, laying down fresh guidelines for the work of the Bureau, gave it a direction it had almost lost in the turbulence of the postwar decade. The approval of plans to construct a great Bureau plant at Gaithersburg bespoke new national needs and a confidence in the future. It also reflected the phenomenal involvement of the Federal Government in postwar science.

Before World War II, Federal participation in research in the physical sciences was negligible. Striving to close the gap in the technology of war, the Federal research budget between 1940 and 1944 rose from \$74 to \$1,377 million. Two decades later, in continuing escalation, Federal research and development exceeded \$15 billion annually or close to 15 percent of the national budget. Almost 60 percent of all research scientists and engineers in the Nation worked wholly or in part on programs financed by the Government. Approximately 68 percent of the \$15 billion went into development research, 22 percent to applied research, and 10 percent to basic research, encompassing every field of physical, biological, and social science. The Department of Defense and the National Aeronautic and Space Administration alone accounted for nearly 80 percent of the total funds, supporting development research in hardware immediately pertinent to the national defense, as well as basic and applied research in meteorology, oceanography, astronomy, high temperature physics, and low temperature physics.³⁰

²⁹ NBS Budget and Management Division, Summary of Files on Gaithersburg (Office of the Director). Early estimates of the cost of the Gaithersburg plant appear in Senate Hearings * * * 1958 (Apr. 11, 1957), p. 138.

³⁰ National Science Foundation, "Federal Funds for Research, Development, and other Scientific Activities" (Washington, D.C., 1964), p. 2 and appendix, table C-32; NSF, "Reviews of Data on Research and Development" (Washington, D.C., 1963), p. 1.



Gaithersburg, showing the high-rise administration building, surrounded by and interconnecting with the general purpose laboratories, as these principal units neared completion in 1965.

It was this fact, the mobilization of national science as a permanent peacetime responsibility of the Government, that made anomalous the Bureau's topheavy role in development research. As a consequence, the Bureau was unable to produce new methods of measurement and standards at the rate required by the Federal science program. The result was a growing measurement pinch in the physical sciences.

An event in 1957, the lofting of Russia's Sputnik I into space, marked the advent of the space age and made glaring the gap in measurement.³¹ Three years before, both the ad hoc committee and the Bureau had expressed concern about the unpredictable advances that were being made in science, about the shortening lead time between basic discoveries and their application. Forty years had separated Maxwell's publication of the laws of the electromagnetic field and the first radio experiments; 10 years the discovery of the neutron and the first nuclear reaction; and 6 years the invention of the transistor and its appearance in an amplifier on the market. Although space science was moving in this country, its slow pace was suddenly mocked by the Russian achievement.

The Nation's missile and space programs lagged badly for want, among other things, of high temperature measurements in the combustion of high-energy missile fuels; accurate thrust measurements in the million-pound range, instead of the hundred-thousand-pound range available; and high and low temperature, corrosion, and radiation damage measurements of metals, alloys, ceramics, and other materials. Measurements were needed on the effects of sudden and violent changes of temperature and pressure on the thousands of components in a missile system, on the materials and mechanisms of their rocket engines, airframes, electronic devices, and guidance systems.³²

Science, industry, and the military establishment looked to the Bureau for new precision measurements that only the most basic research in chemistry, physics, and mathematics could provide. But reflecting public opinion during and after the Korean war, budget cuts over the 5 years after 1950 reduced the basic research capabilities of the Bureau by almost 30 percent.³³

³¹ The significance of the event, and of Russia's support of five standards laboratories and 129 calibration centers, was discussed at Hearings * * * 1959 (Apr. 23, 1958), pp. 421-22.

³² See Beverly Smith, Jr., "The measurement pinch," *Sat. Eve. Post.*, Sept. 10, 1960; "Measurement standards report," *ISA J.*, February 1961, pp. 1-40.

³³ Operations and research funds fell from \$5.5 million in 1951 to \$3.9 million in 1955. By 1957 small congressional increases over the previous 3 years brought the staff up to 75 percent of the 1950 level. Transferred funds still accounted for 63 percent of total Bureau funds, even though half of the transferred fund programs were reported as

Famed for its lead time in measurement to meet the requirements of industry, the Bureau for almost the first time in its history found itself caught in a measurement pinch, by the surging demands of the space age.

As public opinion veered, the budget cuts were reversed. New planning began in order to restaff the Bureau and provide new facilities and programs. Waiting for the Bureau to acquire more physicists, chemists, and mathematicians and space research results, the Army, Navy, and Air Force resorted to long and costly series of empirical trials and test firings. Waiting for the Bureau, the services worked to improve their measurement procedures, training engineers and technicians in metrology and calibration and setting up calibration centers and mobile measurement laboratories.

Even before ground was broken at Gaithersburg, better thrust measurements were in sight, temperature calibrations rose from 2,800° C beyond the 15,000° mark, and intensified research in high-purity materials had begun. Highest priorities were assigned to the construction at Gaithersburg of the mechanical engineering laboratory, to undertake thrust measurements for new missiles; the radiation laboratory, with its linear accelerator in the 100 million-electron-volt range, for safety studies of radiation exposure; and housing for the Bureau's new research reactor, for programs on neutron and fission physics measurements, radiation damage, and radioisotope applications—all of which were impractical or impossible in the Washington laboratories.³⁴ As appropriation of research funds rose, the Bureau came on course.

To meet the challenge of space research, to affirm the purpose, focus, and urgency of Bureau operations, and give meaning to the individual effort of each Bureau staff member, the Director prepared for the staff a formal statement of the Bureau's central, continuing mission. The emergence of science and technology as the paramount concern of the Nation in the 20th century, he declared, demanded the highest order of measurement competence, in order to provide the standards and measurement techniques on which maintenance of scientific progress depended. The paramount mission of the Bureau henceforth, because of its unique responsibility for leadership

close enough to Bureau statutory responsibilities to be put under direct appropriations. Minutes of meeting of the Visiting Committee, Apr. 25, 1957 (Office of the Director).

A special advisory committee of the National Academy of Sciences, chaired by Dr. M. J. Kelly who had headed the ad hoc committee in 1953, was appointed in 1958 at the request of Secretary Weeks to evaluate the operations of all elements of the Department of Commerce. The focus of the restudy of Bureau operations was on the progress of implementation of the 1953 recommendations. The principal finding was that the Nation's need for measurements and standards was not being met by the Bureau, "only because of inadequate funds." NAS-NRC Report, "The role of the Department of Commerce in science and technology," Mar. 2, 1960, pp. 81, 94.

³⁴ Minutes of meeting of the Visiting Committee, June 29, 1959 (Office of the Director).

in physical measurement, must be: (1) Provision of the central basis within the United States of a complete and consistent system of physical measurement, and coordination of that system with the measurement systems of other nations; (2) provision of essential services leading to accurate and uniform physical measurements throughout the Nation's science, industry, and commerce, and consonant with their advancing requirements; (3) provision of data on the properties of matter and materials which are of importance to science, industry, and commerce, and which are not available of sufficient accuracy elsewhere.³⁵

The mission statement by no means encompassed all of the Bureau's future activities. The Bureau had, and would continue to assume, other important tasks within its special competence, as its organic act and amendments provided. But physical measurement, and those specialized services of a supporting nature, such as applied mathematics and instrumentation, were to be the essential focus of future Bureau activities.

RETROSPECT AND PROSPECT

In creating a National Bureau of Standards in the Federal structure at the turn of the century, Congress sought to redress a long-standing need, to provide standards of measurement for commerce and industry, the public, and the Government. Inevitably, the focus was on industry. The United States had only recently become a trading nation, manufacturing for the first time more than it could consume and moving into foreign markets. Recognition of the need for higher standards of measurement, of better quality of product and performance, had prompted manufacturing interests to become the moving force in the founding of the Bureau.

In its first two decades the Bureau won an international reputation for its outstanding achievements in physical measurement, development of standards, and test methods. Through its new standards of measurement, instrumentation, and performance it sought to raise the scientific level of industry. Industry accepted the measurements it so desperately needed but tended to resist the introduction of scientific methods for the achievement of better products and service. In seeking to goad into action those elements of industry reluctant to improve the quality of their product or service, the Bureau championed consumer causes, and in testing commodities purchased for the Government found a lever to move industry.

The latter effort fell short of its goal because the lever could not be fully applied. At the end of World War I the Bureau reluctantly admitted

³⁵ Minutes of meeting of the Visiting Committee, June 29, 1959; NBS AdminBul 60-40, Sept. 9, 1960; NBS Annual Report 1960, p. 150.

that Federal agencies, representing the largest single consumer of products in the Nation, were still far from united on the need for quality or standardization in their purchases, and tended to neglect or ignore test results made by the Bureau on their behalf.

The techniques of mass production introduced during the war nevertheless gave an enormous impetus to standardization of methods and materials, and the wartime impact of science on industry raised Bureau hopes that it might find readier acceptance of its efforts. Determined to foster the new industries born of the war, the Bureau sought to become the national research laboratory for all industry. By the early 1920's a few industries had begun to exploit the new industrial revolution, most successfully in radio and the automobile, but in general industry and commerce resumed their wasteful habits.

Under the Hoover administration, the Bureau continued its efforts to raise the scientific level of industry and saw itself firmly tied to the service of commerce. In Hoover's crusade to eliminate waste in industry, conserve materials and resources, and standardize products and procedures, almost every element of the Bureau participated. The Bureau made notable advances in both scientific and industrial research in the period, but as a result of its almost total identification with industry, shared the obloquy heaped on commerce and industry when the depression came.

Industrial research funds dried up and industrial projects were curtailed or eliminated during the great disenchantment. With greatly reduced appropriations and staff, but its top echelon almost intact, the Bureau turned increasingly to fundamental research during the depression. The fund of basic knowledge acquired in those years served the Nation well in the Second World War, and with the mobilization of science in the Nation vastly extended the limits of technological attainment. Few could have foreseen the wartime developments in nuclear physics, atomic energy, electronics, mathematics, in aviation, and in missile research, requiring the extension of ranges of all former measurements and determination of an array of new measurements never contemplated before.

Unlike the experience after World War I, the impetus given science and technology did not recede but accelerated enormously in the succeeding years. The import of science for the national welfare became so imperative that the Federal Government dared not relinquish its direction of science, and its costs had become so great that only Government could support it. The Bureau found itself in the forefront of the scientific revolution that had overtaken the Nation.

In the stream of the new revolution were the basic programs introduced or built up at the Bureau in nuclear and atomic physics, electronics,

mathematics, computer research, and polymer research, as well as in the instrumentation, standards, and measurement research required by the pace of science and industry. In this period of rapid reorientation some of the long established programs at the Bureau suffered, and for a time the measurement requirements in new fields of science appeared to flourish at the expense of traditional metrology. The onrush of space science put all metrology at hazard. Resolution of that hazard became the aim and continuing achievement of the present decade.

In that same decade, as the Bureau prepared to move to its new laboratories at Gaithersburg, its organization and functions underwent a new realignment of focus and purpose. Believing the Bureau soundly grounded in its role as adjunct of the new science, the Department of Commerce called for reorientation of its services to increase its effectiveness as "a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce."³⁶

Early in 1964 the programs of the Bureau were regrouped into four institutes. The Institute for Basic Standards comprised its long-standing programs in the field of basic measurement standards and its recently established National Standard Reference Data Program. The Institute for Applied Technology brought together the industry-oriented programs of the Bureau and the Department's program in textile technology and its Office of Technical Services, for the promotion of technological innovation and use of the results of science and technology in industry. The Institute for Materials Research combined the Bureau programs in chemistry and metallurgy, with a view to augmenting their measurements of the properties of materials, strengthening and extending the standard samples program, and improving the efficiency of production processes in industrial technology.

A year and a half later the Bureau's Central Radio Propagation Laboratory at Boulder, originally intended as a fourth institute, became scheduled for transfer from the Bureau to a new agency within the Department of Commerce, the Environmental Science Services Administration (ESSA). With inclusion of the U.S. Weather Bureau and the Coast and Geodetic Survey, the new environmental agency of the Commerce Department was planned to provide broader based research and better service to the public, to business, and to industry.³⁷

³⁶ Department of Commerce, Department Order No. 90 (revised), "National Bureau of Standards" (Jan. 30, 1964).

³⁷ Memo, Director NBS for all employees, May 13, 1965. Exempted from the transfer to ESSA was the radio standards work carried on at Boulder, which was to remain a function of NBS.



The Visiting Committee of Commerce to the Bureau in 1957. Left to right, Dr. Clyde E. Williams, Dr. Crawford H. Greenewalt, Dr. Mervin J. Kelly, Dr. Detlev Bronk, Prof. Frederick Seitz, and the Bureau's fifth Director, Dr. Allen V. Astin.

The spin-off of CRPL, the new realignment of functions and purposes, are endemic in the history of the Bureau. Its history over more than half a century discloses a highly viable form, a living organism of the Federal Government, responsive to national needs as they arose. Established to do no more than provide the Nation with its necessary yardsticks of measurement and performance, a seemingly mechanical destiny, the Bureau from the beginning reached out to the whole life, the whole welfare of the Nation.

The present history has tried to show this life force that is the Bureau, acting as individuals and as agency, and the part it has played in the scientific, industrial, and business life of the Nation. As crusader and arbiter, creator and counselor of standards, it works for the future, as it has in the past, for the good society, and by its learning and good will makes itself felt throughout the Nation and the world.



The Exchequer standard corn gallon of Henry VII