APPENDIX A

FERDINAND RUDOLPH HASSLER

First Superintendent of the Coast Survey and of Weights and Measures

When Professor Stratton arrived at the Office of Weights and Measures on B Street in Washington in the spring of 1898 to survey its equipment and operations, he found there in the person of Louis A. Fischer, the adjuster, a link with Ferdinand Rudolph Hassler, the first Superintendent of Weights and Measures in the Federal Government. It was in the atmosphere of the office over which Hassler had presided, Stratton said,

> with its sacred traditions concerning standards, its unsurpassed instrument shop, its world-known experts in the construction and comparison of standards, and especially in the most precise measurement of length and mass, that the boy Fischer, scarcely over 16, found himself when he entered the employ of Government in a minor capacity [about the year 1880]. * * *. Scarcely 40 years had passed since the end of Hassler's services and the beginning of Fischer's. His first instructors were the direct disciples of Hassler and he knew and talked with those who had come in personal contact with the first superintendent.[1]

Fischer's reminiscences concerning the early history of the Weights and Measures office, gathered from his association with the successors of Hassler, were never recorded, to Stratton's regret, and the only biography of Hassler, by Florian Cajori, professor of mathematics at the University of California, centers on his career in the Coast Survey gathered from his association with the successors of Hassler, were never recorded, to in the history of science in the Federal Government, is the principal source of the present sketch.[2]

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[1] Stratton, "Address Memorializing Louis Albert Fischer, 1864–1921," 15th Annual Conference on Weights and Measures, May 23–26, 1922, NBS M51 (1922), p. 3.

[2] Cajori, The Chequered Career of Ferdinand Rudolph Hassler, First Superintendent of the United States Coast Survey: A Chapter in the History of Science in America (Boston: Christopher Publishing House, 1929).

The biography is a sound summary of the known facts about Hassler. It is based on the numerous published reports Hassler made of his work for the Government; on the Hassler correspondence in the Ford Collection of the New York Public Library; Rosalie L. H. Norris's unpublished "Recollections" (written in Paris, 1856) in the Simon Newcomb Papers, Manuscript Division, Library of Congress; and the papers in the Archives of the American Philosophical Society. Considerable use is also made of the 558-page work, Emil Zschokke's Memoirs of Ferdinand Rudolph Hassler, published in Aarau, Switzerland, 1877, with supplementary documents published in 1882, and translated by Rosalie L. H. Norris (Nice: V.-Eng. Gauthier & Co., 1882). Zschokke's actual memoirs occupy pp. 11–31, and a "Sketch of His Life" by Hassler himself, appears on pp. 35–40. The bulk of the Memoirs, an omnium-gatherum, comprises reports, newspaper accounts, letters and other correspondence by or relating to Hassler.

Hassler, a man highly trained in mathematics and of great practical ability as a scientist, had scant talent in the art of living and even less in the management of everyday affairs. Proud, improvident, singleminded in his pursuit of precision, and intolerant of expediency, he was destined by events to a life of unending storm and stress. Had not revolution in Europe brought him to America, he might have found his place in the scientific community abroad. The political and economic climate of the New World had room for the practical, the philosophical scientist, but little for the often impractical but wholly dedicated man of science such as Hassler.[3]

He was born in the town of Aarau, in the northern or German part of Switzerland, on October 7, 1770, his father a member of a distinguished family, a prosperous watch manufacturer, and high local official. At 16, Hassler entered the institute that was later to be the University of Berne and there came under the influence of Johann Georg Tralles, a young professor of mathematics and physics, who turned Hassler from the study of law to mathematics, astronomy, and geodesy.

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[3] The scientific climate Hassler found in America is well depicted in Brooke Hindle's The Pursuit of Science in Revolutionary America, 1735–1789 (University of North Carolina Press, 1956), especially pp. 79, 84, 255–256, 327.

Ferdinand R. Hassler

An engraving of young Hassler, probably made sometime in the 1790's. From the scenery and the spyglass in Hassler's hand, it may be inferred that he and his friend Tralles were at that time mapping the area around Berne, Switzerland. Less than a decade later, Hassler left for America.

Geodetics became their hobby, and in 1791, with apparatus and funds supplied by Hassler, the two began mapping the area around Berne. Since even tolerable maps of any part of the canton did not exist then, the town fathers encouraged the project, seeing that it would promote better land utilization and development. Among the difficulties that confronted Tralles and Hassler was the lack of precise instruments and measurement standards, and so began young Hassler's lifelong preoccupation with instrumentation. Between field expeditions, Hassler traveled to Paris and the university towns of Germany to attend courses, collect books for his growing library, and acquire better instruments and standards for the survey work. His friend Tralles in that same period, as deputy of the Helvetic Republic, was to participate in the establishment of the metric system in France.

The French Revolution of 1798 brought rebellion and French military occupation to Switzerland. That same year Hassler, now 28 and a prominent local official, married Marianne Gaillard, daughter of a schoolteacher. Of a cheerful disposition and great social ambitions, Marianne was not of a very domestic turn and is said to have concerned herself little with the seven sons and two daughters she subsequently bore Hassler.

Under some harassment from the new political regime, and his association with Tralles severed when the latter left to become a member of the Academy of Science in Berlin, Hassler in 1804 joined with a chance acquaintance to organize a stock company for the purchase of large tracts of land in South Carolina, or possibly Louisiana, and there found a Swiss colony. On May 15, 1805, Hassler left his native land with his wife, four children, servants, and 96 trunks and bales for the trip down the Rhine. He had also engaged 120 laborers, artisans, and craftsmen, with their families, to establish the colony, defraying all their expenses. At Amsterdam he chartered the 350-ton ship *Liberty*, out of Philadelphia, and on October 18 after a 6-week voyage the company arrived at that port.

His partner, who had sailed earlier, had in the meantime speculated with the funds entrusted to him and lost them. To maintain his family while waiting for remittances from his father, Hassler sold many of the works of art he had brought with him. He assisted his company of colonists to find new places and, determined not to return home, applied for American citizenship.

Shortly after his arrival in Philadelphia, the seat of Government at that time, he met and was cordially welcomed by his compatriot Albert Gallatin, Secretary of the Treasury, and introduced to President Jefferson. Through them he became a member of the American Philosophical Society in 1807. To the Society he later sold some of his instruments and standards in order to maintain his family, and to the Library of Congress part of his scientific library of about 3,000 volumes.

Hassler came to America intending to lead a rural life as steward of the colony he planned to establish somewhere in the South. His mathematical books and instruments were to be his recreation, and his youthful interest in triangulation and astronomy only recollections of former employments. Instead, a year after his arrival, his possessions much reduced, he settled on a small farm on the banks of the Schuylkill, north of Philadelphia, and began looking for an occupation. He was now 35, possessed of a hardy constitution, considerable learning, but with few immediate prospects. Like many of the well-educated of his time he knew Latin and spoke several languages, in his case German, French, Italian, and English, the latter clear but heavily accented and unidiomatic. Besides his training and experience in political science and jurisprudence, he had an extensive knowledge of mathematics and a good knowledge of chemistry, mineralogy, and all the other branches of natural philosophy. And he was versed in astronomy and practical geodetics.

When he made known his need of an income, his new friends in the Philosophical Society wrote to President Jefferson recommending Hassler's employment in a geodetic survey of the coast then under consideration. On February 10, 1807, Congress appropriated $50,000 for—

> a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as [the President] may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.[4]

Of a number of plans solicited for conducting the survey, Hassler's proved most satisfactory. It provided for the determination of true geographic positions by astronomical means at key points near the coast, networks of precise triangulation between these points, a topographical survey of the coast, and a hydrographic survey of coastal waters controlled by triangulation.[5]

The President recommended that Hassler be appointed to carry out the work, but the solicitations and more pressing affairs of state delayed action on the survey for 4 years.

While awaiting acceptance of his plans for the coast survey, Hassler secured a place as acting professor of mathematics and natural philosophy at West Point, resigning in February 1810 to teach natural science at Union College at Schenectady. He left a year later when Secretary of the Treasury Gallatin commissioned him to go to London to obtain the instruments he would need for the survey. Hassler had stipulated in seeking the post that "good instruments are never to be obtained by buying in shops, where only instruments of inferior quality are put up to sell; they must be made on command and by the best mechanicians." He embarked with his family for Europe on August 29, 1811, to seek out those mechanicians and direct the construction of his instruments.

Hassler's eighth child and sixth son was born to his wife during the 4-year stay in London and named Edward Troughton, after his next door neighbor and the chief instrumentmaker supplying the equipment for the survey. Besides Hassler's reluctance to hurry the construction of his instruments, delays arose when shortly after his arrival war broke out between England and his country, and for a time he was detained in London as an alien. Two years later while his family was living in Paris, England and her allies invaded France, Napoleon escaped from Elba and, collecting troops as he went, marched to his final battle. Hassler went to France to extricate his family.

Not all the instruments that Hassler ordered abroad were for the coast survey. Some were for two astronomical observatories, as "a permanent national institution," that Hassler planned, one in Washington or somewhere in the Southern States, the other in the North. Not until his return were the President or Congress to learn of, and defer, Hassler's "institution."

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[4] Quoted in Annual Report of the Board of Regents of the Smithsonian Institution. Report of the U.S. National Museum, part II, A Memorial of George Brown Goode * * * " [including his] history of science in America (Washington, D.C. 1901), p. 293. Jefferson, anticipating war with Great Britain and aware that the only charts of the coast were those of the early Dutch, English, and French colonists, proposed the survey to Congress in 1806.

[5] A. Joseph Wraight and Elliott B. Roberts, "The Coast and Geodetic Survey, 1807–1957" (Washington, D.C., 1957), p. 5.

When not tending the construction of his instruments and apparatus, the great 24-inch theodolite for measuring the angles of the survey, and the telescopes, transit instruments, astronomical clocks, chronometers, barometers, thermometers, micrometers, and balances he had ordered, Hassler met and discoursed with the astronomers and geodecists in London and Paris on the state and progress in these fields in Europe. He procured new copies of both French and English standard weights and measures, for their like was not known in America and they were needed for the survey, and made comparisons of the meter bars and other measures with Troughton's own scales.

In the spring of 1815, upon the death of his father, he went to Switzerland to settle the estate, returning with his inheritance of some 1,100 pounds sterling. Besides more instruments he bought lavishly of the best and most recent books on astronomy and geodesy, some for the instruction of the young officers who would be employed in the survey, the rest for his own use and instruction.

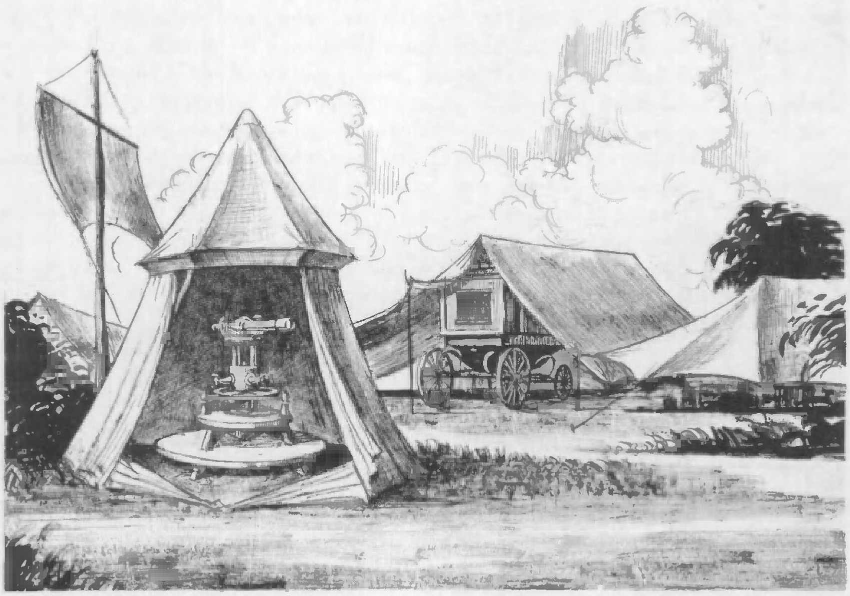
The value of the equipment ordered by Hassler in London and Paris came to $37,550. With his salary of $4,500 and traveling expenses, his accounts came to a grand total of $55,634, well above the congressional appropriation. He had to come home at his own expense. In the first week of August 1815 he and his family left London, to arrive in Philadelphia 9 weeks later. He had, as Gallatin pointed out, outrun his time and his funds, but the instruments he had procured were excellent.

In the spring of 1816, without waiting for formal approval, Hassler set to work. On August 3, 3 months after Congress appropriated funds to initiate the survey itself, Hassler was notified of his appointment as Superintendent of the Survey of the Coast, with a salary of $3,000 and $2,000 for expenses. He had discussed with the Secretary of the Treasury the operation of the survey and the amount of freedom he should have in the work. In a confirming letter that rang like a personal declaration of independence he said in part:

> My task would be fully large enough, to make all the combinations, operations, and principal observations; to bring up the young officers given to me to the capability required for their employment, (as it will in fact be a practical school that I shall have to keep, besides the work), and to direct, inspect, and verify, the detailed surveys, and their uniting in proper charts, etc. To load me with any of the mechanical, or economical parts, would be impeding the work, * * * and place me in a situation not to be supported.

At 46, Hassler's character was fully formed. He was a scientist of unlimited enthusiasm and devotion to his work. He was honest, a proud spirit, and knew his worth. He also habitually planned things on a large scale, without giving much thought to the practical realities or limitations of his projects. The Swiss colony project had been characteristic, and his mentors should have been warned by the apparatus he had purchased for his two unauthorized observatories. And, his biographer notes, as "the head of a large family, the husband of a woman fond of society and unqualified to struggle along devotedly on small means, a scholar who in youth was accustomed to almost unrestricted expenditures for books, scientific instruments, and travel, he was to find himself in maturer years in sharp conflict with economic conditions." But he had on his side warm supporters in the American Philosophical Society, and more valuable, the Presidency. As Jefferson first befriended him, so succeeding Presidents Madison, Monroe, Adams, and Jackson were to come to his defense and to extricate him from his repeated difficulties with accountants and Congress.

A letter from the Treasury in February 1817, 6 months after his appointment, asked Hassler to state the probable time required to complete the survey. He couldn't say, for he had not yet begun. Owing to the severity of the winter, he had not even found



Hassler sets up camp in the field, a drawing based on a reproduction of a time-darkened painting.

Visible under tents are his 24-inch theodolite for measuring angles and his wonderful Jersey wagon, with its wine chamber, disappearing dining and work table, and array of compact instrument and provision chests.

a satisfactory location for a baseline. On the other hand, he had started to train the first of the lieutenants of artillery sent him from West Point as assistants, and there was under construction a remarkable carriage for transporting the theodolite and other delicate instruments to be used.[6] Not until April did he determine on the location for his first baseline, near the Hackensack River in New Jersey, and begin establishing triangulation points.

A year after beginning the survey, Hassler was asked again when it would be completed and was warned of Congress's dissatisfaction with his meager progress. On April 14, 1818, Congress acted, modifying the law authorizing the survey in order to put Army and Navy officers in charge of the work, thereby excluding Hassler from further direction or participation. His biographer is doubtless right in declaring that

[6] As completed a year later, the barouche-like vehicle he designed to convey his instruments, some weighing a hundred pounds or more, was based on a Jersey wagon mounted on strong braces and huge springs, to be drawn by two or four horses. Ruggedly constructed to maneuver on rough roads and hilly terrain, it had numerous compartments in a double bottom for storing smaller instruments, tools, stationery and books, and a music box to keep him company as he worked late into the night. In a locker under the seat were his traveling clothes and "a little spirit-room," containing his supply of Swiss wines and the crackers and cheese he lived on in the field. A tent covering secured the carriage in bad weather. With its suspended table, the vehicle served as Hassler's office by day and, with the table secured, as a sleeping chamber at night.

"Hassler wanted his survey to be not only practically useful, but also a contribution to the science of geodesy * * * on a par with European contributions * * *. Congress had not the least idea of the coast survey as a science; to them it was an enterprise no different from the survey of the Northwest Territory"—a simple matter of using compass and chain and turning out maps and charts with regularity. After a year's work Hassler had no maps to offer.[7]

The next decade was as bleak a period for Hassler as it was for the progress of the survey. A week after militarization of the coast survey, President Monroe appointed Hassler as one of the astronomers in the party sent to fix the boundary line with Canada in upper New York State, as provided in the treaty ending the War of 1812. A year later Hassler, in conflict with the U.S. Commissioner over his progress and his expenses, resigned. He sought a professorship at Jefferson's University of Virginia, still under construction. He considered returning to Europe, but his wife would not consent. He decided to farm and teach, and in 1820, despite the known severity of climate and his complete lack of experience as a farmer, he purchased a tract of land at Cape Vincent in New York State, overlooking the Thousand Islands in the St. Lawrence. There he planned, with characteristic enthusiasm, to establish a normal school and agricultural college.

With high expectations, he sold at a sacrifice most of the furniture and all of the pictures, statuary, and Sèvres porcelain in the house the family was then occupying on the Commons in Newark, N.J., and almost all that was left of his original collection of books. The remaining furniture was packed in two large Jersey wagons, and with Hassler's wonderful instrument carriage, which he purchased when it was sold at auction in 1819, the family set out on the 400-mile journey to Cape Vincent.

The house he had bought sight unseen in New York State for $1,000 proved to be two 1-room log cabins. Gathering together the carpenters and masons in the neighborhood, he began construction of a great 16-room house, destined to be completed but never occupied. Some farming was begun, but the plan for a college was soon abandoned. In the spring of 1823, while Hassler was on one of his frequent absences from home, perhaps attending a meeting of the Philosophical Society in Philadelphia, and his children were in the fields, his wife gathered her personal belongings and left him, never to return.

Leaving his eldest son in charge of the farm, Hassler soon after took a teaching position at Union Hall Academy at Jamaica, Long Island, and brought the other children to New York. When the Academy failed in 1827, he taught at another in Richmond, Va., and continued to seek a university position. But his marked foreign accent, his rather erratic temperament, and his age, then 55, were against him. Always a tireless talker, he had also been a tireless writer, about his projects, his progress in the survey work, his construction of instruments, his scientific observations delivered before the Philosophical Society. Now he turned to writing textbooks, and with some success found publishers for his "Elements of Analytical Trigonometry" (1826), "Elements of Arithmetik, Theoretical and Practical" (1826), "Elements of Geometry of Planes and Solids" (1828), "A Popular Exposition of the System of the Universe with Plates and Tables" (1830), and "Logarithmic and Trigonometric Tables" (1830). the latter with introductions published in five languages.

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[7] Hassler's undertaking, "which Congress supposed would be finished in a few years, has now taken 150 years, and no end is in sight." Elliott B. Roberts, "United States Coast and Geodetic Survey, 1807–1957," Ann. Rep., Smithsonian Institution, 1957, p. 222.

A new employment came in the autumn of 1829 when, impelled by want, Hassler accepted an appointment as gager in the New York Custom House. Then his fortunes began to look up. For some time Congress had been discussing the establishment of standards of weights and measures for the United States. There was much talk about the jeopardy to this country's international trade arising from the different concepts of pounds and bushels entertained by the various collectors of customs. On May 29, 1830, the Senate adopted a resolution directing a comparison of the weights and measures used at the principal customhouses. Five months later, on November 2, President Jackson placed Hassler in charge of the study, at $3,000 per year, to make an inspection and review of the measures used in the customhouses.

After 3 months, Secretary of the Treasury Ingham reported Hassler's inspection "far advanced; and it has exhibited such a remarkable disparity in the weights and measures used at the different customhouses, as to demonstrate the urgent necessity of providing standards for their regulation." Called in from the customhouses,

> the standards, where any such existed, were transmitted to Washington, and it soon appeared that they were of so irregular character, and so unworthy of confidence, that the comparison of them, indefatigably pursued by Mr. Hassler, was a task entirely beneath his attention. The measure which proved the nearest to the standard was a *folding* yard stick from Philadelphia, the length of which is stated at 36.0002465 standard inches.[8]

With no authority but the approval of Secretary Ingham and the President, Hassler determined to adopt standards for the United States and produce and distribute them to the customhouses. From among the standards that he and Gallatin had secured abroad many years earlier for the survey of the coast, Hassler selected the units to be used for the construction and comparison of suitable weights and measures, and out of his knowledge and skill began construction of the balances and other apparatus for their verification. The fundamental units of length, mass (weight), and capacity recommended by Hassler were adopted by the Treasury Department in 1832, and Fdward Troughton Hassler, his 23-year-old son, was taken on to assist in the construction of standards based on those units.[9]

Apprised by Treasury reports of Hassler's progress, Congress in a joint resolution of June 14, 1836, gave its formal approval and directed the Treasury to fabricate for the customhouses the standards of weights and measures that had been established—that is, established by Hassler. By reason of the joint resolution of 1836, the Office of Weights and Measures in the Coast Survey, as the immediate antecedent of the present National Bureau of Standards, is considered formally established as of that date.

Meanwhile, on July 10, 1832, 2 years after calling for the inquiry into the customhouses, Congress reestablished the Coast Survey on the basis of the original act of 1807. Upon President Jackson's recommendation, Hassler again became its Superintendent, at

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[8] Report of Alexander D. Bache in J. Franklin Inst. 13, 238 (1834). Cited in Cajori, p. 156, and available on L/C microfilm reel 283, series 01104.

H. Doc. 229, 22d Cong., 1st sess., 1832 (L/C: J66), is Hassler's report on his examination in 1831 of the weights and measures used in the principal customhouses, and includes his description of the collection of instruments available to him for constructing weights and measures.

[9] The start of the work is described in Hassler's Documents Related to the Construction of Standards of Weights and Measures for the Custom-Houses from March to November 1835 (New York: William van Norden, 1835). L/C: QC1000U58.

a salary of $3,000 and $1,500 for expenses, and was to continue his superintendency over the work in Weights and Measures, without additional compensation..

The survey of the coast that had been carried out after 1818 largely under naval auspices produced a vast body of partial maps and charts at vast expense, Secretary of the Navy Southard reported in 1828. The maps and charts were based on nautical and chronometric surveys, not triangulation, and so far as their use for commercial and naval interests and means for national defense was concerned, Southard declared them "unsafe, and in many instances, useless and pernicious." Hassler resumed the survey on his original plan.

Once again in charge, he borrowed the mathematical books he had sold to West Point more than a decade before, refurbished his traveling carriage brought down from Cape Vincent, and ordered from Troughton of London a new and improved theodolite made to his specifications, as well as a dividing engine, new telescopes and microscopes of his devising, and other instruments. While his son Edward continued the work on weights and measures, Hassler himself began measuring a new baseline at Fire Island, off the south shore of Long Island, "the longest baseline," it was later reported, "ever run in the history of geodetic surveys." At the peak of activities in 1841, Hassler, with the Army topographic engineers and Navy officers detailed to the Survey, had under his superintendence in the two offices a staff of 93 officers and civilians.

The years between 1832 and 1843 were filled with skirmishes with the Secretaries of the Treasury, with accountants and auditors, and with Congress over the financial procedure in operating the offices, over congressional demands that would have meant a less accurate, less scientific, and cheaper survey, and threats to form committees to supervise Hassler's expenditures and progress. In March 1834, possibly to insure more professional administration, the Coast Survey was transferred from the Treasury to the Navy Department, and Hassler at once asked to be relieved from the Survey work. President Jackson intervened, kept the accounting of Survey funds in the Treasury, and Hassler accepted Navy administration.

At the time of the transfer, Hassler insisted that he keep his salary of $3,000 for superintending Weights and Measures alone. Secretary of the Treasury Levi Woodbury replied that the Office need not require much time and attention, and $1,200 or $1,500 was enough for the work. Hassler answered that he had large plans for Weights and Measures. As he wrote to the Secretary, he intended "to form an establishment which has never even been attempted in this country," for which much heavier expenditures would be necessary. He may have had in mind somthing like the bureau established almost 70 years later, but what he intended is not known. Before the plans were committed to paper, President Jackson in March 1836 restored the Coast Survey to the Treasury and to Hassler.

It is said that on the occasion of the restoration a dispute arose about more compensation for Hassler's two superintendencies, and Hassler carried his case to the White House.

> "So, Mr. Hassler, it appears the Secretary and you cannot agree about this matter," remarked Jackson, when Hassler had stated his case in his usual emphatic style. "No, Sir, ve can't." "Well, how much do you really think you ought to have?" "Six thousand dollars, Sir." "Why, Mr. Hassler, that is as much as Mr. Woodbury, my Secretary of the Treasury, himself, receives." "Mr. Voodbury!" declared Hassler, rising from his chair, "There are plenty of Voodburys, plenty of Everybodys who can be made the Secretary of the Treasury. But," said he, pointing his forefinger toward himself, "there is only one, *one* Hassler for the head of the Coast Survey." President Jackson, sympa-

thizing with a character having some traits in common with his own, granted Hassler's demand.[10]

Then in his middle sixties and going strong, Hassler wore flannel both summer and winter, believing it kept off the heat as well as kept out the cold. He never used glasses for reading or writing, but kept his vest pockets filled with snuff, which he was convinced excited the optic nerves and was the only help his eyes needed. Working at night at the Coast Survey office, first on 13th Street and later in adjoining row houses on Capitol Hill, he had for light at his desk six or eight large wax candles, remolded from commercial candles to about 2 inches in diameter with double or triple plaited wicks.[11] His daughter Rosalie in her "Recollections" of her father was to say that he never went to bed before 2 or 3, and finally lost the sight of one eye shortly before his death "by the over fatigue in adjusting the yard and liquid measures." To the last his heavy accent sometimes made it difficult to understand him, "but his singularities of manner," recalled a zealous friend in the House, Joseph L. Tillinghast of Rhode Island, "did not touch his intelligence and eminent capacity in his vocation."

Between 1832 and 1841 Congress appropriated a total of $620,000 for the Coast Survey offices. At Hassler's death in 1843 Survey funds had paid for the triangulation of an area of 9,000 square miles, furnishing determinations of nearly 1,200 geodetic stations for the delineation of 1,600 miles of shoreline. One hundred and sixty-eight topographical maps had been surveyed and 142 hydrographic charts, although only 5 large charts were engraved and ready for publication.[12]

In the Weights and Measures Office, Hassler saw complete sets of weights with their multiples and submultiples finished and delivered to the customhouses and to the States. Half of the capacity measures and a third of the measures of length were constructed, but 13 years would pass before the last of them, and the necessary balances, were delivered.

The summer and fall of 1843 found Hassler, now 73, in the field, surveying in New Jersey and Delaware. In a rain and sleet storm that October he fell and injured himself on a rock while trying to save the tent protecting one of his instruments. As a result of the injury and exposure he developed a fever and inflammation of the lungs that forced him to go home to Philadelphia for medical help, where Rosalie could look after him.

During his last weeks he wrote out his annual report to the Secretary of the Treasury. The comprehensive plan for the continuation and expansion of the work that he outlined in the report had already been approved by the President. Its execution was begun by his successor, Alexander Dallas Bache, and the plan remained the basis for survey operations until the enabling act of 1947 established a new, but not greatly

[10] Reported by T. C. Mendenhall in 1916 and by Cajori in 1929, at least two versions of this anecdote existed prior to 1900, in E. Zschokke's Memoirs, pp. 529–530, and in Harper's, 58, 508 (1878–79). It was therefore very much alive in 1900 when Secretary of the Treasury Lyman Gage retold it as his own story, with reference to Dr. Stratton's proposed salary. See ch. I, p. 45.

[11] Admiral Richard Wainwright, who came to the Survey just after Hassler's death, said he "knew the old office building thoroughly, from the weights and measures in the basement to the computers' rooms in the attic." Centennial Celebration of the U.S. Coast and Geodetic Survey (Washington, D.C., 1916), p. 91.

[12] For an account of Hassler's search for high grade copper plates in this country, Austria, and France, and his importation of two highly trained engravers from Hamburg, see Cajori, p. 216.

According to Dr. Lewis V. Judson, who came to the weights and measures division of the Bureau in 1917, this plaque or nameplate in gold with Hassler's name in black letters was brought from the Office of Weights and Measures on New Jersey Avenue to Connecticut Avenue by Mr. Fischer.

altered statement of functions. Hassler continued to work, writing in his journal, until shortly before his death on November 20, 1843.

He left behind his daughter Rosalie Lätitia Norris; his eldest son John James Scipio, a topographical assistant in the Coast Survey; Edward Troughton, in the Weights and Measures Office; Charles August, a surgeon in the Navy; Ferdinand Eugene, consul at Panama; and his second daughter, Caroline, a childlike woman of 43, in the care of Rosalie. His three other sons had died under age or in infancy. His wife Marianne, whom he saw just once briefly a few years after she left home, lived with friends for a number of years, then with her eldest son in Pennsylvania, later with Rosalie in New Brunswick, and finally with friends on Long Island, where her death occurred in 1858 at the age of 86. Hassler left no debts at this death, nor did he leave any money either. The farm at Cape Vincent was all that his surviving children inherited.

Tribute to Ferdinand Rudolph Hassler as the first scientist of rank in the employ of the Federal Government has increased with the years. His genius lay in the design of instruments for his geodetic work and in his tireless efforts to contrive the best possible standards of weights and measures with the best possible materials. He was dogmatic and uncompromising, qualities destructive in his personal life, perhaps, but true to the spirit of inquiry. As his biographer, Cajori, says, he "stands out greatest in perceiving what was best in the practical geodesy of his time, in making improvements upon what he found, and then clinging [without compromise to what] he had initiated as being the best that the science of his day had brought forth."

At the centennial celebration of the Coast and Geodetic Survey in 1916, with its many tributes to Hassler, it was said:

> To him belongs the credit that to-day the operations of the Survey are bound together by a trigonometric survey with long lines and executed by the most accurate instruments and the most refined methods.

Dr. Stratton on that occasion called him—

> not only the first and foremost man in the scientific work of our country at that time but one of the leading * * * metrologists of his day. I doubt if there were more than half a dozen people in the world at that time who

> possessed the scientific knowledge and the deftness of the artisan necessary to undertake his work.

More recently it has been said:

> His greatest gift to America was not the surveys he accomplished—it was his reverence for sound thinking, integrity, and accuracy, which have endured as basic elements of Survey philosophy * * *. He may have been as consecrated a public servant as ever lived.[13]

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[13] Annual Report, Smithsonian Institution, 1957, pp. 223, 225.

APPENDIX B

THE METRIC SYSTEM IN THE UNITED STATES

THE FRENCH ORIGIN OF THE METRIC SYSTEM

The genesis of the modern metric system was a decimal system, based on the length of an arc of 1 minute of a great circle of the earth, first proposed by Gabriel Mouton, a vicar of Lyons, France, in the late 17th century. The proposal confronted a plethora of arbitrary systems of weights and measures current in France, as in the rest of Europe, their lineage going back to medieval measures based on the size of barley corns and the length of human feet. Mouton's plan was discussed for almost a hundred years before the progress of commerce and science called for more rational measures than the weights and measures in common use.

The beginning of order took place in 1790 when Tallyrand proposed to the French National Assembly the desirability of a system of weights and measures that would not only bring uniformity to France but would also be international in application. It must, therefore, he reasoned, be based on some invariable unit of nature that could not only be readily reproduced but would be capable of being measured with a high degree of precision.

A decree of the National Assembly on May 8, 1790, sanctioned by Louis XVI on August 22, called upon the Academy of Sciences, in concert with the Royal Society of London, "to deduce an invariable standard for all the measures and all the weights."[1] When English interest in a French undertaking could not be obtained, a committee of philosophers of the Academy, composed of Borda, Lagrange, Laplace, Monge, and Condorcet, began deliberations, reporting its conclusions in March 1791. The choice of a fundamental unit as the basis of a rational system of measures was between the length or fraction of the length of a pendulum, vibrating in intervals of 1 second or some chosen unit of time; the quadrant of a great circle of the equator; and the quadrant of a great circle of the earth's meridian. Since the pendulum introduced a new and unlike element, the second, and depended on the varying intensity of the gravitational force on the earth's surface, the committee preferred a terrestrial arc.

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[1] William Hallock and Herbert T. Wade, The Evolution of Weights and Measures and the Metric System (New York: Macmillan, 1906), p. 47. Hallock and Wade and the article by Henrie Moreau, "The Genesis of the Metric System and the Work of the International Bureau of Weights and Measures," J. Chem. Educ. 30, 3 (1953), provide the basis for this account of the metric system. Other sources that have been consulted but not cited here include NBS S17, "History of the standard weights and measures of the United States" (Fischer, 1905), reprinted as M64 (1925); M122, "Weights and measures in Congress" (S. A. Jones, 1936); C570, "Units and systems of weights and measures" (Judson, 1956); C593, "The Federal basis for weights and measures" (R. W. Smith, 1958); TNB 43, 1–3 (1959); and M247, "Weights and measures of the United States" (Judson, 1963). The most complete history of the metric system is that of Guillaume Bigourdan, Le Systême Métrique des Poids et Mesures (Paris, 1901).

As the more practicable of the two earth circles, the committee proposed to measure an arc of meridian between Dunkirk, on the northern coast of France, and Barcelona, on the Mediterranean Sea. From the distance determined, computation would be made of the length of the entire quadrantal arc from the pole to the equator, allowing for the deviation of the earth's form from a true sphere. The ten-millionth part of the total computed length was then to be taken as the base or fundamental unit of length and accurately marked off on a suitable number of specially constructed metal bars, copies of which would provide working standards for science and commerce.

The plan was adopted and the Academy of Sciences assigned the term mètre (meter) from the Greek metron, a measure, to the one ten-millionth part of the quadrant, fixing the new unit provisionally at 3 pieds 11.44 lignes, based on calculations made of a meridian in France by Lacaille in 1740.[2] This unit was roughly similar to the Dutch ell, the English yard, the Italian braccio, and other standard lengths in the nations of Europe.

From the concept of this single length standard, all other weights and measures were to be derived. Decimal multiples and submultiples of the meter were to express its macro and micro versions. A new, single unit of weight or mass, the gram, with similar decimal multiples and submultiples, was to replace existing weights, the new standard corresponding to the mass of 1 cubic centimeter (that is, a cube one-hundredth of a meter on a side) of pure water. The unit of capacity, the liter, would be a volume of pure water equal to 1 cubic decimeter. The measure of volume, especially for cord wood, the stere, was to be a meter cubed. And the unit of land area, the are, was to be a square 10 meters on a side or 100 square meters.

The concept had and still has merit and profundity. But as we shall see, the theoretical perfection of the metric system could not be realized.

Working with the greatest precision attainable with the instruments and knowledge available, members of the Academy measured by triangulation the meridional distance through Paris of the arc from Dunkirk to Barcelona, a strip of country made up of mountainous and inaccessible districts. The work was not only arduous but hazardous, since it was carried out during the Reign of Terror and was subject to repeated harassment.

In April 1795, even before a definitive meter was derived from the astronomical and geodetic measurements along the Dunkirk-Barcelona meridian, the revolutionary government instituted the metric system in France, using the provisional meter as standard and fixing the nomenclature of the new units of measure.

In June 1798, 6 years after beginning the fieldwork, the observations of the parties of geodecists under Méchain and Delambre were completed and at the invitation of the government a committee of delegates from the republics of Europe studied the assembled computations. While one section of the committee examined the measurements of the arc of meridian and the actual length of the meter, another, which included Johann Georg Tralles, deputy of the Helvetic Republic,[3] undertook determination of the unit of mass, the gram. When so small a mass could not be realized with sufficient accuracy, its multiple, the kilogram, was selected for construction of the standard of mass.

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[2] Interestingly, the provisional meter in brass, constructed by Lenoir of Paris in 1795, proved to differ from the meter finally determined by only about 0.33 millimeter.

Before the establishment of the metric system, the principal units in use in France were the pied du Roi (0.325 meter) for lengths and the livre poids de marc (489.5 grams) for weights. The pied du Roi was divided into 144 lignes, and 6 pieds du Roi made a toise (1.949 meters), the common unit of length.

[3] See Hassler appendix for note on Tralles.

The results of the computations gave the distance from the pole to the equator as 5,130,740 toises, with the length of the meter 3 pieds 11.296 lignes. The weight of a cubic decimeter of distilled water at maximum density gave the value 18,827.15 grains (a submultiple of the livre poids de marc), which was adopted as the weight of the kilogram.[4]

THE METER AND KILOGRAM OF THE ARCHIVES

Construction in platinum of the prototype meter and kilogram was completed in June 1799, for deposit in the Archives of the Republic. Iron copies of these standards were then made and distributed among the committee delegates as models for the construction of their new weights and measures. On December 10 the provisional meter was abolished and the new standards adopted by statute as the definitive standards of the measures of length and of weight throughout the Republic.[5] The grand plan of unifying weights and measures was completed.

One of the iron copies of the Meter of the Archives, the gift of Tralles to his friend Hassler, and destined to be known in the United States as the "Committee Meter," was brought to this country by Hassler in 1805. He also brought a copy of the kilogram, another gift of Tralles, and 3 toises, the rival of the meter in France until late in the 19th century.

In financial distress, Hassler in 1806 sold these standards to a member of the American Philosophical Society. They were loaned to him when he became Superintendent of Weights and Measures in the Coast Survey, his Committee Meter serving as the standard of length in the Coast Survey until 1890. With other standards secured by Hassler abroad, it is now preserved in the vault of the National Bureau of Standards.[6]

The advantages of the metric system then as now resided in its simplicity, uniformity, and convenience. It is entirely decimal, like our system of counting.[7] The measures of area, capacity, and volume are obtained by squaring and cubing measures of length. Weights are directly related to the measures of volume. And the names of their multiples and submultiples are obtained by the simple addition of prefixes to the principal unit, for example, kilo (k) = 1,000; hecto (h) = 100; deka (dk) = 10; deci (d) = 0.1; centi (c) = 0.01; milli (m) = 0.001. Thus a kilometer is 1,000 meters, and a milligram is a thousandth (0.001) of a gram.[8]

But the metric system was not beyond cavil. Lukewarm to pronounced opposition under the succeeding imperial government confronted the standards established by the

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[4] Hallock and Wade, p. 62.

[5] Ibid., p. 63.

[6] The metric and English weights and measures acquired by or available to Hassler for his survey of the coast are described in his report to Congress, H. Doc. 299, 22d Cong., 1st Sess., 1832.

[7] The metric system is a decimal system, but the terms "metric" and "decimal" are not synonymous. The decimal system, of oriental origin, refers to a numbers system progressing by tens, based on the biological fact that man has that many articulate fingers. Equally arbitrary and useful numbers systems have been based on 2, 5, 6, 8, and the duodecimal system of 12.

[8] In 1962 the International Committee on Weights and Measures added two new metric prefixes (atto, the submultiple 10^{-18} and femto, 10^{-15}) to the scale already ranging from tera, 10^{12} to pico, 10^{-12}. See NBS TNB 48, 61–62 (1964).

republican regime, as witnessed by the failure of the State to construct and distribute the necessary secondary standards. The new standards were especially threatened by a decree of Napoleon in 1812 that, yielding to prejudice, permitted for a decade a system of *mesures usuelles* using odd multiples and fractions of the metric system to harmonize with the very measures the metric system was intended to replace, those long established in commerce and common usage. In 1837 the State repealed the edict and allowed 3 years for full compliance with the new measures. After January 1, 1840, under pain of severe penalties for the use of any other weights and measures, the metric system was made universal and compulsory throughout France.

The instability of 19th-century Europe, with its profusion of petty kingdoms and principalities and its wars and revolutions acted to retard acceptance of the metric system. Upon Tralles' return from Paris he urged introduction of metric weights and measures into Switzerland and in 1801 saw a law passed adopting them. But the metric system was not made compulsory in that country until 1856.

Some of the Italian provinces adopted it in the early 19th century, in 1816 the metric system was declared obligatory in the Low Countries, and Spain accepted it in 1849. After 1860 adoptions increased rapidly, the entering wedge in most instances the necessity of uniform weights and measures in international trade.

The metric system crossed the Atlantic when by law it came into effect in Mexico in 1862, and before the end of the century it had become the legal system in most South and Central American countries. Italy made the metric system obligatory in 1863. In Great Britain, an act of July 29, 1864, authorized the use of the metric system concurrently with the imperial system. Two years later, with passage of the Metric Act on July 28, 1866, Congress also made use of the metric system legal throughout the United States.[9] By this act, the meter was declared to be 39.37 inches, the kilogram 2.2046 pounds, based on the best metric standards available in this country, Hassler's Committee Meter and the platinum Arago kilogram obtained in 1821 by Secretary of State Gallatin.

The agreement among the federated states of Germany in 1868 to adopt the metric system became obligatory under the empire in 1872, the same year it was officially adopted in Portugal. Austria made its use compulsory in 1876, and Norway in 1882.

THE METRIC CONVENTION

It was not commercial application of the metric system but its growing use in scientific work in Europe that made the accuracy of its fundamental units of increasing concern, especially to mathematicians, geodecists, and physicists. The more accurate measurements of arcs of meridians reported by British and Russian geodecists at the International Geodetic Conference held at Berlin in 1867 resulted in new computations of the shape of the earth and hence the length of the quadrant. The changes in this last quantity therefore affected the length of the meter and raised serious questions about it as a natural and absolute standard.[10]

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[9] An act of Congress on July 27, 1866, authorizing the Secretary of the Treasury to furnish the States with sets of metric weights and measures, actually preceded passage of the Metric Act by 1 day. Hallock and Wade, pp. 128–129.

[10] Hallock and Wade, p. 69. The actual difference in the Meter of the Archives, as in the International Meter that replaced it, is minute but significant in metrology. It is about 0.2 millimeter shorter than its definition, the ten-millionth part of the quadrant of the earth's meridian. Similarly, the International Kilogram exceeds by 0.028 gram

In response, the French Government in 1872 held an international conference, attended by scientific representatives from 26 countries, including the United States, that resolved on the preparation of new prototypes. They would be arbitrary prototypes—as arbitrary, in a sense, as the weights and measures that the metric system supplanted—but practical, and if adopted internationally would place metric standards on a permanent basis for the service of science and commerce.

The conference agreed to the construction of a number of prototype meters and prototype kilograms, their values copied exactly from those of the units in the Archives in Paris, made 75 years before. Upon examination, the meter and kilogram of the Archives were found perfectly preserved, and comparison of the meter with two others constructed at the same time demonstrated it had not appreciably altered in length. The Archives units were therefore to be reproduced in a new metal, a more stable shape, with greater refinement of line, and other precision factors. One each of the new meters and kilograms was to be chosen as the international standard of length and weight, respectively, and to be deposited in an international repository. It was agreed that the repository and its laboratory be located at Paris, its site neutral ground, acccessible to all the participating countries, and under their common care. After selection of the international prototypes, the remaining prototypes were to be distributed by lot to the contracting governments as their national metric standards.

An international treaty, the Metric Convention (Convention du Mètre), concluded in Paris on May 20, 1875, and signed by 18 countries including the United States and Russia, with Great Britain and Holland abstaining, put the recommendations into effect. The Pavilion de Breteuil, orginally a small royal palace, on the bank of the Seine near Sèvres, off the Paris-Versailles Road, was offered by the French Government as the repository and designated the International Bureau of Weights and Measures (Bureau International des Poids et Mésures).

After construction and verification of the new standards, the permanent functions of the Bureau were to include custody of the international metric prototypes, official comparison with national standards, comparison of other units with the metric standards, the standardization of geodetic instruments and other standards and scales of precision, and such other scientific work as international metrology might require.

As organized in 1875 and continuing today, the authority governing the Bureau, its Director, and his staff emanates from the General Conference of Weights and Measures which meets every 6 years, made up of delegates from all the countries belonging to the Metric Convention, presently 40 in number, whose contributions support the expenses of the Bureau. The decisions of the General Conference are put into effect by a permanent International Committee of Weights and Measures, at present numbering 18 scientists or technologists, each from a different member nation that has adopted the metric system, and this committee meets every 2 years at the Bureau at Sèvres.[11]

The new standards constructed in the laboratories of the International Bureau were composed of an alloy of 90 percent platinum and 10 percent iridium. The international prototype meter was defined as the distance between two fine lines on a particular platinum-iridium bar, at 0° C., the temperature of melting ice. The kilogram was determined with reference to its weight in a vacuum, using a new balance of extreme precision, especially constructed for that weighing. The actual work of construction began in 1877.

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its original definition, the mass of a cubic decimeter of pure water at maximum density. See Moreau, p. 13.

[11] The U.S. representatives on the International Committee have been J. E. Hilgard (1875–97), B. A. Gould (1887–96), A. A. Michelson (1897–1905), S. W. Stratton (1905–31), A. E. Kennelly (1933–39), E. C. Crittenden (1946–54), and A. V. Astin (1954–).

The preparation of the standards, the tracing of the defining lines, and comparison with the standards of the Archives were carried out by the French section of the International Bureau. In 1889, at the First General Conference of Weights and Measures, the prototype units were selected and deposited in a multiple-locked subterranean vault located between the pavilion and observatory of Sèvres. Distribution of the remaining identical meters and kilograms began, the national copies of the meter said to agree with the international unit within one-hundredth of a millimeter and with a probable error not exceeding two ten-thousandths of a millimeter. The copies of the kilogram agreed within 1 milligram, with a probable error not exceeding five-thousandths of a milligram. Two thermometers reading to one-hundredth of a degree Centegrade accompanied each pair of national standards.

The initial copies of the international prototype meter and kilogram allotted to the United States, meter No. 27 and kilogram No. 20, arrived in Washington in January 1890 and with appropriate ceremonies were deposited in a fireproof room at the Office of Weights and Measures in the Coast Survey building. The following July, meter No. 2 and kilogram No. 4 were received and deposited with those accepted as the national standards.

The new U.S. standards, meter No. 27 and kilogram No. 20, were formally recognized by an order of the Secretary of the Treasury on April 5, 1893, as the basis for deriving the customary units, the yard and pound, and for constructing and standardizing secondary metric standards. Over the next decade, efforts to legislate adoption of metric weights and measures as the universal standards in this country came closer to realization than at any time in the history of the Nation. Such legislation, seeking uniformity in weights, measures, and coinage, had been under consideration since the Colonies joined in the Articles of Confederation.

THE AMERICAN ATTITUDE TOWARD THE METRIC SYSTEM

The Colonies were in the midst of their war for independence when the question of uniform coinage was raised by Thomas Jefferson. The decimal system he urged was finally adopted by Congress on July 6, 1785, and a law of 1828 established a brass weight obtained by the Minister of the United States at London as the standard troy pound of the U.S. Mint for the control and stabilization of the currency.

From the first, President after President and the successive Secretaries of the Treasury appealed to Congress for uniformity in the weights and measures, as well as the currency, "a subject of great importance," as Washington declared in 1789, "and will, I am persuaded, be duly attended to."

Shortly after adoption of decimal coinage, Jefferson, disapproving of a unit derived from an arc of meridian determined on European soil, proposed instead decimal weights and measures based on a foot derived by taking one-fifth of the length of a rod forming the seconds pendulum.[12] A Senate committee in 1792 reported favorably on its adoption but Congress took no legislative action. Nor was Congress moved by the President's report in 1795 announcing adoption in France of the metric system and urging its adoption also in America.

The Coast Survey was the first Federal agency to require a definite length standard. Its Superintendent, Hassler, chose the iron-bar standard copied by Lenoir of Paris in 1799 from the Meter of the Archives (the U.S. Committee Meter), given

[12] Hallock and Wade, p. 112.

him by Tralles. Thus from the outset Coast Survey operations in the United States were based on a metric standard, and all base measurements of the Survey continued to be referred to this meter until receipt of the national prototype in 1890.

Although arguments for uniformity were raised at almost every session of Congress, the slow progress of the metric system in France did not encourage its introduction in this country. Secretary of State John Quincy Adams in his classic report of 1821, prepared at the request of Congress, wrote that the French system "approaches to the ideal perfection of uniformity applied to weights and measures * * *. The meter will surround the globe in use as well as multiplied extension, and one language of weights and measures will be spoken from the equator to the poles."[13] Nevertheless, Adams did not think its introduction practicable at that time, nor did Congress.

A degree of order in the weights and measures in common use was achieved by Hassler when in 1838 his Office of Weights and Measures began delivering to the States and a year later to the customhouses sets of standard weights, measures of length, capacity measures, and balances, derived from yard and pound standards he had secured in England. In 1893 the incumbent Superintendent of Weights and Measures, T. C. Mendenhall, fixed their values by relating them to the international meter and kilogram. To this day the United States has no legal material standard yard or pound.

USE OF THE METRIC SYSTEM MADE LEGAL

Not until after the Civil War did serious consideration of the metric system arise again, when on July 28, 1866, upon the advice of the National Academy of Sciences, Congress authorized permissive and legal use of the metric system thoughout the Nation. Another act directed the Secretary of the Treasury to furnish a set of standard metric weights and measures to each of the States, and a third act that year authorized use of metric measures by the Post Office Department.[14]

As increasing numbers of scientists and professional men went to Europe in that period for their education and returned trained in the metric system, interest in it spread. About 1870 metric tables began to appear in American college textbooks, particularly in chemistry and physics, and a decade later in high school textbooks.[15] Such active reform groups as the American Metrological Society, established in New York in 1873 (ceased publication in 1888), and the American Metric Bureau, founded in Boston in 1876, sought nationwide acceptance and use of the metric system in place of yards and pounds.[16]

When in 1869 France first proposed to construct new metric standards, the strong interest in this country led the Government to send delegates to Paris to participate in the deliberations. Prof. Joseph Henry, the preeminent physicist in America at that time, and Prof. Julius E. Hilgard, in charge of weights and measures in the Coast Survey,

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[13] Hallock and Wade, p. 117.

[14] For a contemporary account of the provision of metric measures to the States, see Prof. J. E. Hilgard's report to Congress in H. Misc. Doc. 61, 45th Cong., 2d sess., May 18, 1878.

[15] Hallock and Wade, p. 125 n.

[16] At the height of the movement, the first "society for opposing introduction of the French Metric System in this country" was also formed, with the establishment in Boston in 1879 of the International Institute for Preserving and Perfecting Weights and Measures. See Edward F. Cox, "The International Institute: First Organized Opposition to the Metric System," Ohio Hist. Q. 68, 3 (1959).

and later Superintendent of the Survey, were sent to join the committee that assembled in 1872 to oversee the work of construction. On May 20, 1875, when the American Minister to France, Elihu B. Washburn, signed the Metric Convention that established the International Bureau of Weights and Measures, commitment of the United States to the principle of international metric measures was formalized.[17]

The arrival of the national prototype meter and kilogram in 1890 again stirred interest in reform. Early in 1894 the Army Surgeon General's Office, following the Marine Hospital Service and the Navy Bureau of Medicine and Surgery, directed use of the metric system in all transactions pertaining to medical supplies, and Congress moved a step closer when its act of July 12, 1894, defined the national units of electrical measurements in the new international metric terms.[18] In another affirmation, continuation of the metric system, in everyday use in both Puerto Rico and the Philippines when they became a protectorate and possession, respectively, of the United States in 1898, was confirmed. And a known champion of the metric system was raised to bureau status in the Federal Establishment when the Office of Weights and Measures became the National Bureau of Standards in 1901.

Besides acquiring new standards for promulgation in American science and industry, the Bureau was also concerned with reverifying its existing standards. In 1904 Louis A. Fischer took meter No. 27 to Paris for comparison with the standards at the International Bureau and redetermined its value in terms of the International Prototype. The minute difference that Fischer reported, in the first scientific paper published by the Bureau, had little significance at that time; and since the relation of No. 27 to No. 21, the other national prototype, was accurately known, the Bureau considered its standards quite sufficient to guarantee the accuracy and permanency of the measures in the United States.[19]

LEGISLATION FOR THE METRIC SYSTEM

Legislation around the turn of the century for replacement of customary measures with the metric system appeared increasingly imminent and each bill won stronger support than the last. In 1896 a bill to make mandatory the metric system received unanimous recommendation for adoption by the House Committee on Coinage, Weights, and Measures, only to fail of passage in its third reading. Another bill in 1901 was received too late to be considered by the Congress then in session. Hearings were held on similar bills again in 1902 and 1903, and although none proposed compulsory acceptance but only gradual extension of the metric system into universal use, they succumbed in committee. So did a new bill in 1905 that sought establishment of the metric system in all transactions and activities of the Federal Government, whence, it was thought, its use would filter down to industry and eventually to the general public.

A notable impetus towards wider acceptance of the metric system loomed in 1914–15 when American industries supplying the French with war materiel necessarily converted their plants to the metric system. The conversion in industry became widespread in 1917–18 when the American armies in France adopted the metric system not only in ordnance and instrumentation but in all operational computations. But the armies did not bring the metric system home with them, and American industry reverted to its former habits when the war production lines stopped.

[17] Hallock and Wade, pp. 129–130.
[18] Ibid., pp. 195–196, 208–210.
[19] NBS S1, "Recomparison of the United States Prototype Meter" (1904).

By the 1930's metric measures had become sufficiently important in American industry to call for a simple factor for converting inch measurements to metric measurements, and in 1933 the American Standards Association approved an American standard inch-millimeter conversion for industrial use in which the inch was defined as 25.4 millimeters.

As a result of difficulties in interchanging precision parts and products manufactured during World War II, legislation was again sponsored between 1945 and 1947 to define the relation as a standard, this time as 2.54 centimeters. Although passage again failed, the obvious usefulness of the centimeter-inch ratio led to its adoption in 1952 by the National Advisory Committee for Aeronautics.

When the Director of the National Bureau of Standards realized that legislation was not necessary if agreement could be reached with the other national standards laboratories to use the conversion factor, it was proposed to them. Apart from the Coast and Geodetic Survey, which, with its amassed calculations fixed, would be excepted, the proposal won agreement. On July 1, 1959, the directors of the national standards laboratories of Australia, Canada, South Africa, the United Kingdom, and the United States adopted the equivalents, 1 yard=0.9144 meter (whence 1 inch=25.4 millimeters) and 1 avoirdupois pound=0.453 592 37 kilogram. Without national legislation, the differences between the United States inch and pound and the British inch and pound, so important to industry and trade, were reconciled and uniformity was established in the science and technology of the English-speaking nations.

WAVELENGTH DEFINITION OF THE METER

When the National Bureau of Standards was established in 1901, the principal units of weights and measures were the yard and pound as defined by Mendenhall ($\frac{3,600}{3,937}$ meter and 0.453 592 427 7 kilogram, respectively) and the gallon and bushel as defined by Hassler (a volume of 231 cubic inches and of 2,150.42 cubic inches, respectively).[20] These definitions remained unchanged for 58 years, and the last two are still the official values.

Failure of the metric legislation in the United States has not, however, deterred American contributions to continuing refinement of the value of the meter upon which our units depend. When the original basis of the metric system on a terrestrial dimension proved untenable, and a more serviceable and secure basis was found in an internationally accepted definition of the meter, world metrologists continued to seek some other natural, physical standard that would make for higher precision and more universal reproducibility. Such a physical standard became available in 1892–93 when Prof. Albert A. Michelson, on leave from the physics department of the University of Chicago for a year's work at the International Bureau at Sèvres, showed that the standard of length could be replaced by reference to a specific wavelength of light, one of those in the cadmium spectrum.

The line of research stimulated by Michelson's work was not to change the magnitude of the meter unit but to define it as a specified number of wavelengths. More than a quarter of a century later, in 1927, the Seventh General Conference of Weights and Measures provisionally adopted as a supplementary standard of length the equation, 1 meter=1 553 164.13 wavelengths, with an accuracy within 1 part in 10 million, as the relation between the meter and Michelson's red cadmium light wave.

[20] See ch. I, pp. 26–27, 30.

The small palace that is the International Bureau of Weights and Measures near Sèvres, France.

After another three decades of research, which saw light wave measurements pass from those of the elements to their isotopes, the 11th General Congress on October 14, 1960, adopted as a new definition of the meter, 1 650 763.73 wavelengths of the orange-red radiation of the isotope of krypton with mass 86.

Adoption by the National Bureau of Standards of the new definition does not invalidate the fact that the International Prototype Meter is still the major source and support of the common measures of the United States, even though it is no longer necessary to take the U.S. prototype meter to the International Bureau for comparison. And, periodically, legislation will continue to be proposed for conversion in one degree or another to the metric system. Its completeness, uniformity, simplicity, and widespread use elsewhere in the civilized world make its use obligatory in almost all scientific measurements and computations. Besides our coinage, it is found in general use in library catalog cards, in book, pamphlet, postage, and film measurements, in describing the properties of photographic lenses, in track and field events in athletics, in electrical units of measurement, and in exact mechanical work. The thickness of metals, paper, and glass is commonly measured in metric terms, as is the diameter of wire, tubing, and similar products.

The metric system is used in microscopy and spectroscopy, in geodesy and engineering, in the scientific measurement of mass and volume and capacity, and in much of international commerce. No voice disputes the complexity of the system in daily use that still necessitates, as do our "English" measures, weighing copper by one standard, silver by another, medicine by a third, diamonds and other precious stones by a fourth, and chemicals by a fifth, all noninterchangeable.

The varieties of units universally used in trade in the English-speaking countries have their source in a conglomeration of discordant series with no simple relation either between the different sets of units or between units of different size in a given series. The uniformity in measures that the founding fathers sought has yet to be duly attended to.

APPENDIX C

BASIC LEGISLATION

Relating to Standards of Weights and Measures and to the Organization, Functions, and Activities of the National Bureau of Standards*

9 July **1778** ARTICLES OF CONFEDERATION, Art. 9, § 4:

The United States, in Congress assembled, shall also have the sole and exclusive right and power of regulating the alloy and value of coin struck by their own authority, or by that of the respective States; fixing the standard of weights and measures throughout the United States. . . .

CONSTITUTION of the UNITED STATES, Article 1, § 8.

The Congress shall have power . . . To coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures. . . .

Act of 19 May **1828** (4 Stat. 278)—[Adoption of a brass troy pound weight copied by Captain Henry Kater from the British troy pound of 1758 as the standard for coinage. An Act of 12 Feb 1873 (17 Stat. 424, 432) reenacted the provisions of 1828 concerning the troy pound weight.]

An Act . . . for the purpose of securing a due conformity in weight of the coins of the United States. . . . The brass troy pound weight procured by the minister of the United States at London, in the year 1827, for the use of the mint . . . shall be the standard troy pound of the mint of the United States, conformably to which the coinage thereof shall be regulated.

Joint Resolution of 14 June **1836** (5 Stat. 133)—A Resolution Providing for the [construction and] distribution of weights and measures [as modified by Acts of 14 February 1903 and 4 March 1913 transferring the responsibility to the Secretary of Commerce].

That the Secretary of the Treasury be, and he hereby is directed to cause a complete set of all the weights and measures adopted as standards, and now either made or in the progress of manufacture for the use of the several custom-houses, and for other purposes, to be delivered to the Governor of each State in the Union, or such person as he may appoint, for the use of the States respectively, to the end that an uniform standard of weights and measures may be established throughout the United States.

*In most instances only the pertinent parts have been reproduced here.

Joint Resolution of 27 July **1866** (14 Stat. 369)—Joint Resolution to enable the Secretary of the Treasury to furnish to each State one Set of the Standard Weights and Measures of the Metric System [as modified by Acts of 14 February 1903 and 4 March 1913 transferring the responsibility to the Secretary of Commerce].

Be it resolved . . ., That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of the standard weights and measures of the metric system for the use of the States respectively.

Act of 28 July **1866** (14 Stat. 339)—An Act to authorize the Use of the Metric System of Weights and Measures.

Be it enacted . . ., That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted*, That the tables in the schedule hereto annexed [omitted here] shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system. . . .

Joint Resolution of 3 March **1881** (21 Stat. 521)—Joint resolution authorizing the Secretary of the Treasury to furnish States, for the use of agricultural colleges, one set of standard weights and measures and for other purposes [as modified by Acts of 14 February 1903 and 4 March 1913 transferring the responsibility to the Secretary of Commerce].

Resolved . . ., That the Secretary of the Treasury be, and he is hereby, directed to cause a complete set of all the weights and measures adopted as standards to be delivered to the governor of each State in the Union, for the use of agricultural colleges in the States, respectively, which have received a grant of lands from the United States, and also one set of the same for the use of the Smithsonian Institution: *Provided*

That the cost of each set shall not exceed two hundred dollars, and a sum sufficient to carry out the provisions of this resolution is hereby appropriated out of any money in the Treasury not otherwise appropriated.

Act of 11 July **1890** (26 Stat. 242)—An Act Making appropriations . . . for the fiscal year ending June 30, 1891. . . . [to the] Office of Construction of Standard Weights and Measures [as modified by Acts of 14 February 1903 and 4 March 1913 transferring responsibility to the Secretary of Commerce], making sums available:

For construction and verification of standard weights and measures, including metric standards, for the custom-houses, and other offices of the United States, and for the several States. . . .

For the purchase of materials and apparatus . . .: *Provided*, That hereafter such necessary repairs and adjustments shall be made to the standards furnished to the several States and Territories as may be requested by the governors thereof, and also to standard weights and measures that have been, or may hereafter be, supplied to United States custom-houses and other offices of the United States, under act of Congress, when requested by the Secretary of the Treasury.

For the construction of standard gallons and their subdivisions for the use of States and Territories which have not received the same. . . .

For purchase of a balance of precision and its mounting. . . .

[Subsequently, the Sundry Civil Appropriation Act of 18 August 1894 (28 Stat. 383) directed the Secretary of the Treasury to furnish precise copies of standard weights and measures when lost or destroyed, upon defrayment of the expense of their construction.]

Joint Resolution of 12 April 1892 (27 Stat. 395)—Joint resolution to encourage the establishment and endowment of institutions of learning at the National Capital by defining the policy of the Government with reference to the use of its literary and scientific collections by students. [Basis for the admission of Research Associates to the use of the research facilities of the National Bureau of Standards and for providing educational courses for undergraduate members of the staff towards higher degrees.]

Whereas, large collections illustrative of the various arts and sciences and facilitating literary and scientific research have been accumulated by the action of Congress through a series of years at the National Capital; and

Whereas it was the original purpose of the Government thereby to promote research and the diffusion of knowledge, and is now the settled policy and present practice of those charged with the care of these collections specially to encourage students who devote their time to the investigation and study of any branch of knowledge by allowing to them all proper use thereof; and

Whereas it is represented that the enumeration of these facilities and the formal statement of this policy will encourage the establishment and endowment of institutions of learning at the seat of Government, and promote the work of education of attracting students to avail themselves of the advantages aforesaid under the direction of competent instructors: Therefore,

Resolved: That the facilities for research and illustration in the following and any other Governmental collections now existing or hereafter to be established in the city of Washington for the promotion of knowledge shall be accessible, under such rules and restrictions as the officers in charge of each collection may prescribe, subject to such authority as is now or may hereafter be permitted by law, to the scientific investigators and to students of any institution of higher education now incorporated or hereafter to be incorporated under the laws of Congress or of the District of Columbia, to wit: 1. Of the Library of Congress. 2. Of the National Museum. 3. Of the Patent Office. 4. Of the Bureau of Education. 5. Of the Bureau of Ethnology. 6. Of the Army Medical Museum. 7. Of the Department of Agriculture. 8. Of the Fish Commission.

9. Of the Botanic Gardens. 10. Of the Coast and Geodetic Survey. 11. Of the Geological Survey. 12. Of the Naval Observatory.

Also

Deficiency Appropriation Act of 3 March **1901** (31 Stat. 1039):

. . . That facilities for study and research in the Government Departments, the Library of Congress, the National Museum, the Zoological Park, the Bureau of Ethnology, the Fish Commission, the Botanic Gardens, and similar institutions hereafter established shall be afforded to scientific investigators and to duly qualified individuals, students, and graduates of institutions of learning in the several States and Territories, as well as in the District of Columbia, under such rules and restrictions as the heads of the Departments and Bureaus mentioned may prescribe.

Act of 12 July **1894** (28 Stat. 101)—An Act To define and establish the units of electrical measure.

Be it enacted . . ., That from and after the passage of this Act the legal units of electrical measure in the United States shall be as follows:

First. The unit of resistance shall be what is known as the international ohm, which is substantially equal to one thousand million units of resistance of the centimeter-gram-second system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice fourteen and four thousand five hundred and twenty-one ten-thousandths grams in mass, of a constant cross-sectional area, and of the length of one hundred and six and three-tenths centimeters.

Second. The unit of current shall be what is known as the international ampere, which is one-tenth of the unit of current of the centimeter-gram-second system of electro-magnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionth of a gram per second.

Third. The unit of electro-motive force shall be what is known as the international volt, which is the electro-magnetic force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to one thousand fourteen hundred and thirty-fourths of the electromotive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a temperature of fifteen degrees centigrade, and prepared in the manner described in the standard specifications.

Fourth. The unit of quantity shall be what is known as the international coulomb, which is the quantity of electricity transferred by a current of one international ampere in one second.

Fifth. The unit of capacity shall be what is known as the international farad, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

Sixth. The unit of work shall be the Joule, which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expanded in one second by an international ampere in an international ohm.

Seventh. The unit of power shall be the Watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second.

Eighth. The unit of induction shall be the Henry, which is the induction in a circuit when the electro-motive force induced in this circuit is one international volt while the inducing current varies at the rate of one Ampere per second.

SEC. 2. That it shall be the duty of the National Academy of Sciences to prescribe and publish, as soon as possible after the passage of this Act, such specifications of details as shall be necessary for the practical application of the definitions of the ampere and volt hereinbefore given, and such specifications shall be the standard specifications herein mentioned.

Act of 3 March 1901, 31 Stat. 1449 (Public Law 177—56 Congress)— An Act To establish the National Bureau of Standards

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Office of Standard Weights and Measures shall hereafter be known as the National Bureau of Standards.

SEC. 2. That the functions of the bureau shall consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

SEC. 3. That the bureau shall exercise its functions for the Government of the United States; for any State or municipal government within the United States; or for any scientific society, educational institution, firm, corporaion, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments. All requests for the services of the bureau shall be made in accordance with the rules and regulations herein established.

SEC. 4. That the officers and employees of the bureau shall consist of a director, at an annual salary of $5,000; one physicist, at an annual salary of $3,500; one chemist, at an annual salary of $3,500; two assistant physicists or chemists, each at an annual salary of $2,200; one laboratory assistant, at an annual salary of $1,400; one laboratory assistant, at an annual salary of $1,200; one secretary, at an annual salary of $2,000; one clerk, at an annual salary of $1,200; one messenger, at an annual salary of $720; one engineer, at an annual salary of $1,500; one mechanician, at an annual salary of $1,400; one watchman, at an annual salary of $720; and one laborer, at an annual salary of $600.

SEC. 5. That the director shall be appointed by the President, by and with the advice and consent of the Senate. He shall have the general supervision of the bureau, its equipment, and the exercise of its functions. He shall make an annual report to the Secretary of the Treasury, including an abstract of the work done during the year and a financial statement. He may issue, when necessary, bulletins for public distribution, containing such information as may be of value to the public or facilitate the bureau in the exercise of its functions.

SEC. 6. That the officers and employees provided for by this Act, except the director, shall be appointed by the Secretary of the Treasury, at such time as their respective services may become necessary.

SEC. 7. That the following sums of money are hereby appropriated: For the payment of salaries provided for by this Act, the sum of $27,140, or so much thereof as may be necessary; toward the erection of a suitable laboratory, of fireproof construction, for the use and occupation of said bureau, including all permanent fixtures, such as plumbing, piping, wiring, heating, lighting, and ventilation, the entire cost of which shall not exceed the sum of $250,000, $100,000; for equipment of said laboratory, the sum of $10,000; for a site for said laboratory, to be approved by the visiting committee hereinafter provided for and purchased by the Secretary of the Treasury, the sum of $25,000, or so much thereof as may be necessary; for the payment of the general expenses of said bureau, including books and periodicals, furniture, office expenses, stationery and printing, heating and lighting, expenses of the visiting committee, and contingencies of all kinds, the sum of $5,000, or so much thereof as may be necessary, to be expended under the supervision of the Secretary of the Treasury.

SEC. 8. That for all comparisons, calibrations, tests, or investigations, except those performed for the Government of the United States or State governments within the United States, a reasonable fee shall be charged, according to a schedule submitted by the director and approved by the Secretary of the Treasury.

SEC. 9. That the Secretary of the Treasury shall, from time to time, make regulations regarding the payment of fees, the limits of tolerance to be attained in standards submitted for verification, the sealing of standards, the disbursement and receipt of moneys, and such other matters as he may deem necessary for carrying this Act into effect.

SEC. 10. That there shall be a visiting committee of five members, to be appointed by the Secretary of the Treasury, to consist of men prominent in the various interests involved, and not in the employ of the Government. This committee shall visit the bureau at least once a year, and report to the Secretary of the Treasury upon the efficiency of its scientific work and the condition of its equipment. The members of this committee shall serve without compensation, but shall be paid the actual expenses incurred in attending its meetings. The period of service of the members of the original committee shall be so arranged that one member shall retire each year, and the appointments thereafter to be for a period of five years. Appointments made to fill vacancies occurring other than in the regular manner are to be made for the remainder of the period in which the vacancy exists.

Approved, March 3, 1901.

31 Stat. Ch. 872, p. 1449

Act of 14 February **1903** (32 Stat. 825)—An Act to establish the Department of Commerce and Labor [as modified by Act of 4 March 1913].

Be it enacted . . ., That there shall be at the seat of government an executive department to be known as the Department of Commerce and Labor, and a Secretary of Commerce and Labor, who shall be the head thereof. . . .

SEC. 4. That the following named . . . bureaus . . . of the public service, now and heretofore under the jurisdiction of the Department of the Treasury, and all that pertains to the same, known as . . . the National Bureau of Standards . . ., be, and the same hereby are, transferred from the Department of the Treasury to the Department of Commerce and Labor, and the same shall hereafter remain under the jurisdiction and supervision of the last-named Department. . . .

Act of 4 March **1909** (35 Stat. 904)—An Act making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June 30, 1910, and for other purposes. [Beginning of special appropriations to the Bureau.]

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Bureau of Standards:

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For the investigation of the Pentane, Hefner, and other flame standards used in the measurement of the illuminating power of gas, and determining the accuracy practically obtainable in such measurements; also for the determination of the heat of combustion of certain gases which occur in illuminating gas, which are used as a basis for computing the heat value of the gas, and for the determination of the heat combustion of materials employed by engineers in the standardization of industrial calorimeters. . . .

To enable the bureau to collect information relative to the weights and measures used in trade and to aid State sealers and other officers in adopting standard practice as to the establishment of tolerances, methods of inspection and sealing, and other technical details necessary to insure correct weights and measures in commerce and trade. . . .

Sundry Civil Appropriations Act of 25 June **1910** (36 Stat. 743)—[Repealed Act of 16 May 1910 (36 Stat. 369), which transferred the work of investigating structural materials for the use of the United States from the Geological Survey to the Bureau of Mines. The work was transferred, instead, in the regular appropriations act, to the Bureau of Standards, with the sum of $50,000 to continue the investigation.]

Act of 4 March **1911** (36 Stat. 1354)—An Act To amend sections thirty-five hundred and forty-eight and thirty-five hundred and forty-nine of the Revised Statutes of the United States, relative to the standards for coinage.

Be it enacted . . ., That section thirty-five hundred and forty-eight of the Revised Statutes of the United States be, and the same is hereby, amended so as to read as follows:

"SEC. 3548. For the purpose of securing a due conformity in weight of the coins of the United States to the provisions of the laws relating to coinage, the standard troy pound of the Bureau of Standards of the United States shall be the standard troy pound of the Mint of the United States conformably to which the coinage therof shall be regulated."

SEC. 2. That section thirty-five hundred and forty-nine of the Revised Statutes of the United States be, and the same is hereby, amended so as to read as follows:

"SEC. 3549. It shall be the duty of the Director of the Mint to procure for each mint and assay office, to be kept safely thereat, a series of standard weights corresponding to the standard troy pound of the Bureau of Standards of the United States, consisting of a one-pound weight and the requisite subdivisions and multiples thereof, from the hundredths part of a grain to twenty-five pounds. The troy weight ordinarily employed in the transactions of such mints and assay offices shall be regulated according to the above standards at least once in every year, under the inspection of the superintendent and assayer; and the accuracy of those used at the Mint at Philadelphia shall be tested annually, in the presence of the assay commissioner, at the time of the annual examination and test of coins."

Act of 4 March **1913** (37 Stat. 736)—An Act To create a Department of Labor.

Be it enacted . . ., That . . . the Department of Commerce and Labor shall hereafter be called the Department of Commerce, and the Secretary thereof shall be called the Secretary of Commerce, and the Act creating the said Department of Commerce and Labor is hereby amended accordingly.

Act of 4 March **1913** (37 Stat. 945)—An Act Making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June 30, 1914, and for other purposes. [This act, by inference, recognized the testing of materials for the Federal Government, not specified in the Organic Act of the Bureau or elsewhere, as a function of the Bureau.]

. . . Hereafter materials for fireproof buildings, other structural materials, and all materials, other than materials for paving and for fuel, purchased for and to be used by the government of the District of Columbia, when necessary in the judgment of the commissioners to be tested, shall be tested by the Bureau of Standards under the same conditions as similar testing is required to be done for the United States Government.

Act of 29 July **1914**, 38 Stat. 573 (Public Law 155, 63 Congress)—[Transfer of miscellaneous testing laboratory in Bureau of Chemistry, Department of Agriculture, to NBS]

The salaries of employees of the Department of Agriculture transferred to the Department of Commerce for the purpose of testing miscellaneous materials, including the supplies for the Government departments and independent establishments, may be paid from July first, nineteen hundred and fourteen, from the appropriation of $20,000 in the legislative, executive, and judicial appropriation Act for the fiscal year nineteen hundred and fifteen, made for testing miscellaneous materials under the Bureau of Standards.

Act of 3 March **1915**, 38 Stat. 930 (Public Law 271, 63 Congress)—An Act Making appropriations for the naval service. . . .

[NBS representation on National Advisory Committee for Aeronautics]

An Advisory Committee for Aeronautics is hereby established, and the President is authorized to appoint not to exceed twelve members, to consist of two members from the War Department, from the office in charge of military aeronautics; two members from the Navy Department, from the office in charge of naval aeronautics, a representative each of the Smithsonian Institution, of the United States Weather Bureau, and of the United States Bureau of Standards; together with not more than five additional persons who shall be acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences:

Provided, That the members of the Advisory Committee for Aeronautics, as such, shall serve without compensation:

Provided further, That it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions. In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in such laboratory or laboratories:

And provided further, That rules and regulations for the conduct of the work of the committee shall be formulated by the committee and approved by the President.

That the sum of $5,000 a year, or so much thereof as may be necessary, for five years is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available, for experimental work and investigations undertaken by the committee, clerical expenses and supplies, and necessary expenses of members of the committee in going to, returning from, and while attending meetings of the committee:

Provided, That an annual report to the Congress shall be submitted through the President, including an itemized statement of expenditures.

Urgent Deficiency Act of 15 June **1917** (40 Stat. 216)—[Beginning of NBS military research during World War I]

. . . To enable the Bureau of Standards to cooperate with the War and Navy Departments by providing the scientific assistance necessary in the development of instruments, devices, and materials, and the standardization and testing of supplies . . ., $250,000.

. . . To provide by cooperation of the Bureau of Standards the War Department, the Navy Department, and the Council of National Defense, for the standardization and testing of the standard gauges, screw threads, and standards required in manufacturing throughout the United States, and to calibrate and test such standard gauges, screw threads, and standards . . ., $150,000. . . .

Act of 18 July **1918** (40 Stat. 912)—An Act To provide for the appointment of a commission to standardize screw threads [as amended by Act of 3 Mar 1919 (40 Stat. 1291)].

Be it enacted . . ., That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the commission, which shall be composed of nine commissioners, one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the commission; two commissioned officers of the Army, to be appointed by the Secretary of War; two commissioned officers of the Navy, to be appointed by the Secretary of the Navy; and four to be appointed by the Secretary of Commerce, two of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and two from nominations made by the Society of Automotive Engineers.

SEC. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.

SEC. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

SEC. 4. That the commission shall service without compensation but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

SEC. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

SEC. 6. That the commission shall cease and terminate at the end of one year and six months from the date of its original appointment.

[The term of the National Screw Thread Commission was extended for two years from 21 Mar 1920 by Joint Resolution of 23 Mar 1920 (41 Stat. 536), and for five years from 21 Mar 1922 by Joint Resolution of 21 Mar 1922 (42 Stat. 469).]

Appropriation Act of 20 May **1920** (41 Stat. 683)—[Beginning of transferred funds to NBS]

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Department of Commerce

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Bureau of Standards

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During the fiscal year 1921, the head of any department or independent establishment of the Government having funds available for scientific investigations and requiring cooperative work by the Bureau of Standards on scientific investigations within the scope of the functions of that Bureau, and which it is unable to perform within the limits of its appropriations, may, with the approval of the Secretary of Commerce, transfer to the Bureau of Standards such sums as may be necessary to carry on such investigations. The Secretary of the Treasury shall transfer on the books of the Treasury Department any sums which may be authorized hereunder and such amounts shall be placed to the credit of the Bureau of Standards for the performance of work for the department or establishment from which the transfer is made.

Act of 27 February **1925** (43 Stat. 1019)—An Act Making appropriations for the Departments of State and Justice and for the Judiciary, and for the Departments of Commerce and Labor, for the fiscal year ending June 30, 1926, and for other purposes.

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International Obligations.

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International Bureau of Weights and Measures.

For contribution to the maintenance of the International Bureau of Weights and Measures, in conformity with the terms of the convention of May 20, 1875, the same to be paid, under the direction of the Secretary of State, to said bureau on its certificate of apportionment, $3,000.

Economy Act of 30 June **1932** (47 Stat. 410)—[Amendment to Section 8 of the Act establishing the National Bureau of Standards, authorizing payment of fees, except for other Federal agencies, for NBS tests and calibrations]

. . . .

SEC. 312. Section 8 of the Act entitled "An Act to establish the National Bureau of Standards," approved March 3, 1901, as amended and supplemented [U.S.C., title 15, sec. 276], is amended to read as follows:

"SEC. 8. For all comparisons, calibrations, tests, or investigations, performed by the National Bureau of Standards under the provisions of this Act, as amended and supplemented, except those performed for the Government of the United States or State governments within the United States, a fee sufficient in each case to compensate the National Bureau of Standards for the entire cost of the services rendered shall be charged, according to a schedule prepared by the Director of the National Bureau of Standards and approved by the Secretary of Commerce. All moneys received from such sources shall be paid into the Treasury to the credit of miscellaneous receipts."

Act of 30 June **1932,** 47 Stat. 417 (Public Law 212, 72 Congress)—[Restatement of policy of transferring funds, making the policy general throughout the Federal Government]

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Title VI—Interdepartmental Work.

SEC. 601. Section 7 of the Act entitled "An Act making appropriations for fortifications and other works of defense, for the armament thereof, and for the procurement of heavy ordnance for trial and service, for the fiscal year ending June 30, 1921, and for other purposes," approved May 21, 1920 [U.S.C., title 31, sec. 686], is amended to read as follows:

"SEC. 7(a). Any executive department or independent establishment of the Government, or any bureau or office thereof, if funds are available therefor and if it is determined by the head of such executive department, establishment, bureau, or office to be in the interest of the Government so to do, may place orders with any other such department, establishment, bureau, or office for materials, supplies, equipment, work, or services of any kind that such requisitioned Federal agency may be in a position to supply or equipped to render, and shall pay promptly by check to such Federal agency as may be requisitioned, upon its written request, either in advance or upon the furnishing or performance thereof, all or part of the estimated or actual cost thereof, as determined by such department, establishment, bureau, or office as may be requisitioned. . . .:

Provided, however, That if such work or services can be as conveniently or more cheaply performed by private agencies such work shall be let by competitive bids to such private agencies. . . .

Executive Order 10096, 23 January **1950**—Providing for a uniform patent policy for the Government with respect to inventions made by Government employees and for the administration of such policy.

Whereas inventive advances in scientific and technological fields frequently result from governmental activities carried on by Government employees; and

Whereas the Government of the United States is expending large sums of money annually for the conduct of these activities; and

Whereas these advances constitute a vast national resource; and

Whereas it is fitting and proper that the inventive product of functions of the Government, carried out by Government employees, should be available to the Government; and

Whereas the rights of Government employees in their inventions should be recognized in appropriate instances; and

Whereas the carrying out of the policy of this order requires appropriate administrative arrangements:

NOW, THEREFORE, by virtue of the authority vested in me by the Constitution and statutes, and as President of the United States and Commander in Chief of the Armed Forces of the United States, in the interest of the establishment and operation of a uniform patent policy for the Government with respect to inventions made by Government employees, it is hereby ordered as follows:

1. The following basic policy is established for all Government agencies with respect to inventions hereafter made by any Government employee:

(a) The Government shall obtain the entire right, title and interest in and to all inventions made by any Government employee (1) during working hours, or (2) with a contribution by the Government of facilities, equipment, materials, funds, or information, or of time or services of other Government employees on official duty, or (3) which bears a direct relation to or are made in consequence of the official duties of the inventor.

(b) In any case where the contribution of the Government, as measured by any one or more of the criteria set forth in paragraph (a) last above, to the invention is insufficient equitably to justify a requirement of assignment to the Government of the entire right, title and interest to such invention, or in any case where the Government has insufficient interest in an invention to obtain entire right, title and interest therein (although the Government could obtain same under paragraph (a), above), the Government agency concerned, subject to the approval of the Chairman of the Government Patents Board . . . shall leave title to such invention in the employee, subject, however, to the reservation to the Government of a non-exclusive, irrevocable, royalty-free license in the invention with power to grant licenses for all governmental purposes, such reservation, in the terms thereof, to appear, where practicable, in any patent, domestic or foreign, which may issue on such invention. . . .

Act of 29 June **1950,** 64 Stat. 279 (Public Law 583, 81 Congress)—An Act Making appropriations to supply deficiencies in certain appropriations for the fiscal year ending June 30, 1950, and for other purposes.

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Chapter III

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Department of Commerce

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National Bureau of Standards

Working Capital Fund

For the establishment of a working capital fund, to be available without fiscal year limitation, for expenses necessary for the maintenance and operation of the National Bureau of Standards, including the furnishing of facilities and services to other Government agencies, not to exceed $3,000,000. Said funds shall be established as a special deposit account and shall be reimbursed from applicable appropriations of said Bureau for the work of said Bureau, and from funds of other Government agencies for facilities and services furnished to such agencies pursuant to law. Reimbursements so made shall include handling and related charges; reserves for depreciation of equipment and accrued leave; and building construction and alterations directly related to the work for which reimbursement is made.

Act of 21 July **1950**, 64 Stat. 369 (Public Law 617, 81 Congress)—An Act To redefine the units and establish the standards of electrical and photometric measurements.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the date this Act is approved, the legal units of electrical and photometric measurements in the United States of America shall be those defined and established as provided in the following sections.

SEC. 2. The unit of electrical resistance shall be the ohm, which is equal to one thousand million units of resistance of the centimeter-gram-second system of electromagnetic units.

SEC. 3. The unit of electric current shall be the ampere, which is one-tenth of the unit of current of the centimeter-gram-second system of electromagnetic units.

SEC. 4. The unit of electromotive force and of electric potential shall be the volt, which is the electromotive force that, steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

SEC. 5. The unit of electric quantity shall be the coulomb, which is the quantity of electricity transferred by a current of one ampere in one second.

SEC. 6. The unit of electrical capacitance shall be the farad, which is the capacitance of a capacitor that is charged to a potential of one volt by one coulomb of electricity.

SEC. 7. The unit of electrical inductance shall be the henry, which is the inductance in a circuit such that an electromotive force of one volt is induced in the circuit by variation of an inducing current at the rate of one ampere per second.

SEC. 8. The unit of power shall be the watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is the power required to cause an unvarying current of one ampere to flow between points differing in potential by one volt.

SEC. 9. The units of energy shall be (a) the joule, which is equivalent to the energy supplied by a power of one watt operating for one second, and (b) the kilowatt-hour, which is equivalent to the energy supplied by a power of one thousand watts operating for one hour.

SEC. 10. The unit of intensity of light shall be the candle, which is one-sixtieth of the intensity of one square centimeter of a perfect radiator, known as a "black body," when operated at the temperature of freezing platinum.

SEC. 11. The unit of flux light shall be the lumen, which is the flux in a unit of solid angle from a source of which the intensity is one candle.

SEC. 12. It shall be the duty of the Secretary of Commerce to establish the values of the primary electric and photometric units in absolute measure, and the legal values for these units shall be those represented by, or derived from, national reference standards maintained by the Department of Commerce.

SEC. 13. The Act of July 12, 1894 (Public Law 105, Fifty-third Congress), entitled "An Act to define and establish the units of electrical measure," is hereby repealed.

Act of 21 July **1950,** 64 Stat. 370 (Public Law 618, 81 Congress)—An Act To provide authority for certain functions and activities in the Department of Commerce, and for other purposes. [Authorization for the initial planning leading to the move of the Bureau from Washington, D.C. to Gaithersburg, Md.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That . . . .

SEC. 2. Within the limits of funds which may be appropriated therefor, the Secretary of Commerce is authorized to make improvements to existing buildings, grounds, and other plant facilities, including construction of minor buildings and other facilities of the National Bureau of Standards in the District of Columbia and in the field to house special apparatus or material which must be isolated from other activities: *Provided,* That no improvement shall be made nor shall any building be constructed under this authority at a cost in excess of $25,000, unless specific provision is made therefor in the appropriation concerned.

Act of 22 July **1950,** 64 Stat. 371 (Public Law 619, 81 Congress)—An Act To amend section 2 of the Act of March 3, 1901 (31 Stat. 1449), to provide basic authority for the performance of certain functions and activities of the Department of Commerce, and for other purposes. [First complete restatement of Bureau functions since 1901]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 2 of the Act of March 3, 1901 (31 Stat. 1449), as amended, be, and the same hereby is, furthter amended so as to read in full as follows:

SEC. 2. The Secretary of Commerce (hereinafter referred to as the "Secretary") is authorized to undertake the following functions:

(a) The custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurement consistent with those standards, including the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government.

(b) The determination of physical constants and properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

(c) The development of methods for testing materials, mechanisms, and structures, and the testing of materials, supplies, and equipment, including items purchased for use of Government departments and independent establishments.

(d) Cooperation with other Government agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications.

(e) Advisory service to Government agencies on scientific and technical problems.

(f) Invention and development of devices to serve special needs of the Government.

In carrying out the functions enumerated in this section, the Secretary is authorized to undertake the following activities and similar ones for which need may arise in the operations of Government agencies, scientific institutions, and industrial enterprises:

(1) the construction of physical standards;

(2) the testing, calibration, and certification of standards and standard measuring apparatus;

(3) the study and improvement of instruments and methods of measurements;

(4) the investigation and testing of railroad track scales, elevator scales, and other scales used in weighing commodities for interstate shipment;

(5) cooperation with the States in securing uniformity in weights and measures laws and methods of inspection;

(6) the preparation and distribution of standard samples such as those used in checking chemical analyses, temperature, color, viscosity, heat of combustion, and other basic properties of materials; also the preparation and sale or other distribution of standard instruments, apparatus and materials for calibration of measuring equipment;

(7) the development of methods of chemical analysis and synthesis of materials, and the investigation of the properties of rare substances;

(8) the study of methods of producing and of measuring high and low temperatures; and the behavior of materials at high and at low temperatures;

(9) the investigation of radiation, radioactive substances, and x-rays, their uses, and means of protection of persons from their harmful effects;

(10) the study of the atomic and molecular structure of the chemical elements, with particular reference to the characteristics of the spectra emitted, the use of spectral observations in determining chemical composition of materials, and the relation of molecular structure to the practical usefulness of materials;

(11) the broadcasting of radio signals of standard frequency;

(12) the investigation of the conditions which affect the transmission of radio waves from their source to a receiver;

(13) the compilation and distribution of information on such transmission of radio waves as a basis for choice of frequencies to be used in radio operations;

(14) the study of new technical processes and methods of fabrication of materials in which the Government has a special interest; also the study of methods of measurement and technical processes used in the manufacture of optical glass and pottery, brick, tile, terra cotta, and other clay products;

(15) the determination of properties of building materials and structural elements, and encouragement of their standardization and most effective use, including investigation of fire-resisting properties of building materials and conditions under which they may be most efficiently used, and the standarization of types of appliances for fire prevention;

(16) metallurgical research, including study of alloy steels and light metal alloys; investigation of foundry practice, casting, rolling, and forging; prevention of corrosion of metals and alloys; behavior of bearing metals; and development of standards for metals and sands;

(17) the operation of a laboratory of applied mathematics;

(18) the prosecution of such research in engineering, mathematics, and the physical sciences as may be necessary to obtain basic data pertinent to the functions specified herein; and

(19) the compilation and publication of general scientific and technical data resulting from the performance of the function specified herein or from other sources when such data are of importance to scientific or manufacturing interests or to the general public, and are not available elsewhere, including demonstration of the results of the Bureau's work by exhibits or otherwise as may be deemed most effective.

SEC. 3. The Bureau shall exercise its functions for the Government of the United States; for any State or municipal government within the United States; or for any scientific society, educational institution, firm, corporation, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments. All requests for the services of the Bureau shall be made in accordance with the rules and regulations herein established.

SEC. 4. (Salaries of officers and employees. This section superseded by Classification Act.)

SEC. 5. The Director shall be appointed by the President, by and with the advice and consent of the Senate. He shall have the general supervision of the Bureau, its equipment, and the exercise of its functions. He shall make an annual report to the Secretary of Commerce, including an abstract of the work done during the year and a financial statement. He may issue, when necessary, bulletins for public distribution, containing such information as may be of value to the public or facilitate the Bureau in the exercise of its functions.

SEC. 6. The officers and employees of the Bureau, except the Director, shall be appointed by the Secretary of Commerce at such time as their respective services may become necessary.

SEC. 7. The Secretary shall charge for services performed under the authority of Section 3 of this Act, except in cases where he determines that the interest of the Government would be best served by waiving the charge. Such charges may be based upon fixed prices or cost. The appropriation or fund bearing the cost of the services may be reimbursed, or the Secretary may require advance payment subject to such adjustment on completion of the work as may be agreed upon.

SEC. 8. In the absence of specific agreement to the contrary, additional facilities, including equipment, purchased pursuant to the performance of services authorized by Section 3 of this Act shall become the property of the Department of Commerce.

SEC. 9. The Secretary of Commerce shall, from time to time, make regulations regarding the payment of fees, the limits of tolerance to be attained in standards submitted for verification, the sealing of standards, the disbursement and receipt of moneys, and such other matters as he may deem necessary for carrying this Act into effect.

SEC. 10. There shall be a visiting committee of five members to be appointed by the Secretary of Commerce, to consist of men prominent in the various interests involved, and not in the employ of the Government. This committee shall visit the Bureau at least once a year, and report to the Secretary of Commerce upon the efficiency of its scientific work and the condition of its equipment. The members of this committee shall serve without compensation, but shall be paid the actual expenses incurred in attending its meetings. The period of service of the members of the committee shall be so arranged that one member shall retire each year, and the appointments to be for a period of five years. Appointments made to fill vacancies occurring other than in the regular manner are to be made for the remainder of the period in which the vacancy exists.

SEC. 11. (a) The Secretary of Commerce is authorized to accept and utilize gifts or bequests of real or personal property for the purpose of aiding and facilitating the work authorized therein.

(b) For the purpose of Federal income, estate, and gift taxes, gifts and bequests accepted by the Secretary of Commerce under the authority of this Act shall be deemed to be gifts and bequests to or for the use of the United States.

SEC. 12. (a) The National Bureau of Standards is authorized to utilize in the performance of its functions the Working Capital Fund established by the Act of June 29, 1950 (64 Stat. 275), and additional amounts as from time to time may be required for the purposes of said Fund are hereby authorized to be appropriated.

(b) The working capital of the Fund shall be available for obligation and payment for any activities authorized by the Act of March 3, 1901 (31 Stat. 1449), as amended, and for any activities for which provision is made in the appropriations which reimburse the Fund.

(c) In the performance of authorized activities, the Working Capital Fund shall be available and may be reimbursed for expenses of hire of automobile, hire of consultants, and travel to meetings, to the extent that such expenses are authorized for the appropriations of the Department of Commerce.

(d) The Fund may be credited with advances and reimbursements, including receipts from non-federal sources, for services performed under the authority of Section 3 of this Act.

(e) As used in this Act the term cost shall be construed to include directly related expenses and appropriate charges for indirect and administrative expenses.

(f) The amount of any earned net income resulting from the operation of the Fund at the close of each fiscal year shall be paid into the general fund of the Treasury; provided, that such earned net income may be applied first to restore any prior impairment of the Fund.

SEC. 13. To the extent that funds are specifically appropriated therefore, the Secretary of Commerce is authorized to acquire land for such field sites as are necessary for the proper and efficient conduct of the activities authorized herein.

SEC. 14. Within the limits of funds which are appropriated for the National Bureau of Standards, the Secretary of Commerce is authorized to undertake such construction of buildings and other facilities and to make such improvements to existing buildings, grounds, and other facilities occupied or used by the National Bureau of Standards as are necessary for the proper and efficient conduct of the activities authorized herein: PROVIDED, That no improvement shall be made nor shall any building be constructed under this authority at a cost in excess of $40,000 unless specific provision is made therefor in the appropriation concerned.

SEC. 15. In the performance of the functions of the National Bureau of Standards the Secretary of Commerce is authorized to undertake the following activities: (a) The purchase, repair, and cleaning of uniforms for guards; (b) the repair and alteration of buildings and other plant facilities; (c) the rental of field sites and laboratory, office, and warehouse space; (d) the purchase of reprints from technical journals or other periodicals and the payment of page charges for the publication of research papers and reports in such journals; (e) the furnishing of food and shelter without repayment therefor to employees of the Government at Arctic and Antarctic stations; (f) for the conduct of observations on radio propagation phenomena in the Arctic or Antarctic regions, the appointment of employees at base rates established by the Secretary of Commerce which shall not exceed such *Maximum rates as may be* specified from time to time in the appropriation concerned, and without regard to the civil service and classification laws and titles II and III of the Federal Employees Pay Act of 1945; and (g) the erection on leased property of specialized facilities and working and living quarters when the Secretary of Commerce determines that this will best serve the interests of the Government.

Act of 20 June **1956,** 70 Stat. 321 (Public Law 604)—An Act Making appropriations for the Department of Commerce and related agencies for the fiscal year ending June 30, 1957, and for other purposes. [Formal approval for the construction of a new Bureau plant at Gaithersburg.]

Be it enacted . . . That the following sums are appropriated . . . for the Department of Commerce . . . namely:

Title I—Department of Commerce

. . . .

National Bureau of Standards

. . . .

Construction of facilities: For acquisition of necessary land and to initiate the design of the facilities to be constructed thereon for the National Bureau of Standards outside of the District of Columbia to remain available until expended, $930,000, to be transferred to the General Services Administration.

THE NATIONAL BUREAU OF STANDARDS IN THE FEDERAL ADMINISTRATION

UNITED STATES PRESIDENTS	DEPARTMENT SECRETARIES	NBS DIRECTORS
William McKinley 1897-1901 Theodore Roosevelt 1901-9 William Howard Taft 1909-13 Woodrow Wilson 1913-21	Lyman J. Gage Secretary of Treasury 1897-1901 Leslie M. Shaw 1901 George B. Cortelyou Secretary of Commerce and Labor, 1903-4 Victor H. Metcalf 1904-6 Oscar S. Straus 1906-9 Charles Nagel 1909-13 William C. Redfield Secretary of Commerce 1913-19 Joshua W. Alexander 1919-21	Samuel W. Stratton 1901-22
Warren G. Harding 1921-23 Calvin Coolidge 1923-29 Herbert C. Hoover 1929-33	Herbert C. Hoover 1921-28 William F. Whiting 1928-29 Robert P. Lamont 1929-32	George K. Burgess 1922-32
Franklin D. Roosevelt 1933-45 Harry S. Truman 1945-53	Roy D. Chapin 1932-33 Daniel C. Roper 1933-39 Harry L. Hopkins 1939-40 Jesse Jones 1940-45 Henry A. Wallace 1945-46 W. Averell Harriman 1947-48 Charles W. Sawyer 1948-52	Lyman J. Briggs 1932-46 Edward U. Condon 1946-51
Dwight D. Eisenhower 1953-61 John F. Kennedy 1961-63 Lyndon B. Johnson 1963-	Sinclair Weeks 1952-58 Lewis L. Strauss 1958-59 Frederick H. Mueller 1959-61 Luther H. Hodges 1961-65 John T. Connor 1965-	Allen V. Astin 1951-

APPENDIX E

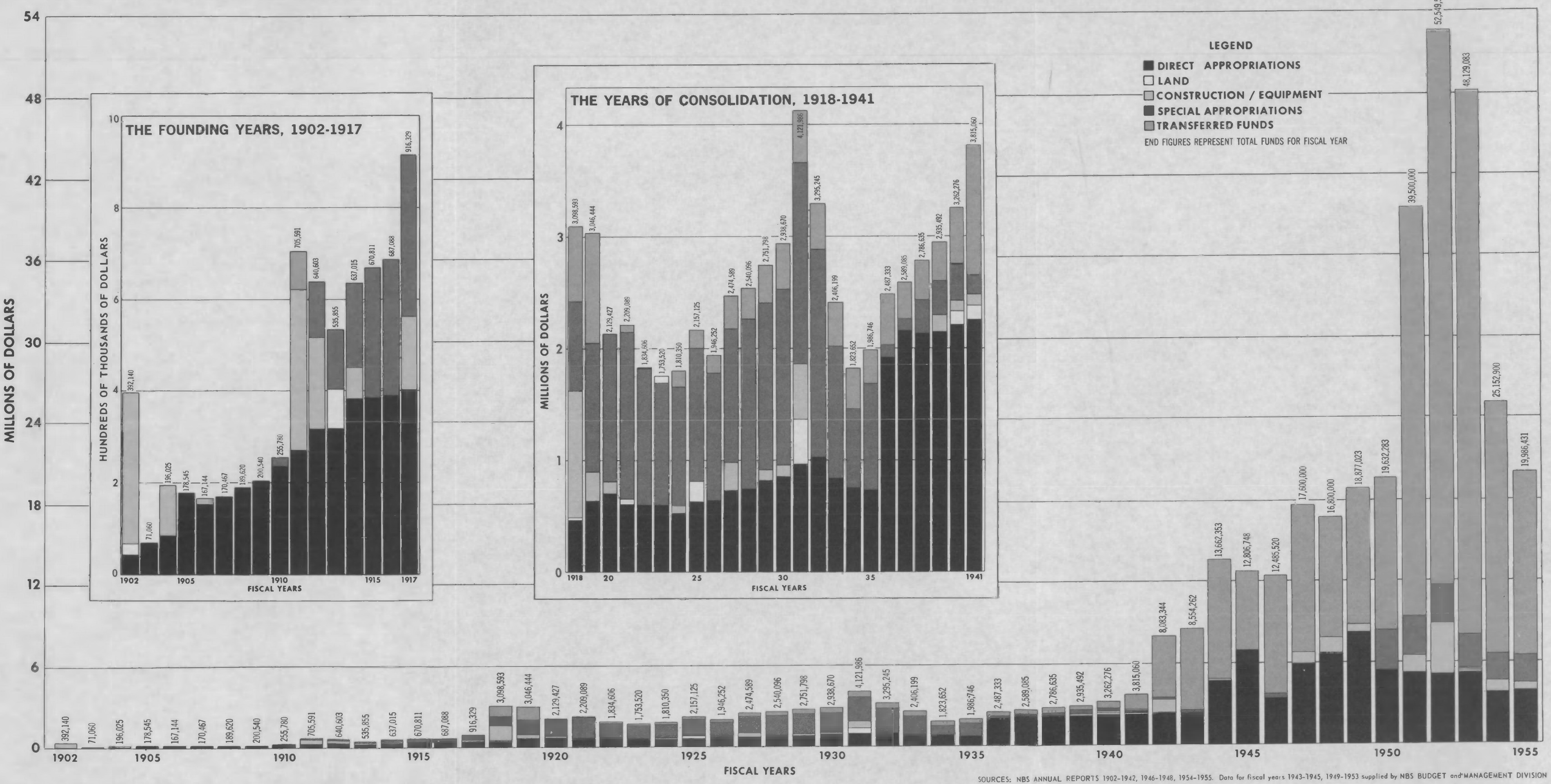
MEMBERS OF THE VISITING COMMITTEE of the Secretary of Commerce to the National Bureau of Standards[1]

	Term
ALBERT LADD COLBY Consulting engineer in metallurgy, South Bethlehem, Pa., and secretary, Association of American Steel Manufacturers.	1901–07
DR. ELIHU THOMSON Electrical engineer, General Electric Co., Lynn, Mass.	1901–18
DR. IRA REMSEN Director of Chemical Laboratory and president, Johns Hopkins University.	1901–09
DR. HENRY S. PRITCHETT President, Massachusetts Institute of Technology; later president, Carnegie Foundation for the Advancement of Teaching.	1901–10
PROF. EDWARD L. NICHOLS Professor of physics, Cornell University.	1901–11
DR. ROBERT S. WOODWARD President, Carnegie Institution of Washington.	1908–12
PROF. HENRY M. HOWE Professor of metallurgy, Columbia University.	1909–14
PROF. ARTHUR G. WEBSTER Director, Physics Laboratory, Clark University.	1910–15
PROF. JOHN F. HAYFORD Director, College of Engineering, Northwestern University.	1912–21
PROF. ARTHUR E. KENNELLY Professor of electrical engineering, Harvard University.	1912–17
JOHN R. FREEMAN Consulting engineer, Providence, R.I.	1915–24, 1926–31
PROF. WILLIAM A. NOYES Director, Chemical Laboratory, University of Illinois.	1915–20
PROF. JOSEPH S. AMES Director, Physical Laboratory, Johns Hopkins University.	1917–22
PROF. FRED W. McNAIR President, Michigan College of Mines, Houghton, Mich.	1921–23
PROF. WILDER D. BANCROFT Professor of physical chemistry, Cornell University.	1920–25
DR. AMBROSE SWASEY Chairman of the Board, Warner & Swasey Co., Cleveland, Ohio.	1921–26
DR. SAMUEL W. STRATTON President, Massachusetts Institute of Technology.	1923–31

[1] Sources: NARG 167, NBS Box 296; NARG 40, files of Secretary of Commerce, 67009/5; current files, Office of the Director, NBS.

	Term
GANO DUNN	1923–48
President, J. G. White Engineering Corp., New York.	
PROF. WILLIAM F. DURAND	1924–29
Professor of mechanical engineering, Leland Stanford University.	
DR. WILLIS R. WHITNEY	1925–30
Director, General Electric Research Laboratory, Schenectady, N.Y.	
DR. CHARLES F. KETTERING	1929–34, 1947–52
Director of research and vice president, General Motors Corp.	
DR. CHARLES L. REESE	1930–35
Consulting chemist to E. I. du Pont de Nemours & Co.	
MORRIS E. LEEDS	1931–41
President, Leeds & Northrup Co., Philadelphia, Pa.	
DR. KARL T. COMPTON	1931–47
President, Massachusetts Institute of Technology.	
DR. WILLIAM D. COOLIDGE	1935–49
Vice president and director of research, General Electric Co.	
DR. FRANK B. JEWETT	1935–45
Vice president in charge of research and development, American Telephone & Telegraph Co.; president, National Academy of Sciences.	
DR. VANNEVAR BUSH	1942–46
President, Carnegie Institution of Washington; director, Office of Scientific Research and Development.	
DR. HAROLD C. UREY	1945–50
Research professor of chemistry, University of Chicago.	
DR. EUGENE P. WIGNER	1946–51
Metallurgical Laboratory, University of Chicago; director of research, Clinton Laboratories, Oak Ridge, Tenn.	
DR. ROBERT F. MEHL	1948–53
Director, Metals Research Laboratory, Carnegie Institute of Technology.	
DR. DONALD H. MENZEL	1949–54
Chairman, Department of Astronomy, Harvard University; associate director, Harvard Observatory.	
DR. DETLEV W. BRONK	1950–60
President, Johns Hopkins University.	
PROF. JOHN H. VAN VLECK	1951–56
Dean, Division of Applied Science, Harvard University.	
DR. MERVIN J. KELLY	1952–62
President, Bell Telephone Laboratories.	
DR. CLYDE E. WILLIAMS	1953–58
Director, Battelle Memorial Institute, Columbus, Ohio.	
DR. CRAWFORD H. GREENEWALT	1954–64
President, E. I. du Pont de Nemours & Co.	
PROF. FREDERICK SEITZ	1956–61
Chairman, Department of Physics, University of Illinois.	
DR. LLOYD V. BERKNER	1957–62
Scientific research administrator; chairman, Space Science Board, National Academy of Sciences.	
PROF. CHARLES H. TOWNES	1960–65
Department of Physics, Columbia University, consultant, Brookhaven National Laboratories.	

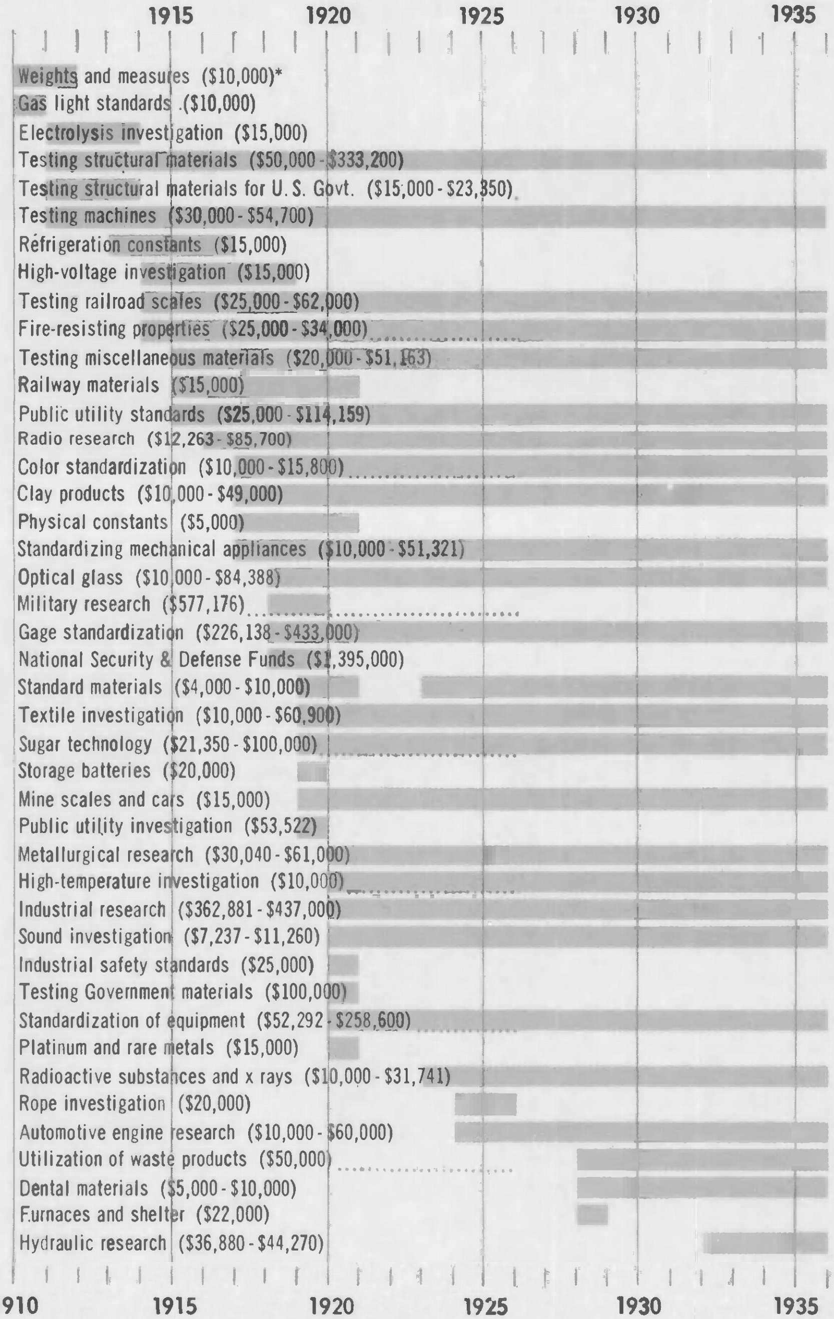
NBS Appropriations and Other Supporting Funds, 1902-1955



SOURCES: NBS ANNUAL REPORTS 1902-1942, 1946-1948, 1954-1955. Data for fiscal years 1943-1945, 1949-1953 supplied by NBS BUDGET and MANAGEMENT DIVISION

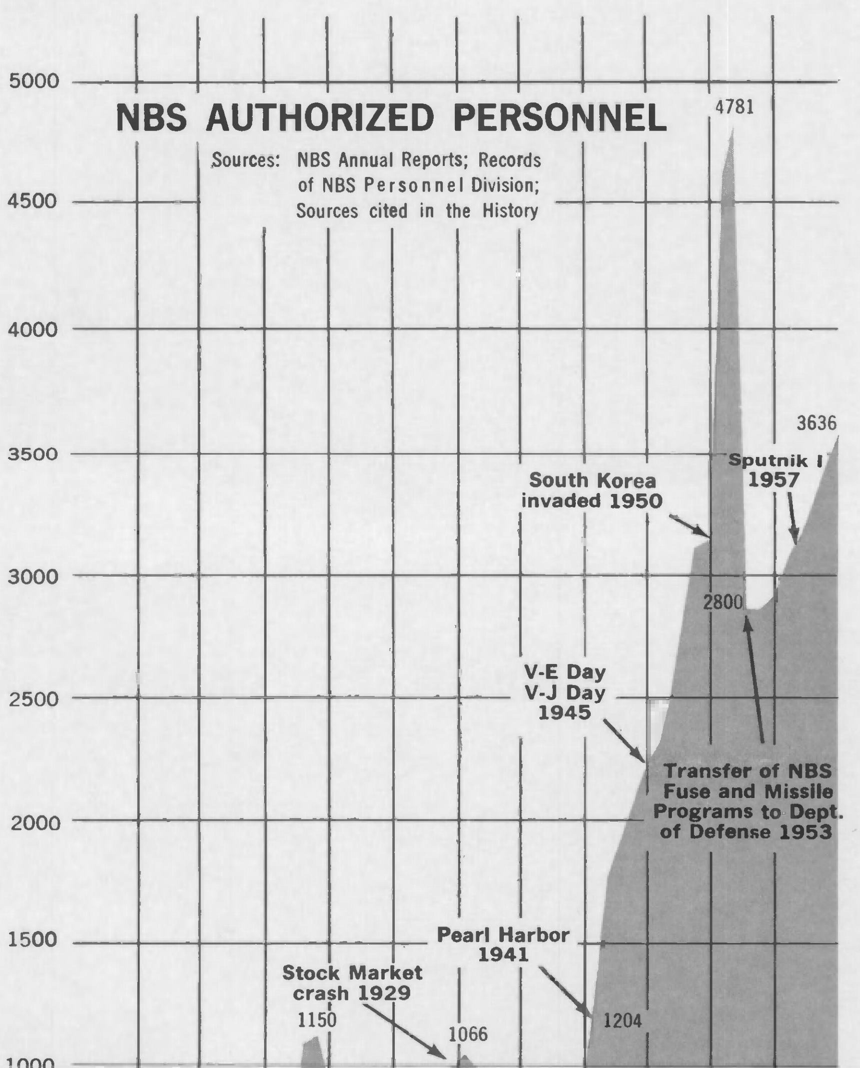
NBS SPECIAL APPROPRIATIONS, 1910-1935

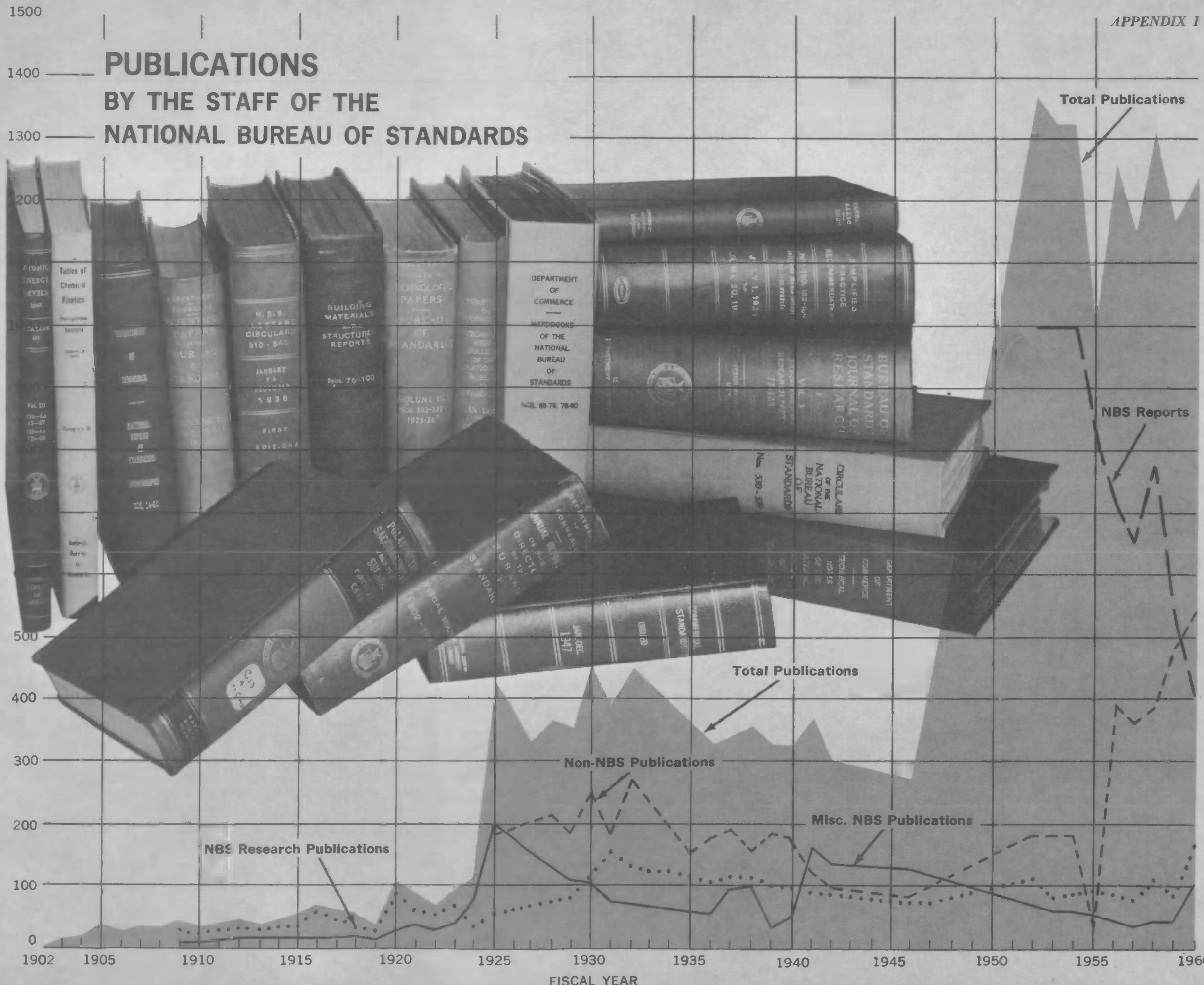
APPENDIX G



*Figures represent initial and maximum appropriations.

Note: Special appropriations continued after 1935 in special annual appropriations for Standards for commerce (1936-1946), Investigation of building materials (1938-1942), and Radio propagation and standards (1950-1955).


NBS AUTHORIZED PERSONNEL
Sources: NBS Annual Reports; Records of NBS Personnel Division; Sources cited in the History
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
4781
3636
Sputnik I 1957
South Korea invaded 1950
2800
V-E Day V-J Day 1945
Transfer of NBS Fuse and Missile Programs to Dept. of Defense 1953
Pearl Harbor 1941
Stock Market crash 1929
1150
1066
1204
World War II begins 1939
668
World War I begins 1914
AEF arrives in France 1917
135
14
FY 1900
1910
1920
1930
1940
1950
1960
STRATTON
BURGESS
BRIGGS
CONDON
ASTIN


PUBLICATIONS
BY THE STAFF OF THE
NATIONAL BUREAU OF STANDARDS
1500
1400
1300
500
400
300
200
100
0
Total Publications
NBS Reports
Total Publications
Non-NBS Publications
Misc. NBS Publications
NBS Research Publications
1902
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
FISCAL YEAR

PUBLICATIONS

OF THE NATIONAL BUREAU OF STANDARDS

NOTES

The Annual Reports of the Bureau, 1901–1960, are the source for the basic data of this publications chart.

Dash lines on the chart span years when the Annual Report omitted publication data. In some instances of omission the number of publications was determined by actual count in NBS C460, which lists all formal Bureau publications issued by the Government Printing Office from 1901 to 1947, and in Supplements to C460 for publications since 1947.

Not represented on the chart are revisions, reprints, and new editions of Bureau publications (as many as 50 to 90 annually by 1915) ; publicity releases and general articles in the periodical literature on the work of the Bureau; nor calibration and test reports prepared by the staff.

NBS RESEARCH PUBLICATIONS include the early Scientific Papers (1904–1928) and Technologic Papers (1910–1928), combined in 1928 in a single Journal of Research as Research Papers until the reorganization of NBS publications in 1959, noted below.

MISCELLANEOUS NBS PUBLICATIONS in the chart comprise:

Circulars, the compilations of information related to NBS scientific, technologic, and engineering activities, published from 1903 to 1959. They include the extensive NBS and U.S. Government Specifications series in the years 1912–1937.

Miscellaneous Publications (1905 to date), which include the NBS Annual Reports, Weights and Measures Conference Reports, the Standards Yearbook from 1927 through 1933, and charts, directories, and administrative reports.

Handbooks (1921 to date).

Building and Housing Publications (1922–1932).

Simplified Practice Recommendations (1923 to date).

Technical News Bulletin, published monthly (1924 to date).

Letter Circulars, in mimeograph form (1924 to date).

Commercial Standards (1929 to date).

Building Materials and Structures Reports (1930–1939).

Mathematical Tables (1941–1945).

Applied Mathematics Series (1948 to date).

Basic Radio Propagation Predictions, published monthly (1952–1959) ; Central Radio Propagation Laboratory Ionospheric Predictions (1960 to date).

NON-NBS PUBLICATIONS, first recorded in 1925, comprise articles by members of the staff appearing in the journals of professional and scientific societies.

NBS REPORTS, on research conducted under transferred funds and formalized in 1951 (estimated in 1952 as more than a thousand reports), actually began before World War II as nonpublished reports to NACA on special research for that agency, and later as reports to NDRC, OSRD and other wartime agencies. They continue to comprise classified and unclassified reports to other Government agencies on projects supported by transferred funds.

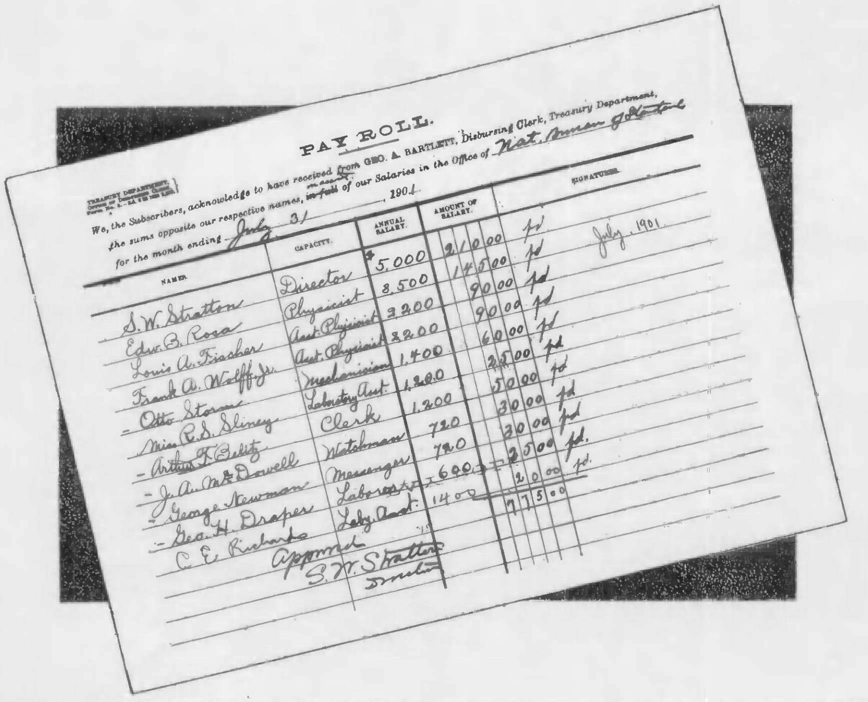
Reorganization of NBS Publications: In 1959 the Journal of Research was reorganized into four separately published sections: A. Physics and Chemistry; B. Mathematics and Mathematical Physics; C. Engineering and Instrumentation; D. Radio Propagation.

Two nonperiodicals, Monographs (papers too long for the Journal) and Technical Notes (scientific data of limited or transient interest) were established that same year.

Continuing nonperiodicals included the Applied Mathematics Series, Handbooks, and Miscellaneous Publications. Commercial Standards and Simplified Practice Recommendations, discontinued as NBS publications from 1951 to 1963, were resumed as Bureau publications.

Continuing monthly periodicals included the Technical News Bulletin and CRPL Ionospheric Predictions (former Basic Radio Propagation Predictions).

APPENDIX J



PAY ROLL.

We, the Subscribers, acknowledge to have received from GEO. A. BARTLETT, Disbursing Clerk, Treasury Department, the sums opposite our respective names, on account of our Salaries in the Office of Nat. Bureau of Standards for the month ending July 31, 1901.

NAMES.	CAPACITY.	ANNUAL SALARY.	AMOUNT OF SALARY.		SIGNATURES.
S. W. Stratton	Director	$5,000	210 00	pd	July, 1901.
Edw. B. Rosa	Physicist	3,500	145 00	pd	
Louis A. Fischer	Asst. Physicist	2,200	90 00	pd	
Frank A. Wolff Jr.	Asst. Physicist	2,200	90 00	pd	
Otto Storm	Mechanician	1,400	60 00	pd	
Miss R. S. Sliney	Laboratory Asst.	1,200	25 00	pd	
Arthur F. Beltz	Clerk	1,200	50 00	pd	
J. A. McDowell	Watchman	720	30 00	pd	
George Newman	Messenger	720	30 00	pd	
Geo. H. Draper	Laborer	600	25 00	pd.	
C. E. Richards	Lab. Asst.	1400	20 00	pd.	
			775 00		

Approved S. W. Stratton Director

Almost certainly the first official NBS payroll and roster, these half-monthly payments, according to the paybook cover, were made on July 15.

The appearance of Miss Sliney's name on the roll cannot be explained. She may have been a temporary appointment before Dr. Stratton took over. Her name does not appear on subsequent payrolls or on staff rosters.

APPENDIX J

DIVISION AND SECTION CHIEFS OF THE SCIENTIFIC AND TECHNICAL STAFF NATIONAL BUREAU OF STANDARDS

as of July 1, 1905*

DIRECTOR	**Stratton, Dr Samuel W.**	**1901–22**
WEIGHTS AND MEASURES	Fischer, Louis A.	1901–21
Comparison of Capacities	Ferner, Roy Y.	1903–18
Weights and Measures Assistant	Pienkowsky, Arthur T.	1905–44
HEAT AND THERMOMETRY	Waidner, Dr Charles W.	1901–22
Low Temperature Investigations	Waidner, Dr Charles W.	
High Temperature Investigations	Burgess, Dr George K.	1903–32
Comparison of Thermometers	Dickinson, Dr Hobart C.	1903–45
Heat and Thermometry Assistant	Mueller, Eugene F.	1905–44
LIGHT AND OPTICAL INSTRUMENTS	Stratton, Dr Samuel W.	
Spectroscopy	Nutting, Dr Perley G.	1903–12
Magneto-optics	Bates, Frederick J.	1903–47
Computer	Coblentz, Dr William W.	1905–44
ENGINEERING INSTRUMENTS AND MATERIALS	*Sponsler, Charles F.	1902–13
Engineering Instruments and Materials Assistants	*Merrill, Albert S.	1903–06
	*Lange, Oscar G.	1902–37
ELECTRICITY	Rosa, Dr Edward B.	1901–21
Inductance and Capacity	Rosa, Dr Edward B.	
	*Grover, Dr Frederick W.	1903–11

*This 1905 roster is based on information in MS, N. Ernest Dorsey, "Some memories of the early days of the NBS," Oct. 28, 1943 (NBS Historical File).

The names preceded by an asterisk are staff members who left the Bureau before the next roster. Their subsequent employment or other reason for separation is noted below.

The dates on the right both mark the first appearance of a staff member in these rosters and his inclusive dates of association with the Bureau.

*Sponsler, resigned Mar. 22, 1913.

*Merrill, resigned May 3, 1906; returned briefly Mar.–July 1920.

*Lange, retired Nov. 30, 1937.

*Grover, to Colby College, 1911–20; to Department of Electrical Engineering, Union College, Schenectady, N.Y., 1920.

ELECTRICITY—Continued		
Magnetism and Absolute Measurement of Current	*Guthe, Dr Karl E.	1903–06
Electrical Measuring Instruments	Brooks, Herbert B.	1903–39, 1942–45
	*Lloyd, Dr Morton G.	1902–10, 1917–41
	Reid, Clarence E.	1903–05
Photometry	*Hyde, Dr Edward P.	1903–08
Electrical Resistance and Electromotive Force	Wolff, Dr Frank A.	1901–41
	*Middlekauff, Dr George W.	1903–17
Electricity Assistants	*Cady, Francis E.	1903–20
	Durston, Franklin S.	1903–17
	*Dorsey, Dr N. Ernest	1903–20, 1928–43
	*Shoemaker, Maynard P.	1905–36
Naval Radio Research Laboratory	*Austin, Dr Louis W.	
Army Signal Service Radio Laboratory	*Cramm, E. R.	
CHEMISTRY	*Noyes, Dr William A.	1903–08
Chemistry Assistants	*Stokes, Dr Henry N.	1903–09
	Cain, Dr John R.	1905–21, 1936–45
	Waters, Campbell E.	1904–42

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*Guthe, to State University of Iowa as chairman, Physics Department, 1906.

*Lloyd, to "Electrical Review and Western Electrician," Chicago, as technical editor, 1910–17.

*Hyde, to NELA Research Laboratory, General Electric, 1908.

*Middlekauff, resigned 1917.

*Cady, to National Lamp Works, Nela Park, 1920.

*Dorsey, private consultant and consultant in physics to NBS, 1920–28; independent research worker at NBS, 1928–43; died July 6, 1959.

*Shoemaker, retired 1936.

*Austin, died June 27, 1932.

*Cramm, no data available.

*Noyes, to Department of Chemistry, University of Illinois, as chairman, 1908.

*Stokes, to "Library Critic," as editor, 1909.

CHIEFS OF THE SCIENTIFIC AND TECHNICAL STAFF

as of September 1, 1910*

DIRECTOR	**Stratton, Dr Samuel W.**	
I. ELECTRICITY	Rosa, Dr Edward B.	
Inductance and Capacity	Curtis, Dr Harvey L.	1907–46
Precision Resistance Measurement	Wenner, Dr Frank	1907–43
Electrical Measuring Instruments	Brooks, Herbert B.	
Magnetism	Burrows, Dr Charles W.	1906–18
Electrical Testing	Vinal, Dr George W.	1904–50
Photometry	Crittenden, Dr. Eugene C.	1909–50
Electrolysis	McCollum, Burton	1909–26
Electromotive Force and Resistance	Wolff, Dr Frank A.	
Electricity Assistants	*Agnew, Dr Paul G.	1906–20
	Taylor, Dr A. Hadley	1909–21
	McBride, Russell S.	1909–20
	Grover, Dr. Frederick W.	
II. WEIGHTS AND MEASURES	Fischer, Louis A.	
Length and Expansion Measurements	Gray, Dr. Arthur W.	1909–16
Capacity Measurements	Ferner, Roy Y.	
Mass	Pienkowsky, Arthur T.	
Density	(Vacant)	
Time	Ferner, Roy Y.	
Trade Weights and Measures	Holbrook, Fay S.	1909–40
Weights and Measures Assistant	Bearce, Henry W.	1908–45
III. THERMOMETRY, PYROMETRY AND HEAT MEASUREMENT	Waidner, Dr Charles W.	
Thermometry	Dickinson, Dr Hobart C.	
Calorimetry	Mueller, Dr Eugene F.	
Pyrometry	Burgess, Dr George K.	
Low Temperature Investigations	Kanolt, Clarence W.	1909–25

*This and subsequent rosters are based on NBS personnel records, NBS telephone directories, archival materials, and interviews with present and past staff members. In some instances available records were incomplete; in others, the Federal Records Center at St. Louis, Mo., reported "no records found."

*Agnew, to American Engineering Standards Committee as executive secretary, 1920.

III. THERMOMETRY, PYROMETRY AND HEAT MEASUREMENT—Continued		
Thermometry, Pyrometry and Heat Assistant	Buckingham, Dr Edgar	1906–37
IV. OPTICS	Stratton, Dr Samuel W.	
Radiometry	Coblentz, Dr William W.	
Polarimetry	Bates, Frederick J.	
Spectroscopy and Applied Optics	Priest, Irwin G.	1907–32
Interferometry	*Nutting, Dr Perley G.	
V. CHEMISTRY	Hillebrand, Dr William F.	1908–25
Electrochemistry	Blum, Dr William	1909–52
Oils, Rubber, Paper, Textiles	Waters, Campbell E.	
Metals, Cement, Bituminous Materials	Voorhees, Samuel S.	1910–21
ENGINEERING INSTRUMENTS	Hersey, Dr Mayo D.	1910–20, 1927–31
STRUCTURAL, ENGINEERING AND MISCELLANEOUS MATERIALS	Wormeley, Philip L.	1910–47
Structural Materials	*Howard, James E.	1910–14
Cement	Pearson, Joseph C.	1910–24
Lime	(Not known)	
Metals	(Not known)	
Protective Coatings	(Not known)	
Paper and Textiles	*Clark, Dr Frederick C.	1910–19
PITTSBURGH LABORATORY	Bleininger, Dr Albert V.	1910–23
	Emley, Warren E.	1910–43
	Bates, Phaon H.	1910–45
NORTHAMPTON LABORATORY	*Humphrey, Richard L.	1910–10
ATLANTIC CITY LABORATORY	Wig, Rudolph J.	1910–14

*Nutting, to research laboratory of Eastman Kodak Co., Rochester, N.Y., 1912; to Westinghouse Electric Co. as research director, 1916.

*Howard, transferred to Interstate Commerce Commission, 1914.

*Clark, to American Writing Paper Co., Holyoke, Mass., 1919.

*Humphrey, NBS member Aug. 5–10, 1910; no further record.

CHIEFS
OF THE SCIENTIFIC AND TECHNICAL STAFF

as of July 1, 1915

DIRECTOR — **Stratton, Dr Samuel W.**

I. ELECTRICITY	Rosa, Dr Edward B.	
Inductance and Capacity	Curtis, Dr Harvey L.	
Precision Resistance Measurement	Wenner, Dr Frank	
Electrical Measuring Instruments	Brooks, Dr Herbert B.	
Magnetic Measurements	Burrows, Dr Charles W.	
Electrochemistry	Vinal, Dr George W.	
Photometry	Crittenden, Dr Eugene C.	
Electrolysis	McCollum, Burton	
Radio Measurements	Dellinger, Dr J. Howard	1907–48
Radio Engineering	Kolster, Frederick A.	1911–21
Electromotive Force and Resistance	Wolff, Dr Frank A.	
Electrical Service Standards	Meyer, Dr J. Franklin	1913–41
Electricity Assistants	Agnew, Dr. Paul G.	
	Silsbee, Dr Francis B.	1911–59
II. WEIGHTS AND MEASURES	Fischer, Louis A.	
Mass	Pienkowsky, Dr Arthur T.	
Density and Capacity	Peffer, Elmer L.	1913–48
Trade Weights and Measures Investigations	Holbrook, Fay S.	
Time and Length	*Ferner, Roy Y.	
III. THERMOMETRY, PYROMETRY, AND HEAT MEASUREMENT	Waidner, Dr Charles W.	
Thermometry	Dickinson, Dr Hobart C.	
Pyrometry	Foote, Dr Paul D	1911–27
Calorimetry	Mueller, Eugene F.	
Low Temperature Investigations	Kanolt, Clarence W.	
Fire Resistance	Ingberg, Simon H.	1914–47
IV. OPTICS	Stratton, Dr Samuel W.	
Radiometry	Coblentz, Dr William W.	
Polarimetry	Bates, Frederick J.	
Spectroscopy	Meggers, Dr. William F.	1914–58
Colorimetry	Priest, Irwin G.	
Interferometry	Peters, Chauncey G.	1913–49
Dispersoids	Wells, Dr Philip V.	1913–23

*Ferner, to go into private business, 1918.

V. CHEMISTRY	Hillebrand, Dr William F.	
Electrochemistry	Blum, Dr William	
Metals, Cement, Bituminous Materials	Voorhees, Samuel S.	
Gas Chemistry	Weaver, Elmer R.	1912–57
Reagents and Apparatus	Smither, Frederick W.	1914–46
Paint, Varnish, Soap, etc.	Walker, Dr Percy H.	1914–37
VI. ENGINEERING RESEARCH AND TESTING	Stratton, Dr Samuel W.	
Engineering Instruments and Mechanical Appliances	Stutz, Walter F.	1912–47
Aviation Instruments	Hersey, Dr Mayo D.	
VII. METALLURGY	Burgess, Dr George K.	
Foundry and Mechanical Plant	Karr, Carydon P.	1913–25
Microscopy of Metals	Rawdon, Dr Henry S.	1912–45
Working of Metals	*Woodward, Dr Raymond W.	1914–21
	*Merica, Dr Paul D.	1914–19
VIII. STRUCTURAL, ENGINEERING AND MISCELLANEOUS MATERIALS	Bates, Phaon H.	
Clay	Bates, Phaon H.	
Lubricating Oils	Herschel, Dr Winslow H.	1913–43
Cement, Sand, Stone	Pearson, Joseph C.	
Rubber, Leather, Textiles	Wormeley, Philip L.	
PITTSBURGH LABORATORY	Bleininger, Dr Albert V.	
Optical Glass	Bleininger, Dr Albert V.	
Lime, Gypsum, Sand, Brick	Emley, Warren E.	

*Woodward, to Whitney Manufacturing Co., Hartford, Conn., as chief metallurgist, 1921.

*Merica, to International Nickel Co., Bayonne, N.J., 1919.

WARTIME PROJECTS OF THE SCIENTIFIC AND TECHNICAL STAFF

as of September 1918*

DIRECTOR	**Stratton, Dr Samuel W.**	
Technical Assistant to the Director	*Schlink, Frederick J.	1913–19
ELECTRICAL DIVISION	Rosa, Dr Edward B.	
Technical Assistants	Agnew, Dr Paul G.	
	Crittenden, Dr Eugene C.	
Standards of Resistance		
Airplane gun control and other problems	Wenner, Dr Frank	
	Macaulay, D. L.	
High frequency sound waves in water	*Wright, Winthrop R.	1917–19
Centrifugal gun and other problems	*Purington, Ellison S.	1915–19
Inductance and Capacity		
Ballistics of large caliber guns	Curtis, Dr Harvey L.	
Exterior ballistics of large caliber guns	*Duncan, Robert C.	1917–21
	Richards, Horace C.	
	*Moore, Harry H.	1915–23
Interior ballistics of large caliber guns	Kester, Frederick E.	
Subterranean sound investigations	Hufford, Mason E.	
	Wood, Capt. H. O.	
	Crane, 1st Lt. E. C.	
Machine gun synchronization	*Morgan, Raymond	1917–42
Jump and whip of gun at time of firing	Mertz, Pierre	
Electrical Measuring Instruments		
Fire-control apparatus	Brooks, Dr Herbert B.	
	*Stannard, Winfield H.	1909–19
Ignition	Silsbee, Dr Francis B.	
	*Dempsey, James B.	1916–39
	*Gorton, William S.	1917–19
Electric trucks and tractors	Farmer, T. O.	

*Source: Letter, Director NBS to Technical Information Section, Bureau of Aircraft Production, WD, for the General Staff, Sept. 20, 1918 (NBS Box 10, IG).

*Schlink, to instrument control department, Firestone Tire and Rubber Co., 1919; assistant secretary, AESC, 1922; technical director and president, Consumers' Research, Inc., 1929.

*Wright, returned to teaching, 1919.

*Purington, to Hammond Radio Laboratory, Gloucester, Mass., 1919.

*Duncan, to Bureau of Ordnance, Navy Department, 1921.

*Moore, to Navy Department, 1923.

*Morgan, to Department of Physics, University of Maryland, 1942.

*Stannard, to Central Scientific Co., Chicago, 1919.

*Dempsey, retired, May 11, 1939.

*Gorton, to Western Electric Co., New York, 1919.

Magnetic Measurement		
Supervision of section; magnetic mines	Sanford, Raymond L.	
Magnetic testing of metals for rifle barrels	*Kouwenhoven, Prof. William B.	
Magnetic testing of airplane tie wires	*Fisher, Melvin F.	1913–43
Airplane and marine compasses	Dawson, Leo H.	
Magnetic testing of welded ship plates	Becker, James A.	
Photometry and Illuminating Engineering		
Special illuminating equipment	Taylor, Dr A. Hadley	
	*Commery, Eugene W.	1917–19
Properties of incandescent lamps	*Skogland, James F.	1908–31
Methods of photometric measurement	*Morse, Marie L. T.	1918–31
Field searchlights	Karrer, Enoch	
	*Willis, Benjamin S.	1917–24
	Zahn, E. T.	
Radio Communications Section		
Vacuum tube measurements	Beltz, H. H.	
Radio measurements	Grover, Dr Frederick W.	
	*Freeman, Herbert M.	1917–19
	*Breit, Gregory	1918–19
	Harmon, H. W.	
	Merriman, A. G.	
	Montgomery, N.	
	Snow, H. A.	
	Werden, E. T.	
Radio design	Buckley, J. P.	
Radio development	Dellinger, Dr J. Howard	
	*Dunmore, Francis W.	1918–49
	*Hull, Lewis M.	
	Hillebrand, L. E.	
	Kolster, Frederick A.	
	*Lowell, Percival D.	1913–24, 1941–62
	*McDowell, Louise S.	
	*Miller, John M.	1907–19
	Ould, Richard S.	1918–23
	*Preston, J. L.	

*Kouwenhoven, returned to Johns Hopkins University staff.
*Fisher, died Dec. 23, 1943.
*Commery, to National Lamp Works, Nela Park, Cleveland, Ohio.
*Skogland, died Feb. 10, 1931.
*Morse, resigned, illness 1931.
*Willis, to Iowa State College, 1919.
*Freeman, to Westinghouse Electric and Manufacturing Co., Pittsburgh, Pa., 1919.
*Breit, to University of Leiden, Holland, on National Research Fellowship, 1919, and then to Carnegie Institution, Washington, D.C.
*Dunmore, retired, 1949.
*Hull, L. M. to Radio Frequency Laboratory, Boonton, N.J.
*Lowell, retired, 1962 (now consultant).
*McDowell, to Wellesley College, Mass.
*Miller, to Atwater Kent Radio Corp., 1919.
*Preston, to Bureau of Lighthouses.

Radio Communications Section—Continued

Radio development—Continued		
	*Southworth, George C.	1917–18
	*Whittemore, Laurens E.	1917–24
	Wade, W. G.	
	*Willoughby, John A.	1916–22
Electrolysis Prevention		
Sound ranging	McCollum, Burton	
	Eckhardt, Dr Englehardt A.	
	*Weibel, Dr Ernest E.	
	*Karcher, Dr J. C.	
	*Peters, Orville S.	1910–29
	*Fisher, J. Carl	
	Melton, E. R.	
	Goren, David	
	*Snyder, Carl F.	1909–60
Electrolysis mitigation	*Shepard, Edgar R.	1914–33
Standards of electric railway service	Logan, Kirk H.	
	Baller, M. J.	
	Monroe, W. P.	
Electrical Safety Engineering		
Public utility standards	Lloyd, Dr Morton G.	
Industrial safety standards	*Oakes, Charles E.	1917–21
Electrical safety standards	Sahm, Paul A. B.	1916–NRF
	*Waldschmidt, Albert	
	Congdon, W. E.	
Wind pressure on wires	Dahm, P. E.	
Gas Engineering		
Coke ovens, toluol, gas standards	McBride, Russell S.	
	*Reinecker, Charles E.	1916–23
	Lausley, J. W.	
Hydrogen gas plant operation	*Berry, Walter M.	1916–23

*Southworth, to Yale University, 1918; American Telephone & Telegraph Co., New York, 1923.
*Whittemore, to Bureau of Navigation, Department of Commerce, 1920; to American Telephone & Telegraph Co., New York, 1925.
*Willoughby, to the Naval Research Laboratory, 1922.
*Weibel, killed in France, August 1918.
*Karcher, to Western Electric, Chicago, 1923; later to Amerada Oil Co.
*Peters, resigned to become consultant engineer, 1929.
*Fisher, to Consolidated Gas and Electric Co., Baltimore, Md.
*Snyder, retired 1960.
*Shepard, to Department of Agriculture, 1933.
*Oakes, to Pennsylvania Power and Light Co., Allentown, Pa.
*Waldschmidt, to Patent Office, Department of Commerce, 1920.
*Reinecker, to United Gas Improvement Co., Philadelphia, Pa.
*Berry, to California Gas Research Council, Los Angeles, Calif.

Gas Engineering—Continued		
Natural gas, economic problems, standards	Morgan, C. S.	
	Frankel, M. J.	
Assistants in gas engineering	Gray, G. A.	
	*Eiseman, John H.	1916–57
Electrical Service Standards		
Electric light and power service	Meyer, J. Franklin	
Jurisdiction of state public service commissions	Crawford, J. P.	
Telephone Service Standards		
Supervision of telephone investigations	Wolff, Dr Frank A.	
Telephone traffic investigations	Macomber, G. S.	
Telephone equipment investigations	Brown, W. E.	
Methods of measurement	*Taylor, Dr Hawley O.	
Assistant to Dr Taylor	Pike, C. E.	
Standard cell and microphone investigations	*Shoemaker, Maynard P.	1905–36
The audion and its applications	Beltz, H. H.	
Transmission investigations	*Sasuly, Max	1913–24
Microphone investigations	Godfrey, C. M.	
Electrochemistry		
Battery research and testing	Vinal, Dr George W.	
Chemistry of primary and storage batteries	*Holler, Dr H. D.	
	Sefton, Miss L. B.	
Development of galvanic piles	Schott, R. C.	
Dry cell and small storage batteries	Koller, L. R.	
Storage batteries	Cole, T. S.	
Radioactivity and X–Ray Measurements		
Properties, use, and measure of luminous materials	Dorsey, Dr N. Ernest	
X-ray apparatus and materials	Huff, Dr W. B.	
Self-luminous materials	*Brown, Prof. T. B.	
	Richmond, J. E.	
	Taylor, M. D.	
Assistant observer in investigations	McCrea, W. D.	
Application of self-luminous materials	Yung-Kwai, Elizabeth	
X-ray protective materials	Alderton, Nina M.	

*Eiseman, retired Dec. 31, 1957.
*Taylor, H. O., to the Franklin Union, Boston, Mass., as director of the electrical department, 1921.
*Shoemaker, to the Treasury Department, 1936.
*Sasuly, reduction in force, 1924.
*Holler, to Geology Department, Vassar College.
*Brown, to George Washington University.

WEIGHTS AND MEASURES	Fischer, Louis A.	
Length, Time, and Capacity Section		
Calibration of scales, haemacytometers	Judson, Dr Lewis V.	
	Maslin, M.	
Stop watches (Ordnance), clocks (Shipping Board)	Beal, Arthur F.	
Gas measuring devices, aviation instruments	Stillman, Marcus H.	
Packaging of materials for oversea shipment	Roeser, Harry W.	1914–34
Laws, Weights, and Measures		
Density and thermal expansion of liquids	Peffer, Elmer L.	
Dilution pipettes (haemacytometers)	Hill, E. E.	
Gas Measuring Instruments		
Aircraft inclinometers, telephone transmitters, gas measuring, photography	Stillman, Marcus H.	
Thermal Expansivity		
Thermal expansion of airplane alloys, spark plug insulators, etc., silicon	Souder, Dr Wilmer	
	Hidnert, Dr Peter	
	Eisinger, J. O.	
Mil scale study for Signal and Navy; rulings for Ordnance	Souder, Dr Wilmer	
Gage Research		
Supervision of gage research	*Van Keuren, Harold L.	1914–19
Miscellaneous gages; weighing	*Briggs, Clarence A.	1910–24
	Gordon, E. D.	
	Fullmer, Irwin H.	
	*Haigh, Joseph A.	1917–44
	Bean, Howard S.	
HEAT AND THERMOMETRY	Waidner, Dr Charles W.	
Thermometry		
Thermometer testing; airplane thermometry	Wilhelm, Robert M.	1908–20
	Martin, Frank W.	
Thermal properties of methane	Finkelstein, Joseph L.	
Pyrometry		
Chief of high temperature investigations	Foote, Dr Paul D.	
Optical and radiation pyrometry	Fairchild, Charles O.	
Optical glass	Tool, A. Q.	
	Valasek, Joseph	

*Van Keuren, to Wilton Tool Co., 1919.
*Briggs, to Department of Agriculture, 1924.
*Haigh, retired, Aug. 17, 1944 (disability).

Pyrometry—Continued		
Gas explosions; spark plugs for airplanes	Mohler, Dr Fred L.	
Optical pyrometry and ionization	Rognley, O.	
Thermocouple testing; specific heats	*Harrison, Thomas R.	1915–20
Melting points of refractories	Dana, Leo I.	
Coke ovens and optical glass (Signal Corps)	Christie, Pvt. J. L.	
Heat Measurements		
Heat measurement problems	Mueller, Eugene F.	
Thermal conductivity; balloon problems	VanDusen, Dr Milton S.	
Thermal properties of methane at low temperatures	*Osborne, Nathan S.	1903–39
	Stimson, Dr Harold F.	1916–60
	*Sligh, Thomas S. Jr.	1916–26
	Cragoe, Carl S.	1918–50
	Jessup, Ralph S.	
Torpedo investigations	Meyers, Cyril H.	
	DuPriest, J. R.	
Thermodynamics		
Technical thermodynamics	Buckingham, Dr Edgar	
Low Temperature		
Operation of liquid air plant	Ford, Thomas B.	
Low temperature testing	Cook, J. Williamson	
Fire Resistance		
Fire tests of building columns	Ingberg, Simon H.	
	*Griffin, Harry K.	1908–21
Fire tests of reinforced concrete columns	*Hull, W. A.	
	Fulton, W. C.	
Fire resistance of structural materials; methane	Kanolt, Clarence W.	
Fire resistance and aspects of city building codes	*Glading, Frank W.	1914–19
Airplane Power Plant		
Supervisor of airplane engine research	Dickinson, Dr Hobart C.	
Assistant to supervisor	*James, William S.	1911–24
Aeronautic engine performance	Anderson, G. V.	
	Boreman, R. W.	
	Brinkerhoff, V. W.	
	Lapp, Sgt. C. J.	
	Lee, T. E.	

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*Harrison, resigned, 1920.
*Osborne, retired 1939.
*Sligh, to Studebaker Corp., 1926.
*Griffin, to Barnett Co., 1921.
*Hull, to Terra Cotta Service, Chicago, Ill., 1924.
*Glading, to Baldwin Locomotive Works as industrial engineer.
*James resigned, 1924.

Airplane Power Plant—Continued		
Aeronautic engine performance—Continued	Long, A. R.	
	McKenzie, D.	
	Sparrow, Stanwood W.	
	Stern, A. G.	
	Scholz, W. P.	
	Thomson, Malcolm	
	Walden, C. O.	
	Wetherill, Frederic V.	
Spark plugs	Arnold, S. B.	
	Bradshaw, G. R.	
	Fonseca, Edward L.	
	Honaman, R. Karl	
	Johnson, G. M.	
	Sawyer, L. G.	
Lubrication	Bingham, F. C.	
	Grosklaus, O.	
	Markle, F. H.	
	Menzies, W. C.	
	Schulze, J. E.	
	Willey, B.	
Carburetion	Blackwell	
	Brewer, R. E.	
	Stanton, W. F.	
	Tice, P. S.	
Physical properties of carburetor air	*Hoxton, Dr Llewelyn G.	1901–04, 1917–18
Radiators	Brown, William B.	
	Castleman, Robert A. Jr.	
	*Harper, Dr D. Roberts Jr.	1909–25
	Harvey, A. R.	
	Haydoch, E.	
	Kleinschmidt, Robert V.	
	Parsons, S. R.	
	Van de Water, Jean	
	Voorhees, L. E.	
Indicators	Newell, F. B.	
LIGHT AND OPTICAL INSTRUMENTS		
Spectroscopy		
Infra-red spectroscopy and photography	Meggers, Dr William F.	
	*Burns, Dr Keivin	1913–19
	Kiess, Carl C.	1917–
Color sensitive photographic emulsions	*Merrill, Dr Paul W.	1916–19
	Ellis, J. H.	
	*Walters, Francis M.	

*Hoxton, returned to Physics Department, University of Virginia.
*Harper, to engineering laboratory of General Electric Co., Schenectady, N.Y., Sept. 30, 1925.
*Burns, to Allegheny Observatory, Pittsburgh, Pa.
*Merrill, to Mt. Wilson Observatory.
*Walters, to Carnegie Institute of Technology.

Spectroscopy—Continued		
Photographic lens design	*Mellor, Lewis L.	
Glass weathering, spectroscopic analysis	*Burka, Samuel M.	
Polarimetry		
Magneto optics; sugar technology	Bates, Frederick J.	
Physical chemistry of carbohydrates	*Jackson, Dr Richard F.	1907–43
Physics relating to sugar testing	Phelps, Francis P.	
Interferometry and Colorimetry		
Color standards; spectrophotometry; chromatic camouflage	Priest, Irwin G.	
	Gibson, Dr Kasson S.	
	*Tyndall, E. P. T.	
	McNicholas, Harry J.	
Dyes	Mathewson, Capt. W. E.	
Lens Testing		
Effect of striae on optical glass	*Bennett, A. H.	
	Smith, Thomas T.	
Glass for goggles	Wensel, Dr Henry T.	
Camera designing for the Navy	Curtis, Dr Heber D.	
Optical designing for the Navy	*Michelson, Albert A.	
Lens design	Eckel, Arthur F.	
	Schultz, Harry I.	1913–NRF
	White, H. S.	
Radiometry		
Radiometers; photoelectric signaling	Coblentz, Dr William W.	
Assistant	Kahler, H.	
Sound		
Transmission of sound in airplane ranging	Jones, A. T.	
CHEMISTRY	Hillebrand, Dr William F.	
Physical Chemistry		
Physical constants and purification of methane; standard samples	*McKelvy, Ernest C.	1907–19
	Taylor, Dr Cyril S.	
	*Isaacs, Aaron	1913–34
Analysis of gasolines	*Yurow, Louis	1913–19
	Simpson, D. H.	
	Ruderman, A.	

*Mellor, to Bell & Howell.
*Burka, to Optical Division, Patterson Airfield, Dayton, Ohio.
*Jackson, died June 1, 1943.
*Tyndall, to Iowa State University.
*Bennett, to American Optical Co.
*Michelson, returned to Physics Department, University of Chicago.
*McKelvy, accidental death, Nov. 29, 1919.
*Isaacs, resigned, 1934.
*Yurow, resigned, 1919.

Electrochemistry		
Electrodeposition	Blum, Dr William	
Commercial electroplating	Hogaboom, G. B.	
	Liscomb, F. J.	
	Slattery, T. J.	
Analytical methods for plating	Jencks, E. Z.	
	Ritchie, LeMarr	
	Ham, L. B.	
Physical-chemical methods for plating	Bell, A. D.	
Special plating problems	Madsen, C. P.	
Gas Chemistry		
Balloon fabrics: life tests, permeability	*Edwards, Junius D.	1913–19
	Moore, Irwin L.	
	Pickering, S. F.	
	Schoch, H. K.	
	Saper, P. G.	
Automatic gas analysis: nitrate plant; submarines	*Franklin, Dr E. C.	
	Frantz, H. W.	
	Gordon, B. D.	
	Mackenzie, J. D.	
	Palmer, P. E.	
	Crump, C. C.	
	Weaver, Elmer R.	
	Young, S. W.	
	*Bliss, Dr W. J. A.	
Balloon gases	Ledig, P. G.	
Balloon temperatures	Long, Maurice B.	
Gas engine exhaust analysis	MacPherson, Dr Archibald T.	1918–
Reagents and Apparatus		
Chemistry of the platinum metals	Smither, Frederick W.	
	Wichers, Dr Edward	1917–63
	Gilchrist, Dr Raleigh A.	1918–62
Methods of testing chemical reagents	Sive, Benjamin E.	
Analytical Methods and Standard Samples		
Tungsten, molybdenum, zirconium analysis	Lundell, Dr Gustave E. F.	1917–48
Methods of iron and steel analysis	*Witmer, Luther F.	1909–20
	Hoffman, James I.	1918–62
	Silwinski, A. A.	
Determination of zirconium in ores	*Knowles, Howard B.	1913–50
Determination of tungsten in ores	Rennie, W. E.	

*Edwards, resigned, 1919.
*Franklin, returned to Chemistry Department, Stanford University.
*Bliss, returned to Chemistry Department, Johns Hopkins University.
*Witmer, resigned, 1920.
*Knowles, retired, June 29, 1950.

Oils, Rubber, Paper, Textiles, Ink, Glue

Lubricants	Waters, Campbell E.	
Airplane dopes and related subjects	Smith, W. Harold	1910–57
	Jacobson, I. M.	
Leather	Whitmore, Lester M.	
Dyestuffs	Mathewson, W. E.	
	Clark, Edgar R.	
Textile dyeing	Sleeper, R. R.	
Rubber analysis	Epstein, Samuel W.	
Printing inks	Basseches, J. L.	

Metals, Cement, and Bituminous Materials

Cement, alloys, and bituminous materials	Voorhees, Samuel S.	
	Bright, Harry A.	1913–60
	*Fitch, Roy O.	1913–18
	*Scherrer, John A.	1910–40
	Burger, E. N.	
Corrosion of metals	Finn, Alfred N.	1911–42
Toluol benzol	Washburn, Frederic McL.	

Paint, Varnish, and Soap

Paint, varnish, detergents	Walker, Dr Percy H.	1918–37
	*Bower, John H.	1914–48
	McNeil, Hiram C.	
	*Schmidt, George C.	1914–22
	*Lewis, A. J.	1914–20
	Demovsky, A.	
	Cooke, Sgt. G. W.	
Varnish, drying oils, enamels	*Wertz, Franklin A.	1913–18
Preservative materials	Prince, Lt. K. P.	

ENGINEERING INSTRUMENTS

Mechanical Appliances and Engineering Instruments

Mechanical applicances	Wormeley, Philip L.	
Theory and design of measuring instruments	Schlink, Frederick J.	
Engineering instruments	Stutz, Walter F.	
	Hodge, Orlando J.	
	Baster, F. S.	

Aviation Instruments

Altimeters, elasticity, viscosity	Hersey, Dr Mayo D.	
Ground speed indicators	Hunt, Dr Franklin L.	1917–24
Gyroscopic stabilizers and bomb sights	Franklin, Dr W. S.	
Vibrations in airplanes	*Nusbaum, Dr Christian	

*Fitch, died Oct. 13, 1918.
*Scherrer, retired, Dec. 31, 1940.
*Bower, retired, June 30, 1948.
*Schmidt, resigned 1922.
*Lewis, to H. H. Franklin Manufacturing Co., Syracuse, 1920.
*Wertz, resigned, 1918.
*Nusbaum, returned to Case School of Applied Science, Cleveland, Ohio.

Aviation Instruments—Continued		
Tachometers	Washburn, George E.	
	Sylvander, Roy C.	
	Rawlins, C. H.	
Elastic properties of diaphragms	Nelms, W. S.	
Rate of climb indicators	Mears, Atherton H.	
Oxygen control apparatus	Hoffman, Leslie A.	
	Smith, B. A.	
	Keat, W. G.	
Air speed indicators	Stearns, Howard O.	
Inclinometers	Stillman, Marcus H.	
Bimetallic strips	Peterson, J. B.	
Aviation Physics		
Aerodynamical laboratory investigations	Briggs, Dr Lyman J.	
Wind tunnel investigations	Heald, Roy H.	
	Upton, Frederick E.	
	McMurdie, Alex M.	
	Cook, Robert	
Scientific instrument design	Simpson, W. S.	
	Blackwood, W. J.	
Construction of research apparatus	Dolmar, M.	
	Oser, O.	
ENGINEERING, STRUCTURAL, AND MISCELLANEOUS MATERIALS	Voorhees, Dr Samuel S.	
Metals		
Metal airplane construction	Whittemore, Dr. Herbert L.	
	Johnston, R. S.	
Airplane instruments	*McNair, Dr F. W.	
	Templin, Richard L.	
Calibration testing machines	Moore, H. F.	
Strength of welded ship plates	Hoffman, Charles P.	
	Curts, H. L.	
Strength of reinforced concretes	Larson, L. J.	
Impact strength of steel	Cushing, B. L.	
Impact strength of wood	Robbins, L. L.	
Causes of failure in steel rails	Anderson, H. A.	
Strength of full-length airplane beams	Sorey, T. L.	
Strength of military construction materials	Wise, F. J.	
	Rynders, G. W.	
Cement, Concrete, Stone, Gravel, Sand		
Reversal of stress on concrete beams	*Smith, George A.	1916–26
Concrete investigations	Kessler, Daniel W.	

*McNair, to presidency of Michigan School of Mines.
*Smith, resigned, 1926.

Cement, Concrete, Stone, Gravel, Sand—Continued		
Concrete ship construction problems	Maconi, G. V.	
	Davis, Watson	
Design of reinforced concrete	Slater, W. A.	
Effect of alkali and sea water on concrete	*Williams, Guy M.	1911–23
Volume change in concrete	Laubly, Charles S.	
Miscellaneous Materials		
Section chief	Worméley, Philip L.	
Lubricants	Herschel Dr Winslow H.	
Leather	Hart, Reeves W.	
	Cheney, Walter L.	
	Bowker, Roy C.	
	Wallin, F. W.	
Rubber	*Patrick, Erwin C.	1912–20
	Collier, S.	
	Morgan, W. F.	
	Linscott, R. F.	
	Bond, E. R.	
Textiles		
Airplane fabrics	*Walen, Ernest D.	1914–19
	Fisher, Russell T.	
Cotton fabrics	Dickson, E. E.	
	Bauldry, C. E.	
	Perkins, J. H.	
Wool fabrics and felt	Webster, P.	
	Spicer, E.	
	McGavan, F. R.	
General military fabrics	Duman, R. W.	
	Philpot, I.	
	Wackman, C. F.	
Textile microscopy	Basche, H.	
Ceramics (Pittsburgh Laboratory)		
Chemistry of cements, clay, glass	Stecker, H. C.	
	Royal, H. F.	
	Maag, O. L.	
Structural Materials (Pittsburgh Laboratory)		
Physical properties of portland and sorel cements	*Parsons, Walter E.	1916–20
	Greenwald, A. H.	
Properties of cements and concretes	Bates, Phaon H.	
Fire Resisting Materials (Pittsburgh Laboratory)		
Fire-resisting qualities of structural materials.	*Hull, Walter A.	1914–23
	Fulton, W. C.	
	Gunning, R. T.	

*Williams, resigned, 1923.

*Patrick, to Mason Tire and Rubber Co., Kent, Ohio, as chief chemist and engineer, 1920.

*Walen, to manager, Textile Research Co., Boston, 1919.

*Parsons, reduction in force, 1920.

*Hull, W. A., to Northwestern Terra Cotta Co., Chicago, Ill., 1923.

Steel, Concrete, Cement (Pittsburgh Laboratory)

Steel columns, building tile	*Hathcock, Bernard D.	1916–NRF
	*Griffith, John H.	1911–NRF
Earth resistance of cement and concrete	Virgin, W. H.	
Cement, concrete, wire rope, manila rope	*Newell, Palmer F.	1913–NRF

Paper

Section chief	Clark, Dr Frederick C.	
Wall board, adhesives, test methods	*Conley, Albert D.	1916–NRF
Paper for gas masks and airplane fabrics	Durgin, Albert G.	
	Harding, R. H.	
Operation of paper machine for gas masks	Houston, P. L.	
	Bicking, G. W.	
Microphotography of balloon fabrics	Loftan, R. E.	
Optical methods for testing gas mask paper	Curtis, Cpl. Frederick A.	
Paper samples from military agencies	Mendel, Pvt. J. P.	

METALLURGY DIVISION	Burgess, Dr George K.	

Microscopy of Metals

Microscopy studies; corrosion of nonferrous alloys	Rawdon, Dr Henry S.	
Microstructure of ordnance steels, brass	Nauss, George M.	

Heat Treatment and Thermal Analysis

Heat treatment of steels; rust proofing	Grossmann, Marcus A.	
Heat treatment of metallic alloys	Freeman, John R. Jr.	
	*Scott, Howard	1912–25

Physical Properties and Miscellaneous

Light aluminum alloys; electric welding	Merica, Dr Paul D.	
	*Waltenberg, Romaine G.	1912–21
	France, R.	
	Oesterle, Pvt. J. F.	
Bearing metals; tin conservation	*Woodward, Dr Raymond W.	1914–21
Tin conservation; solders	Gurevich, Louis J.	
Electric welding	Hurvitz, B.	

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*Hathcock, resigned, 1919.
*Griffith, resigned, 1919.
*Newell, resigned, 1919.
*Conley, resigned, 1919.
*Scott, resigned, 1925.
*Waltenburg, resigned, 1921.
*Woodward, to Whitney Manufacturing Co., Hartford, Conn., as chief metallurgist, 1921.

Chemical Metallurgy		
Preparation of alloys	Jordan, Louis	
	Owens, A. W.	
Methods for determining gases in steel, iron	Wetmore, A. S.	
General metallurgical research	Cain, Dr John R.	
Foundry and Mechanical Plant		
Aluminum alloys for airplane work	Karr, Carydon P.	
Foundry work in aluminum alloy research	Flegel, A.	
Molding sands; vitreous enamels for metals	Staley, Prof. Homer F.	
CLAY PRODUCTS	Bleininger, Dr Albert V.	
Ceramics		
Special spark plugs, optical glass, light clay aggregates for concrete ships, graphite crucibles, porcelain studies	Bleininger, Dr Albert V.	
	Riddle, F. H.	
	Wright, Joseph W.	
	Fuller, D. E.	
	McDaniel, W. W.	
	*Cutler, Charles H.	1914–31
Spark plugs for airplanes	Geiger, C. F.	
Containers for firing airplane spark plugs	Hornung, M. R.	
Optical Glass		
Optical glass research	Gregory, M. C.	
	Rand, C. C.	
	Payne, A. R.	
	Dodd, L. E.	
	Roberts, George C.	
	McKee, A. P.	
	Zimmer, Casper	
	Williams, W. S.	
	Noyes, M. P.	
Lime		
Lime and gypsum products	Kirkpatrick, Frank A.	
	Orange, William B.	
	Householder, F. F.	

*Cutler, retired, Nov. 30, 1931.

CHIEFS
OF THE SCIENTIFIC AND TECHNICAL STAFF

as of January 1, 1920

DIRECTOR	***Stratton, Dr Samuel W.**	
Technical Assistant to the Director	Brown, Dr Fay C.	1919–27
I. ELECTRICAL	*Rosa, Dr Edward B.	
1. Standards of Resistance	Wenner, Dr Frank	
2. Inductance and Capacity	Curtis, Dr Harvey L.	
3. Electrical Measurings Instruments	Brooks, Dr Herbert B.	
4. Magnetic Measurements	Sanford, Raymond L.	1910–54
5. Photometry and Illuminating Engineering	*Taylor, Dr A. Hadley	
6a. Radio Research and Testing	Dellinger, Dr J. Howard	
6b. Radio Development	*Kolster, Frederick A.	
7. Electrolysis Prevention	McCollum, Burton	
8. Safety Engineering	Lloyd, Dr Morton G.	
9. Gas Engineering	*McBride, Russell S.	
10. Electrical Service Standards	Meyer, Dr J. Franklin	
11. Telephone Service Standards	Wolff, Dr Frank A.	
12. Electrochemistry	Vinal, Dr George W.	
13. Radioactivity and X-ray Measurements	Dorsey, Dr N. Ernest	
II. WEIGHTS AND MEASURES	*Fischer, Louis A.	
1. Length	Judson, Dr Lewis V.	1917–65
2. Mass	Pienkowsky, Dr Arthur T.	
3. Time	*Beal, Arthur F.	1917–23
4. Capacity and Density	Peffer, Elmer L.	
5. Gas Measuring Instruments	*Stillman, Marcus H.	1910–20
6. Thermal Expansivity	Souder, Dr Wilmer	1910–13, 1917–54

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*Stratton, to M.I.T. as president, Jan. 1, 1923; died Oct. 18, 1931.
*Rosa, died May 17, 1921.
*Taylor, A. Hadley, to Nela Park, Cleveland, 1921.
*Kolster, resigned to join Federal Telegraph Co., 1921.
*McBride, to McGraw-Hill, 1920, later private consulting chemical engineer.
*Fischer, died July 25, 1921.
*Beal, to Census Bureau, 1923.
*Stillman, to Fairbanks Scale Co., 1920.

II. WEIGHTS AND MEASURES—Continued		
7. Weights and Measures Laws and Administration	Holbrook, Fay S.	
8. Investigation, Testing of Scales	Holbrook, Fay S.	
9. Gages	Bearce, Henry W.	1908–45
III. HEAT AND THERMOMETRY	*Waidner, Dr Charles W.	
1. Thermometry	*Wilhelm, Robert M.	
2. Pyrometry	Foote, Dr Paul D.	
3. Heat Measurements	Mueller, Eugene F.	
4. Thermodynamics	*Buckingham, Dr Edgar	
5. Cryogenic Laboratory	Kanolt, Clarence W.	
6. Fire Resistance	Ingberg, Simon H.	
7. Airplane and Automotive Power Plant	Dickinson, Dr Hobart C.	
IV. LIGHT AND OPTICAL INSTRUMENTS	Skinner, Dr Clarence A.	1919–41
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Colorimetry	Priest, Irwin G.	
4. Refractometry and Optical Instruments	*Schultz, Harry I.	1913–20
5. Radiometry	Coblentz, Dr William W.	
6. Dispersoids	*Wells, Dr Philip V.	
7. Photographic Technology	(Planned)	
8. Interferometry	Peters, Chauncey G.	
9. Searchlight Investigations	*Karrer, Enoch	1918–22
V. CHEMISTRY	Hillebrand, Dr William F.	
1. Physical Chemistry	*Taylor, Dr Cyril S.	1913–20
2. Electrochemistry	Blum, Dr William	
3. Metallurgical Chemistry	*Cain, Dr John R.	
4. Gas Chemistry	Weaver, Elmer R.	
5. Reagents and Apparatus	Smither, Frederick W.	
6. Analytical Methods, Standard Samples	Lundell, Dr Gustave E. F.	
7. Oils, Rubber, Paper, etc.	Waters, Campbell E.	
8. Metals, Cement, Bituminous Materials	*Voorhees, Samuel S.	
9. Paint, Varnish, Soap	Walker, Dr Percy H.	

*Waidner, died Mar. 11, 1922.
*Wilhelm, to C. J. Tagliabue Manufacturing Co., Aug. 31, 1920.
*Buckingham, consultant to engineering physics division, NBS, 1923–37; retired 1937; died Apr. 29, 1940.
*Schultz, resigned to set up private business, 1920.
*Wells, to E. I. duPont (Redpath Laboratories), Parlin, N.J., 1923.
*Karrer, to General Electric, 1922.
*Taylor, to Aluminum Company of America, in research laboratory, 1920.
*Cain, NBS Research Associate, 1921–36; member of NBS, 1936 until retirement May 31, 1945.
*Voorhees, died Sept. 21, 1921.

VI. ENGINEERING PHYSICS	Stratton, Dr Samuel W.	
1. Mechanical Appliances	Wormeley, Philip L.	
2. Engineering Instruments	Stutz, Walter F.	
3. Aviation Instruments	*Hersey, Dr Mayo D.	
4. Aviation Physics	Briggs, Dr Lyman J.	1917–46
5. Special Investigations (Sound)	*Hayford, John F.	1917–21
VII. ENGINEERING, STRUCTURAL, AND MISCELLANEOUS MATERIALS	Stratton, Dr Samuel W.	
1. Metal Structures	Whittemore, Herbert L.	1917–46
2. Cement, Sand, Stone, etc.	*Pearson, Joseph C.	
3. Rubber, Leather, etc.	Wormeley, Philip L.	
4. Textiles	*McGowan, Frank R.	1918–25
5. Paper	*Curtis, Frederick A.	1918–24
6. Lubricating Oils	*Herschel, Dr Winslow H.	
7. Lime, Gypsum, Sand, Brick	Emley, Warren E.	
VIII. METALLURGY	Burgess, Dr George K.	
1. Microscopy of Metals	Rawdon, Dr Henry S.	
2. Heat Treatment and Thermal Analysis	French, Herbert J.	1919–29
3. Physical Properties of Metals	Burgess, Dr George K.	
4. Chemical Metallurgy	Cain, Dr John R.	
5. Foundry and Mechanical Plant	*Karr, Carydon P.	
IX. CERAMICS	*Bleininger, Dr Albert V.	
1. Clay Products	Bleininger, Dr Albert V.	
2. Optical Glass	*Taylor, William H.	1918–25
3. Refractories	*Staley, Homer F.	1918–20
4. Enameled Metal Products	Staley, Homer F.	
MISCELLANEOUS		
Sound	Eckhardt, Dr Englehardt A.	1917–25

*Hersey, NBS consultant, 1921–22; in physics laboratory of U.S. Bureau of Mines, 1922–26; returned to Bureau 1926.

*Hayford, completed investigation, June 30, 1921.

*Pearson, to Lehigh Portland Cement Co., Allentown, Pa., 1924.

*McGowan, to Cotton Textile Institute, New York, as director, Jan. 30, 1925; continued as consultant to NBS.

*Curtis, to American Writing Paper Co., Holyoke, Mass., 1924.

*Herschel, section discontinued; continued research until retirement, Aug. 31, 1943.

*Karr, died June 10, 1925.

*Bleininger, to Homer Laughlin China Co., West Virginia, 1923.

*Taylor, W. Hadley, to Pittsburgh Plate Glass Co., 1925.

*Staley, former professor in department of ceramic engineering, Iowa State College; resigned to enter commercial work, Dec. 31, 1920.

CHIEFS
OF THE SCIENTIFIC AND TECHNICAL STAFF

as of February 1, 1925

DIRECTOR	**Burgess, Dr George K.**	
Assistant to the Director	*Brown, Dr Fay C.	
I. ELECTRICAL	Crittenden, Dr Eugene C.	
1. Resistance Measurements	Wenner, Dr Frank	
2. Inductance and Capacitance	Curtis, Dr Harvey L.	
3. Electrical Measuring Instruments	Brooks, Dr Herbert B.	
4. Magnetic Measurements	Sanford, Raymond L.	
5. Photometry and Illuminating Engineering	Meyer, Dr J. Franklin	
6. Radio Communication	Dellinger, Dr J. Howard	
7. Electrolysis Prevention	*McCollum, Burton	
8. Safety Engineering	Lloyd, Dr Morton G.	
9. Electrochemistry	Vinal, Dr George W.	
10. Telephone Standards	Wolff, Dr Frank A.	
II. WEIGHTS AND MEASURES	Holbrook, Fay S., and Bearce, Henry W.	
1. Length	Judson, Dr Lewis V.	
2. Mass	Pienkowsky, Dr Arthur T.	
3. Time	Gould, Ralph E.	1918–50
4. Capacity and Density	Peffer, Elmer L.	
5. Gas Measuring Instruments	Bean, Howard S.	1917–58
6. Thermal Expansivity	Souder, Dr Wilmer	
7. Weights and Measures Laws Administration	Smith, Ralph W.	1920–50
8. Investigation and Testing of Scales	*Roeser, Harry W.	
9. Gages	Miller, David R.	1908–52
III. HEAT AND POWER	Dickinson, Dr Hobart C.	
1. Thermometry	Mueller, Eugene F.	
2. Pyrometry	*Fairchild, Charles O.	1915–26

*Brown, to Museum of the Peace Arts (later renamed New York Museum of Science and Industry) as director, 1927.

*McCollum, to McCollum Geological Exploration Inc., as technical director, 1926.

*Roeser, separated in reduction in force, June 30, 1934; contract employee from 1944 to death in 1950.

*Fairchild, to Tagliabue Manufacturing Co., Brooklyn, N.Y., 1926.

III. HEAT AND POWER—Continued		
3. Heat Measurements	Mueller, Eugene F.	
4. Heat Transfer	(Vacant)	
5. Cryogenic Laboratory	*Kanolt, Clarence W.	
6. Fire Resistance	Ingberg, Simon H.	
7. Automotive Power Plant	*Sparrow, Stanwood W.	1918–26
IV. OPTICS	Skinner, Dr Clarence A.	
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Colorimetry	Priest, Irwin G.	
4. Optical Instruments	Gardner, Dr Irvine C.	1921–59
5. Radiometry	Coblentz, Dr William W.	
6. Atomic Physics, Radium, X-Ray	*Foote, Dr Paul D.	
7. Photographic Technology	Davis, Raymond	1911–58
8. Interferometry	Peters, Chauncey G.	
V. CHEMISTRY	*Hillebrand, Dr William F.	
1. Paints, Varnishes, Bituminous Materials	Walker, Dr Percy H.	
2. Detergents, Cement, Corrosion	Smither, Frederick W.	
3. Rubber, Lubricants, Textiles, Inks	Waters, Campbell E.	
4. Metal and Ore Analysis and Standard Samples	Lundell, Dr Gustave E. F.	
5. Reagents	Wichers, Dr Edward	
6. Electrochemistry	Blum, Dr William	
7. Gas Chemistry	Weaver, Elmer R.	
VI. MECHANICS AND SOUND	Briggs, Dr Lyman J.	
1. Engineering Instruments and Mechanical Appliances	Stutz, Walter F.	
2. Sound	*Eckhardt, Dr Englehardt A.	
3. Aeronautic Instruments	Eaton, Herbert A.	1918–53
4. Aerodynamical Physics	Dryden, Dr Hugh L.	1918–47
5. Engineering Mechanics	Whittemore, Herbert L.	
VII. STRUCTURAL ENGINEERING AND MISCELLANEOUS MATERIALS	Bates, Phaon H.	
1. Structural and Engineering Materials	(Vacant)	

*Kanolt, to Cryogenic Laboratory, Bureau of Mines, 1925; later to Farrand Optical Co., N.Y.

*Sparrow, to Studebaker Corp. as director of research, 1926.

*Foote, to Gulf Research and Development Co., Pittsburgh, as director of research, Aug. 1, 1927; returned through National Academy of Sciences in 1960 as Executive Secretary of NAS–NRC Technical Advisory Panels to NBS

*Hillebrand, died Feb. 7, 1925.

*Eckhardt, to Gulf Research and Development Co. as geophysicist, 1925; to Marlan Refining Co., Oklahoma, as assistant chief of research, 1927.

VII. STRUCTURAL ENGINEERING AND MISCELLANEOUS MATERIALS—Continued		
2. Cement, Sand, Stone	*Hitchcock, Frank A.	1918–26
3. Rubber, Leather, etc.	Wormeley, Philip L.	
4. Textiles	(Vacant)	
5. Paper	Scribner, Bourdon W.	1923–52
6. Lime, Gypsum, etc.	*Porter, John M.	1921–28
VIII. METALLURGY	*Gillett, Dr Horace W.	1924–29
1. Optical Metallurgy	Rawdon, Dr Henry S.	
2. Thermal Metallurgy	*French, Herbert J.	
3. Mechanical Metallurgy	*Freeman, John R. Jr.	1918–29
4. Chemical Metallurgy	Jordan, Louis	1917–36
5. Experimental Foundry	Saeger, Charles M. Jr.	1918–45
IX. CERAMICS	Bates, Phaon H.	
1. Pottery	*Wadleigh, Walter H.	1918–34
2. Optical Glass	Finn, Alfred N.	1911–42
3. Refractories	Geller, Roman F.	1918–55
4. Enameled Metals	*Wolfram, Harold G.	1923–26
BUILDING AND HOUSING	*Gries, Dr John M.	1921–28
SIMPLIFIED PRACTICE	*Hudson, Ray M.	1922–29
STANDARDIZATION OF SPECIFICATIONS	Burgess, Dr George K. (Chairman, Federal Specifications Board)	
Federal Specifications	*Harriman, Norman F.	1921–33
Industrial Specifications	McAllister, Dr Addams S.	1923–45

*Hitchcock, to George Washington University, 1926.
*Porter, to American Cyanamid Co., 1928.
*Gillett, to Battelle Memorial Institute, Columbus, Ohio, as director, 1929.
*French, to research laboratory, International Nickel Co. of New Jersey, 1929 (died 1955).
*Freeman, to American Brass Co., Waterbury, Conn., 1929.
*Wadleigh, reduction in force, June 30, 1934.
*Wolfram, to Porcelain Enamel Manufacturing Co., Baltimore, Md., 1926.
*Gries, to Division of Public Construction, Department of Commerce, 1928.
*Hudson, to New England Council, Boston, as technical advisor, 1929.
*Harriman, to Treasury Department, 1933.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of April 1, 1930

DIRECTOR	***Burgess, Dr George K.**	
Assistant Director for Research and Testing	Briggs, Dr Lyman J.	
Assistant Director for Commercial Standardization	McAllister, Dr Addams S.	
I. ELECTRICAL	Crittenden, Dr Eugene C.	
1. Resistance Measurements	Wenner, Dr Frank	
2. Inductance and Capacitance	Curtis, Dr Harvey L.	
3. Electrical Instruments	Brooks, Dr Herbert B.	
4. Magnetic Measurements	Sanford, Raymond L.	
5. Photometry	Meyer, Dr J. Franklin	
6. Radio	Dellinger, Dr J. Howard	
7. Underground Corrosion	Logan, Kirk H.	1911–44
8. Safety Standards	Lloyd, Dr Morton G.	
9. Electrochemistry	Vinal, Dr George W.	
10. Telephone Standards	Wolff, Dr Frank A.	
II. WEIGHTS AND MEASURES	Holbrook, Fay S., and Bearce, Henry W.	
1. Length	Judson, Dr Lewis V.	
2. Mass	Pienkowsky, Dr Arthur T.	
3. Time	Gould, Ralph E.	
4. Capacity and Density	Peffer, Elmer L.	
5. Gas Measuring Instruments	Bean, Howard S.	
6. Thermal Expansivity	Souder, Dr Wilmer	
7. Weights and Measures Laws and Administration	Smith, Ralph W.	
8. Railroad Scales and Test Cars	Holbrook, Fay S.	
9. Gages	Miller, David R.	
III. HEAT AND POWER	Dickinson, Dr Hobart C.	
1. Thermometry	Busse, Miss Johanna	1918–49
2. Pyrometry	Wensel, Dr Henry T.	1917–46
3. Heat Measurements	Mueller, Eugene F.	
4. Heat Transfer	VanDusen, Dr Milton S.	1913–46
5. Cryogenic Laboratory	Brickwedde, Dr Ferdinand G.	1925–57
6. Fire Resistance	Ingberg, Simon H.	

*Burgess, died July 2, 1932.

III. HEAT AND POWER—Continued		
7. Automotive Power Plant	Cummings, Herbert K.	1922–53
8. Friction and Lubrication	*Hersey, Dr Mayo D.	
IV. OPTICS	Skinner, Dr Clarence A.	
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Colorimetry	*Priest, Irwin G.	
4. Optical Instruments	Gardner, Dr Irvine C.	
5. Radiometry	Coblentz, Dr William W.	
6. Atomic Physics, Radium, X-rays	Mohler, Dr Fred L.	1917–60
7. Photographic Technology	Davis, Raymond	
8. Interferometry	Peters, Chauncey G.	
V. CHEMISTRY	*Washburn, Dr Edward W.	1926–34
1. Physico-chemical Research	Washburn, Dr Edward W.	
2. Paints, Varnish, Bituminous Materials	Walker, Dr Percy H.	
3. Detergents, Cement, Corrosion	Smither, Frederick W.	
4. Rubber, Lubricants, Textiles	Waters, Campbell E.	
5. Metal and Ore Analysis, Standard Samples	Lundell, Dr Gustave E. F.	
6. Reagents and Platinum Metals	Wichers, Dr Edward	
7. Electrochemistry	Blum, Dr William	
8. Gas Chemistry	Weaver, Elmer R.	
VI. MECHANICS AND SOUND	Briggs, Dr Lyman J.	
1. Engineering Instruments and Mechanical Appliances	Stutz, Walter F.	
2. Sound	Heyl, Dr Paul R.	1920–42
3. Aeronautic Instruments	Brombacher, Dr William G.	1927–54
4. Aerodynamical Physics	Dryden, Dr Hugh L.	
5. Engineering Mechanics	Whittemore, Herbert L.	
6. Hydraulic Laboratory	Eaton, Herbert N.	
VII. ORGANIC AND FIBROUS MATERIALS	Emley, Warren E.	
1. Rubber	Wormeley, Philip L.	
2. Textiles	Appel, William D.	1922–59
3. Paper	Scribner, Bourdon W.	
4. Leather	Bowker, Roy C.	1918–43
VIII. METALLURGY	Rawdon, Dr Henry S.	
1. Optical Metallurgy	Rawdon, Dr Henry S.	
2. Thermal Metallurgy	*Dowdell, Dr Ralph L.	1928–30
3. Mechanical Metallurgy	Swanger, William H.	1921–42
4. Chemical Metallurgy	Jordan, Louis	
5. Experimental Foundry	Saeger, Charles M. Jr.	

*Hersey, senior physicist, 1928–31; to Vacuum Oil Co., New Jersey, 1931.
*Priest, died July 19, 1932.
*Washburn, died Feb. 6, 1934.
*Dowdell, to University of Minnesota, as Chairman, Department of Metallurgy, 1930.

IX. CLAY AND SILICATE PRODUCTS	Bates, Phaon H.	
1. Whiteware	Geller, Roman F.	
2. Glass	Finn, Alfred N.	
3. Refractories	Heindl, Raymond A.	1923–55
4. Enamels	Harrison, William N.	1922–63
5. Heavy Clay Products	Stull, Ray T.	1927–44
6. Cement and Concrete Materials	Tucker, John Jr.	1916–17, 1926–49
7. Masonry Construction	Parsons, Douglas E.	1923–63
8. Lime and Gypsum	*Murray, James A.	1926–30
9. Stone	Kessler, Daniel W.	1914–52
X. SIMPLIFIED PRACTICE	Ely, Edwin W.	1923–47
1. Stone, Clay and Glass	*Colwell, Herbert R.	1921–31
2. Wood, Textiles and Paper	Schuster, George	
3. Metal Products and Construction Materials	*Dunn, Peter H. H.	1927–33
4. Containers	Braithwaite, William E.	
5. Promotion and Adherence	*Galt, Alexander B.	1924–33
XI. BUILDING AND HOUSING	*Taylor, James S.	1921–34
1. Building Codes	Thompson, George N.	1923–55
2. Building Practice and Homebuilders' Problems	Phelan, Vincent B.	1927–50
3. City Planning and Zoning	Taylor, James S.	
4. Construction Economics	*Riggleman, Dr John R.	1929–33
5. Mechanics Liens	*Wheeler, Daniel H.	1923–33
XII. SPECIFICATIONS	McAllister, Dr Addams S.	
1. Certification: Producer Contacts	*Martino, Robert A.	1923–33
2. Labeling: Consumer Contacts	McAllister, Dr Addams S.	
3. Directory of Specifications	*Ingels, Clarence W.	1928–33
4. Encyclopedia of Specifications	*Wardlaw, George A.	1930–33
XIII. TRADE STANDARDS	Fairchild, Ihler J.	1922–45
1. Wood Products, Paper, Rubber, etc.	*Steidle, Harry H.	1928–38
2. Metal Products	Fairchild, Ihler J.	
3. Textiles and Garments	Fairchild, Ihler J.	
4. Ceramic Products and Cement	Wray, George W.	

*Murray, to Warner Co., Pittsburgh, as Director of Research, 1930; died 1960.
*Colwell, to President's Emergency Committee for Employment, 1931.
*Dunn, to Department of Interior, 1933.
*Galt, resigned 1933.
*Taylor, to Federal Housing Administration, 1934.
*Riggleman, to National Recovery Administration, 1933.
*Wheeler, to Federal Emergency Administration, 1933.
*Martino, to National Recovery Administration, 1933; returned briefly to NBS in 1940.
*Ingels, to Navy Department, 1933.
*Wardlaw, to Navy Department, 1933
*Steidle, to private industry, 1938.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of November 15, 1934

DIRECTOR	**Briggs, Dr Lyman J.**	
Assistant to the Director	Hubbard, Henry D.	1901–38
ASSISTANT DIRECTORS		
Assistant Director for Research and Testing	Crittenden, Dr Eugene C.	
Assistant Director for Commercial Standardization	McAllister, Dr Addams S.	
I. ELECTRICAL	Crittenden, Dr Eugene C.	
1. Resistance Measurements	Wenner, Dr Frank	
2. Inductance and Capacitance	Curtis, Dr Harvey L.	
3. Electrical Instruments	*Brooks, Dr Herbert B.	
4. Magnetic Measurements	Sanford, Raymond L.	
5. Photometry	Meyer, Dr J. Franklin	
6. Radio	Dellinger, Dr J. Howard	
7. Underground Corrosion	Logan, Kirk H.	
8. Electrochemistry	Vinal, Dr George W.	
9. Telephone Standards	Wolff, Dr Frank A.	
II. WEIGHTS AND MEASURES	*Holbrook, Fay S., and Bearce, Henry W.	
1. Length	Judson, Dr Lewis V.	
2. Mass	Pienkowsky, Dr Arthur T.	
3. Time	Gould, Ralph E.	
4. Capacity and Density	Peffer, Elmer L.	
5. Gas Measuring Instruments	Bean, Howard S.	
6. Thermal Expansivity, Dental Materials	Souder, Dr Wilmer	
7. Weights and Measures Laws and Administration	Smith, Ralph W.	
8. Railroad Scales and Test Cars	Holbrook, Fay S.	
9. Gage Standardization	Miller, David R.	
III. HEAT AND POWER	Dickinson, Dr Hobart C.	
1. Thermometry	Busse, Miss Johanna	
2. Pyrometry	Wensel, Dr Henry T.	
3. Heat Measurements	Mueller, Eugene F.	

*Brooks retired Jan. 31, 1939.
*Holbrook, died Feb. 4, 1940.

III. HEAT AND POWER—Continued		
4. Heat Transfer	VanDusen, Dr Milton S.	
5. Cryogenic Laboratory	Brickwedde, Dr Ferdinand G.	
6. Fire Resistance	Ingberg, Simon H.	
7. Automotive Power Plant	Cummings, Herbert K.	
8. Lubrication and Liquid Fuels	Bridgeman, Dr Oscar C.	1927–45
IV. OPTICS	Skinner, Dr Clarence A.	
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Colorimetry	Gibson, Dr Kasson S.	1916–55
4. Optical Instruments	Gardner, Dr Irvine C.	
5. Radiometry	Coblentz, Dr William W.	
6. Atomic Physics, Radium, X-Ray	Mohler, Dr Fred L.	
7. Photographic Technology	Davis, Raymond	
8. Interferometry	Peters, Chauncey G.	
V. CHEMISTRY	*Walker, Dr Percy H.	
0. Physico-chemical Research	Smith, Dr Edgar R.	1926–57
1. Paints, Varnishes, etc.	Hickson, Eugene F.	1918–50
2. Detergents, Cement, etc.	Smither, Frederick W.	
3. Organic Chemistry	Waters, Campbell E.	
4. Metal and Ore Analysis, Standard Samples	Lundell, Dr Gustave E. F.	
5. Reagents and Platinum Metals	Wichers, Dr Edward	
6. Electrochemistry (Plating)	Blum, Dr William	
7. Gas Chemistry	Weaver, Elmer R.	
VI. MECHANICS AND SOUND	Briggs, Dr Lyman J.	
1. Engineering Instruments and Mechanical Applicances	Stutz, Walter F.	
2. Sound	Heyl, Dr Paul R.	
3. Aeronautical Instruments	Brombacher, Dr William G.	
4. Aerodynamical Physics	Dryden, Dr Hugh L.	
5. Engineering Mechanics	Whittemore, Herbert L.	
6. Hydraulic Laboratory	Eaton, Herbert N.	
VII. ORGANIC AND FIBROUS MATERIALS	Emley, Warren E.	
1. Rubber	McPherson, Dr Archibald T.	
2. Textiles	Appel, William D.	
3. Paper	Scribner, Bourdon W.	
4. Leather	Bowker, Roy C.	
5. Testing and Specifications	Wormeley, Philip L.	
6. Industrial Utilization of Farm Wastes	Acree, Dr Solomon F.	1927–45

*Walker, retired, August 1937; consulting chemist to National Lead Co. subsidiary, 1937.

VIII. METALLURGY	Rawdon, Dr Herbert S.	
1. Optical Metallurgy	McAdam, Dr Dunlop, J. Jr.	1930–48
2. Thermal Metallurgy	*Jordan, Louis	
3. Mechanical Metallurgy	Swanger, William H.	
4. Chemical Metallurgy	Thompson, Dr John G.	1921–24, 1930–56
5. Experimental Foundry	Saeger, Charles M., Jr.	
IX. CLAY AND SILICATE PRODUCTS	Bates, Phaon H.	
1. Whiteware	Geller, Roman F.	
2. Glass	Finn, Alfred N.	
3. Refractories	Heindl, Raymond A.	
4. Enameled Metals	Harrison, William N.	
5. Heavy Clay Products	Stull, Ray T.	
6. Cement and Concreting Materials	Tucker, John Jr.	
7. Masonry Construction	Parsons, Douglas E.	
8. Lime and Gypsum	Wells, Dr Lansing S.	1930–54
9. Stone	Kessler, Daniel W.	
X. SIMPLIFIED PRACTICE	Ely, Edwin W.	
1. Wood, Textiles, Paper	Schuster, George	
2. Metal Products and Construction Materials	Schuster, George	
3. Containers and Miscellaneous Products	Braithwaite, William E.	
4. Handling Equipment and Ceramics	Ely, Edwin W.	
XI. TRADE STANDARDS	Fairchild, Ihler J.	
1. Wood, Wood Products, Oils, etc.	Fairchild, Ihler J.	
2. Metal Products	Fairchild, Ihler, J.	
3. Textiles and Garments	Ehrman, H. A.	
4. Ceramic and Cement Products	Reynolds, Floyd W.	1918–19, 1930–NRF
5. Chemical and Miscellaneous Products.	Reynolds, Floyd W.	
XII. CODES AND SPECIFICATIONS	McAllister, Dr Addams S.	
1. Safety Codes	Lloyd, Dr Morton G.	
2. Building Codes	Thompson, George N.	
3. Building Practice and Specifications	Phelan, Vincent B.	
4. Producer Contacts and Certification	Wray, George W.	
5. Consumer Contacts and Labeling	McAllister, Dr Addams S.	

*Jordan, to American Institute of Mining and Metallurgical Engineering, Jan. 25, 1936.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of May 1, 1940

DIRECTOR	**Briggs, Dr Lyman J.**
Assistant to the Director	*Hubbard, Henry D.
ASSISTANT DIRECTORS	
Assistant Director for Research and Testing	Crittenden, Dr Eugene C.
Assistant Director for Commercial Standardization	*McAllister, Dr Addams S.
I. ELECTRICITY	Crittenden, Dr Eugene C.
1. Resistance Measurements	*Wenner, Dr Frank
2. Inductance and Capacitance	Curtis, Dr Harvey L.
3. Electrical Instruments	Silsbee, Dr Francis B.
4. Magnetic Measurements	Sanford, Raymond L.
5. Photometry	*Meyer, Dr J. Franklin
6. Radio	Dellinger, Dr J. Howard
7. Underground Corrosion	Logan, Kirk H.
9. Electrochemistry	Vinal, Dr George W.
10. Telephone Standards	*Wolff, Dr Frank A.
II. WEIGHTS AND MEASURES	Bearce, Henry W.
1. Length	Judson, Dr Lewis V.
2. Mass	*Pienkowsky, Dr Arthur T.
3. Time	Gould, Ralph E.
4. Capacity and Density	Peffer, Elmer L.
5. Gas Measuring Instruments	Bean, Howard S.
6. Thermal Expansion, Dental Research	Souder, Dr Wilmer
7. Weights and Measures Administration	Smith, Ralph W.
8. Large-capacity Scales	Smith, Ralph W.
9. Limit Gages	Miller, David R.

*Hubbard, retired Sept. 1, 1938; died 1945.
*McAllister, retired, Feb. 28, 1945.
*Wenner, retired, 1943.
*Meyer, retired, Jan. 31, 1941 (ill health).
*Wolff, retired, Apr. 30, 1941.
*Pienkowsky, retired, 1944, and joined staff of Torsion Balance Co.; died Dec. 31, 1960.

III. HEAT AND POWER	Dickinson, Dr Hobart C.	
1. Thermometry	Busse, Miss Johanna	
2. Pyrometry	*Wensel, Dr Henry T.	
3. Heat Measurements	*Mueller, Eugene F.	
4. Heat Transfer	VanDusen, Dr Milton S.	
5. Cryogenic Laboratory	Brickwedde, Dr Ferdinand G.	
6. Fire Resistance	Ingberg, Simon H.	
7. Automotive Power Plants	Cummings, Herbert K.	
8. Lubrication and Liquid Fuels	Bridgeman, Dr Oscar C.	
9. Aviation Engines and Accessories	*Peters, Melville F.	1922–43
IV. OPTICS	*Skinner, Dr Clarence A.	
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Colorimetry and Spectrophotometry	Gibson, Dr Kasson S.	
4. Optical Instruments	Gardner, Dr Irvine C.	
5. Radiometry	*Coblentz, Dr William W.	
6. Atomic Physics, Radium, X-Rays	Mohler, Dr Fred L.	
7. Photographic Technology	Davis, Raymond	
8. Interferometry	Peters, Chauncey G.	
V. CHEMISTRY	Lundell, Dr Gustave E. F.	
1. Paints, Varnishes, etc.	Hickson, Eugene F.	
2. Detergents, Cement, etc.	Smither, Frederick W.	
3. Organic Chemistry	*Waters, Campbell C.	
4. Metal and Ore Analysis, Standard Samples	Bright, Harry A.	1913–60
5. Reagents and Platinum Metals	Wichers, Dr Edward	
6. Electrochemistry (Plating)	Blum, Dr William	
7. Gas Chemistry	Weaver, Elmer R.	
8. Physical Chemistry	Smith, Dr Edgar R.	
9. Thermochemistry and Constitution of Petroleum	Rossini, Dr Frederick D.	1928–50
VI. MECHANICS AND SOUND	Dryden, Dr Hugh L.	
1. Engineering Instruments	Stutz, Walter F.	
2. Sound	*Heyl, Dr Paul R.	
3. Aeronautical Instruments	Brombacher, Dr William G.	
4. Aerodynamics	Dryden, Dr Hugh L.	
5. Engineering Mechanics	Whittemore, Herbert L.	
6. Hydraulics	Eaton, Herbert N.	

*Wensel, to General Staff, USA (Manhattan Project) 1942; acting chief, heat and power division 1945; assistant to Director on atomic energy research, 1946.
*Mueller, retired, 1944.
*Peters, to Titeflex Metal Hose Co., 1943.
*Skinner, retired, Jan. 31, 1941; died 1961.
*Coblentz, retired Jan. 1, 1945; NBS consultant; died Sept. 15, 1962.
*Waters, retired, 1942.
*Heyl, retired, July 1, 1942; died 1961.

VII. ORGANIC AND FIBROUS MATERIALS	*Emley, Warren E.	
1. Rubber	McPherson, Dr Archibald T.	
2. Textiles	Appel, William D.	
3. Paper	Scribner, Bourdon W.	
4. Leather	*Bowker, Roy C.	
5. Testing and Specifications	Wormeley, Philip L.	
6. Fiber Structure	Acree, Dr Solomon F.	
7. Organic Plastics	Kline, Dr Gordon M.	1929–63
VIII. METALLURGY	Rawdon, Dr Herbert S.	
1. Optical Metallurgy	Rawdon, Dr Herbert S.	
2. Thermal Metallurgy	McAdam, Dr Dunlop J., Jr.	
3. Mechanical Metallurgy	*Swanger, William S.	
4. Chemical Metallurgy	Thompson, Dr John G.	
5. Experimental Foundry	*Saeger, Charles M., Jr.	
IX. CLAY AND SILICATE PRODUCTS	Bates, Phaon H.	
1. Whiteware	Geller, Roman F.	
2. Glass	*Finn, Alfred N.	
3. Refractories	Heindl, Raymond A.	
4. Enameled Metals	Harrison, William N.	
5. Heavy Clay Products	*Stull, Ray T.	
6. Cement and Concreting Materials	Tucker, John Jr.	
7. Masonry Construction	Parsons, Douglas E.	
8. Lime and Gypsum	Wells, Dr Lansing S.	
9. Stone	Kessler, Daniel W.	
X. SIMPLIFIED PRACTICE	Ely, Edwin W.	
1. Wood, Textiles, Paper	Schuster, George	
2. Metal Products and Construction Materials	Schuster, George	
3. Containers and Miscellaneous Products	Braithwaite, William E.	
4. Materials Handling Equipment and Ceramics	Ely, Edwin W.	
XI. TRADE STANDARDS	Fairchild, Ihler J.	
1. Wood, Wood Products, etc.	Medley, James W.	1938–NRF
2. Metal Products	Fairchild, Ihler J.	
3. Textiles	Ehrman, H. A.	
4. Apparel	Gilbert, L. R.	
5. Petroleum, Chemicals, Rubber	Reynolds, Floyd W.	
6. Export Standards	*Countryman, Milton E.	1940–42

*Emley, retired, Oct. 1, 1943; to War Production Board, 1943.
*Bowker, to OSRD, 1943.
*Swanger, died Aug. 19, 1942.
*Saeger, retired, June 27, 1945.
*Finn, died Sept. 21, 1942.
*Stull, died Jan. 5, 1944.
*Countryman, to War Production Board, 1942.

XII. CODES AND SPECIFICATIONS	McAllister, Dr Addams S.	
1. Safety Codes	*Lloyd, Dr Morton G.	
2. Building Codes	Thompson, George N.	
3. Building Practices and Specifications	Phelan, Vincent B.	
4. Producer Contracts and Certification	Wray, George W.	
5. Consumer Contracts and Labeling	Martino, Robert A.	
FIELD STATIONS		
Allentown, Pa. (Cement and Concrete Materials)	Moyer, W. N.	
Riverside, Calif. (Cement and Concrete Materials)	Evans, D. N.	
San Francisco, Calif. (Cement and Concrete Materials)	Furlong, I.	
Denver, Colo. (Cement and Concrete Materials)	Cox, O. H.	
Seattle, Wash. (Cement and Concrete Materials)	Carlson, Elmer T.	1928–NRF
Clearing, Ill. (Large-capacity Scale Testing)	Richard, C. L.	
San Jose, Calif. (Cement and Concrete Materials)	Foster, Bruce E.	1935–NRF
Beltsville, Md. (Radio Transmitting Station)	George, William D.	1929–63
Meadows, Md. (Radio Sending Station)	*Kirby, Samuel S.	1926–41

*Lloyd, died Apr. 26, 1941.
*Kirby, died Jan. 26, 1941.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of July 1, 1945

DIRECTOR	***Briggs, Dr Lyman J.**	
ASSISTANT DIRECTOR	Crittenden, Dr Eugene C.	
I. ELECTRICITY	Crittenden, Dr Eugene C. Silsbee, Dr Francis B. (Assistant)	
1. Resistance Measurements	Thomas, Dr James L.	1927–
2. Inductance and Capacitance	*Curtis, Dr Harvey L.	
3. Electrical Instruments	Silsbee, Dr Francis B.	
4. Magnetic Measurements	Sanford, Raymond L.	
5. Radio	*Dellinger, Dr J. Howard	
7. Underground Corrosion	*Logan, Kirk H.	
9. Electrochemistry	Vinal, Dr George W.	
II. WEIGHTS AND MEASURES	*Bearce, Henry W. Souder, Dr Wilmer (Assistant)	
1. Length	Judson, Dr Lewis V.	
2. Mass	McCurdy, Lloyd B.	
3. Time	*Gould, Ralph E.	
4. Capacity and Density	*Peffer, Elmer L.	
5. Gas Measuring Instruments	Bean, Howard S.	
6. Thermal Expansion; Dental Research	Souder, Dr Wilmer	
7. Weights and Measures Administration	Smith, Ralph W.	
8. Large-capacity Scales	Russell, H. Haig	1919–
9. Limit Gages	Miller, David R.	
III. HEAT AND POWER	*Dickinson, Dr Hobart C. Cragoe, Carl S. (Assistant)	1918–50
1. Thermometry	*Busse, Miss Johanna	

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*Briggs, retired, Nov. 5, 1945; died Mar. 25, 1963.
*Curtis, to Ordnance Development Division, 1946; retired late that year.
*Dellinger, retired, Apr. 30, 1948; NBS consultant.
*Logan, to Cast Iron Pipe Research Association, 1944.
*Bearce, retired Sept. 30, 1945.
*Gould, retired, 1950.
*Peffer, died July 1948.
*Dickinson, retired Oct. 31, 1945; died Nov. 27, 1949.
*Cragoe, resigned 1950.
*Busse, Miss, retired, 1949.

III. HEAT AND POWER—Continued		
2. Pyrometry	*VanDusen, Dr Milton S.	
3. Heat Measurements	Cragoe, Carl S.	
4. Heat Transfer	Dill, Richard S.	1928–57
5. Cryogenics	Brickwedde, Dr Ferdinand G.	
6. Fire Resistance	*Ingberg, Simon H.	
7. Automotive Power Plants	*Brooks, Donald B.	1922–24, 1927–49
8. Lubricants and Liquid Fuels	*Bridgeman, Dr Oscar C.	
9. Aircraft Engines	*Cummings, Herbert K.	
IV. OPTICS	*Bates, Frederick J. Gibson, Dr Kasson S. (Assistant)	
1. Spectroscopy	Meggers, Dr William F.	
2. Polarimetry	Bates, Frederick J.	
3. Photometry and Colorimetry	Gibson, Dr Kasson S.	
4. Optical Instruments	Gardner, Dr Irvine C.	
5. Radiometry	Humphreys, Dr Curtis J.	1928–53
6. Atomic Physics	Mohler, Dr Fred L.	
7. Photographic Technology	Davis, Raymond	
8. Interferometry	*Peters, Chauncey G.	
9. Radioactivity	Curtiss, Dr Leon F.	1926–61
10. X-Rays	Taylor, Dr Lauriston S.	1927–
V. CHEMISTRY	*Lundell, Dr Gustave E. F. Wichers, Dr Edward (Asst.)	
1. Paints, Varnishes, Bituminous Materials	Hickson, Eugene F.	
2. Detergents, Cements, Miscellaneous Materials	*Smither, Frederick W.	
3. Organic Chemistry	Smith, W. Harold	
4. Metal and Ore Analysis; Standard Samples	Bright, Harry A.	
5. Reagents and Platinum Metals	Gilchrist, Dr Raleigh	1918–62
6. Electrochemistry (Plating)	Blum, Dr William	
7. Gas Chemistry	Weaver, Elmer R.	
8. Physical Chemistry	Smith, Dr Edgar R.	
9. Thermochemistry	Rossini, Dr Frederick D.	
10. pH Standards	*Acree, Dr Solomon F.	

*VanDusen, retired, 1946.
*Ingberg, retired, July 1, 1947.
*Brooks, retired, 1949.
*Bridgeman, to Phillips Petroleum Co., 1945.
*Cummings, section discontinued; NBS consultant, 1948– .
*Bates, F. J., retired, Jan. 31, 1947.
*Peters, retired, 1949; died 1955.
*Lundell, retired, June 1948; NBS consultant, 1948–50; died June 8, 1950.
*Smither, retired, August 1946; died Mar. 8, 1961.
*Acree, retired, Dec. 31, 1945; died Oct. 23, 1957.

VI. MECHANICS AND SOUND	*Dryden, Dr Hugh L.	
	*Tuckerman, Dr Louis B. (Assistant)	1919–49
1. Engineering Instruments	*Stutz, Walter F.	
2. Sound	Cook, Dr Richard K.	1935–
3. Aeronautical Instruments	Brombacher, Dr William G.	
4. Aerodynamics	Dryden, Dr Hugh L.	
5. Engineering Mechanics	*Whittemore, Herbert L.	
6. Hydraulics	Eaton, Herbert N.	
7. Special Projects	Eaton, Herbert N.	
VII. ORGANIC AND FIBROUS MATERIALS	McPherson, Dr Archibald T.	
	*Wormeley, Philip L. (Assistant)	
1. Rubber	Wood, Dr Lawrence A.	1935–
2. Textiles	Appel, William D.	
3. Paper	Scribner, Bourdon W.	
4. Leather	Wallace, Everett L.	
5. Testing and Specifications	Wormeley, Philip L.	
6. Organic Plastics	Kline, Dr Gordon M.	
VIII. METALLURGY	*Rawdon, Dr Herbert S.	
	Thompson, Dr John G. (Assistant)	
1. Optical Metallurgy	Rawdon, Dr Herbert S.	
2. Thermal Metallurgy	*McAdam, Dr Dunlop J. Jr.	
3. Mechanical Metallurgy	Roeser, William F.	1920–64
4. Chemical Metallurgy	Thompson, Dr John G.	
5. Experimental Foundry	Krynitsky, Alexander I.	1918–50
IX. CLAY AND SILICATE PRODUCTS	*Bates, Phaon H.	
	Parsons, Douglas E. (Asst.)	
1. Whiteware	Geller, Roman F.	
2. Glass	Hahner, Clarence H.	1929–
3. Refractories	Heindl, Raymond A.	
4. Enameled Metals	Harrison, William N.	
6. Cement and Concreting Materials.	*Tucker, John Jr.	

*Dryden, assistant director, NBS, January 1946; associate director, NBS, June 1946; to National Advisory Committee for Aeronautics as director of research, September 1947; deputy administrator, National Aeronautics and Space Administration, August 1958.
*Tuckerman, retired, Sept. 30, 1949.
*Stutz, retired, 1947.
*Whittemore, retired, Oct. 31, 1946.
*Wormeley, retired, Dec. 31, 1947.
*Rawdon, retired, Oct. 31, 1945.
*McAdam, retired, 1947; NBS consultant, 1948–
*Bates, P. H., retired, Sept. 15, 1945.
*Tucker, died, Nov. 20, 1949.

IX. CLAY AND SILICATE PRODUCTS—Continued		
7. Masonry Construction	Parsons, Douglas E.	
8. Lime and Gypsum	Wells, Dr Lansing S.	
9. Stone	Kessler, Daniel W.	
X. SIMPLIFIED PRACTICE	Ely, Edwin W. Schuster, George (Asst.)	
1. Wood, Textiles, Paper, Rubber	Schuster, George	
2. Metal and Mechanical Products.	Umhau, George E.	
3. Containers and Miscellaneous Products.	Braithwaite, William E.	
4. Materials Handling Equipment and Ceramics.	Ely, Edwin W.	
5. Electrical Products	*Tait, Andres C.	1942–50
6. Construction Materials	*Poiesz, Clemens J.	1942–49
7. Metal and Wood Working Tools.	Umhau, George E.	
XI. TRADE STANDARDS	*Fairchild, Ihler J. Reynolds, Foyd W. (Asst.)	
1. Wood, Wood Products, Paper	Medley, J. W.	
2. Metal Products	*Powell, Franklin E.	1943–50
3. Textiles	Ehrman, H. A.	
4. Apparel	Gilbert, L. R.	
5. Chemical and Miscellaneous Products	Reynolds, Floyd W.	
6. Export Standards	Barrett, Edward C.	1942–56
7. Petroleum and Rubber Products	*Gale, G. S.	1942–47
XII. CODES AND SPECIFICATIONS	Thompson, George N. *Dickinson, John A. (Asst.)	1919–59
1. Safety Codes	Dickinson, John A.	
2. Building Codes	Thompson, George N.	
3. Building Practices and Specifications	*Phelan, Vincent B.	
4. Producer Contacts and Certification	*Booth, Sherman F.	1939–62
5. Consumer Contacts and Labeling	*Cooley, Paul A.	1943–47

*Tait, transferred to Treasury Department, 1950.
*Poiesz, to Bureau of Indian Affairs, 1949.
*Fairchild, retired, 1945; to Plumbing Fixtures Association.
*Powell, transferred to Defense Department, 1950.
*Gale, reduction in force, 1947.
*Dickinson, J. A., retired, Sept. 30, 1959.
*Phelan, retired, Aug. 31, 1950.
*Booth, retired, 1962.
*Cooley, to Commodity Standards Division, Department of Commerce, 1947; to Bureau of Foreign and Domestic Commerce, 1951.

ORDNANCE DEVELOPMENT	*Diamond, Harry	1927–48
Assistant	Astin, Dr Allen V.	1932–
Chief Engineer	Hinman, Wilbur S. Jr.	1928–53
1. Proof Operations	Godfrey, Theodore B.	1928–53
2. Analysis and Recording	*White, Dr Thomas N.	1942–46
3. Electronic Engineering	Page, Dr Chester H.	1941–
4. Mechanical Engineering	Rabinow, Jacob	1934–53
5. Production Engineering	*Brunetti, Dr Cledo	1941–49
6. Control Testing	*Heilprin, Dr Laurence B.	1941–51
7. Basic Engineering	*Miller, Dr Bertrand J.	1943–48
8. Special Projects	Silsbee, Dr Francis B.	
FIELD STATIONS		
Beltsville, Md. (Radio Transmitting Station).	George, William D.	
Sterling, Va. (Radio Receiving Station).	*Pineo, Victor C.	1942–57
Clearing, Ill. (Standardization of Test Weight Cars).	Russell, H. Haig	
Allentown, Pa. (Cement Testing and Inspection).	Moyer, W. N.	
San Jose, Calif. (Cement Testing and Inspection).	Foster, Bruce E.	
Riverside, Calif. (Cement Testing and Inspection).	Evans, D. N.	
Seattle, Wash. (Cement Testing and Inspection).	Winblade, F. N.	
Denver, Colo. (Cement and Concrete Materials Testing).	Cox, O. H.	
San Francisco, Calif. (Cement, Concrete and Miscellaneous Materials).	Bohn, Richard A.	1928–NRF

*Diamond, died, Mar. 21, 1948.
*White, to Strategic Air Command, 1946.
*Brunetti, to Stanford Research Institute as associate director, 1949.
*Heilprin, to Taut Engineering Co. as consultant physicist, 1951.
*Miller, to Zenith Radio Corp., June 1948.
*Pineo, to Lincoln Laboratory, M.I.T., 1957.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of March 1, 1950

DIRECTOR	**Condon, Dr. Edward U.**	**1945–51**
ASSOCIATE DIRECTORS	*Crittenden, Dr Eugene C.	
	*Brode, Dr Wallace R.	1923–28, 1947–58
ASSISTANTS TO THE DIRECTOR	Vinogradoff, Dmitri I.	
	Golovin, Nicholas E.	1949–58
	Odishaw, Hugh	1946–59
OFFICE OF SCIENTIFIC PUBLICATIONS	Odishaw, Hugh	
OFFICE OF WEIGHTS AND MEASURES	*Smith, Ralph W.	
	Bussey, William S. (Assistant)	1948–
I. ELECTRICITY AND OPTICS	Silsbee, Dr Francis B.	
	Gibson, Dr Kasson S. (Assistant)	
1. Resistance Measurements	Thomas, Dr James L.	
2. Inductance and Capacitance	*Moon, Dr Charles	1923–53
3. Electrical Instruments	Defandorf, Dr Francis M.	1916–
4. Magnetic Measurements	*Sanford, Raymond L.	
5. Photometry and Colorimetry	Gibson, Dr Kasson S.	
6. Optical Instruments	Gardner, Dr Irvine C.	
7. Photographic Technology	Davis, Raymond	
8. Electrochemistry	*Vinal, Dr George W.	
II. METROLOGY	Souder, Dr Wilmer	
	*Miller, David R. (Assistant)	
1. Length	Judson, Dr Lewis V.	
2. Mass	Macurdy, Lloyd B.	

*Crittenden, retired, Dec. 31, 1950; died Mar. 8, 1956.
*Brode, at Ohio State University, professor of organic chemistry, 1928–47; guest worker 1958 to date.
*Smith, retired, Nov. 1, 1950; NBS consultant, 1950 to date.
*Moon, died Jan. 31, 1953.
*Sanford, retired, 1954; NBS consultant, 1954 to date.
*Vinal, retired, June 30, 1950.
*Miller, retired, 1952.

II. METROLOGY—Continued		
3. Time	*Bowman, Horace A.	1946–
4. Capacity, Density, Fluid Measures	Bean, Howard S.	
6. Thermal Expansion	*Hidnert, Dr Peter	1911–57
7. Dental Materials	Schoonover, Dr Irl C.	1928–
8. Scales	Russell, H. Haig	
9. Gages	Miller, David R.	
III. HEAT AND POWER	Brickwedde, Dr Ferdinand G.	
1. Temperature Measurements	*Wilson, Dr Raymond E.	1947–53
2. Thermodynamics	Brickwedde, Dr Ferdinand C.	
3. Cryogenics	Scott, Russell B.	1928–
4. Engines and Lubrication	*McKee, Samuel A.	1921–53
5. Engine Fuels	Howard, Dr Frank L.	1937–
6. Combustion	Fiock, Dr Ernest F.	1926–
IV. ATOMIC AND RADIATION PHYSICS	Huntoon, Dr Robert D.	1941–
Assistant	Taylor, Dr Lauriston S.	
Consultant on Radioactivity	Curtiss, Dr Leon F.	
Consultant on Stable Tracers	Mohler, Dr Fred L.	
AEC Coordinator	Huntoon, Dr Robert D.	
Atomic Physics Laboratory	Huntoon, Dr Robert D.	
1. Spectroscopy	Meggers, Dr William F.	
2. Radiometry	*Humphreys, Dr Curtis J.	
3. Mass Spectrometry	Mohler, Dr Fred L.	
4. Physical Electronics	*Bennett, Dr Willard H.	1946–50
5. Electron Physics	Marton, Dr Ladislaus L.	1946–
6. Atomic Physics	*Hipple, Dr John A.	1947–53
7. Neutron Measurements	Curtiss, Dr Leon F.	
Radiation Physics Laboratory	Taylor, Dr Lauriston S.	
8. Nuclear Physics	Fano, Dr Ugo	1946–
9. Radioactivity	Taylor, Dr Lauriston S.	
10. X Rays	Wyckoff, Dr Harold O.	1941–
11. Betatron	Koch, Dr Herman W.	1949–
12. Nucleonic Instrumentation	Wyckoff, Dr Harold O.	
13. Radiological Equipment	Smith, Dr Scott W.	1947–

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*Bowman, attached to division 6, sec. 6, Mass and Scale, 1954.

*Hidnert, transferred to Office of Weights and Measures, 1954; retired, Mar. 31, 1957; died June 10, 1964.

*Wilson, to Emerson Research Laboratories as principal physicist, 1954.

*McKee, retired, 1953.

*Humphreys, transferred to Corona Laboratories, September 1951; to Naval Ordnance Laboratory, 1953.

*Bennett, resigned, September 1950.

*Hipple, to Mineral Industries Experiment Station, Pennsylvania State College as director, 1953.

V. CHEMISTRY	Wichers, Dr Edward	
	*Blum, Dr William (Assistant)	
1. Paint, Varnish, Lacquers	*Hickson, Eugene F.	
2. Surface Chemistry	Hoffman, Dr James I.	1918–62
3. Organic Chemistry	Smith, W. Harold	
4. Analytical Chemistry	Bright, Harry A.	
5. Platinum Metals and Pure Substances	Gilchrist, Dr Raleigh	
6. Electrodeposition	Blum, Dr William	
7. Gas Chemistry and pH Standards	Weaver, Elmer R.	
8. Physical Chemistry	Smith, Dr Edgar R.	
9. Thermochemistry and Hydrocarbons	*Rossini, Dr Frederick D.	
10. Spectrochemistry	Scribner, Bourdon F.	1927–
VI. MECHANICS	Ramberg, Dr Walter	1931–59
1. Sound	Cook, Dr Richard K.	
2. Mechanical Instruments	*Brombacher, Dr William G.	
3. Aerodynamics	Schubauer, Dr Galen B.	1936–
4. Engineering Mechanics	Wilson, Bruce L.	1929–
5. Hydraulics	*Eaton, Herbert N.	
VII. ORGANIC AND FIBROUS MATERIALS	McPherson, Dr Archibald T.	
	Kline, Dr Gordon M. (Assistant)	
	*Simha, Dr Robert (Consultant)	1944–51
1. Rubber	Wood, Dr Lawrence A.	
2. Textiles	Appel, William D.	
3. Paper	*Scribner, Bourdon W.	
4. Leather	Wallace, Everett L.	
5. Testing and Specifications	Stiehler, Dr Robert D.	1946–
6. Organic Plastics	Kline, Dr Gordon M.	
VIII. METALLURGY	Thompson, Dr John G.	
	Roeser, William F. (Assistant)	
1. Optical Metallurgy	Ellinger, George A.	1929–
2. Thermal Metallurgy	Digges, Thomas G.	1920–62
3. Mechanical Metallurgy	Roeser, William F.	
4. Chemical Metallurgy	*Cleaves, Harold E.	1912–15, 1930–53

*Blum, retired, Jan. 1, 1952.
*Hickson, retired, 1950.
*Rossini, to Chairman, Department of Chemistry, Carnegie Institute of Technology, 1950.
*Brombacher, retired, 1954.
*Eaton, retired, Jan. 31, 1953; NBS consulting engineer, 1953 to date.
*Simha, to New York University, 1951; subsequently to University of Southern California.
*Scribner, died Mar. 5, 1952.
*Cleaves, retired, 1953.

VIII. METALLURGY—Continued		
5. Experimental Foundry	*Krynitsky, Alexander I.	
6. Underground Corrosion	*Denison, Dr Irving A.	1929–53
IX. MINERAL PRODUCTS	Insley, Dr Herbert	1922–53
1. Porcelain and Pottery	Geller, Roman F.	
2. Glass	Hahner, Clarence H.	
3. Refractories	Heindl, Raymond A.	
4. Enameled Metals	Harrison, William N.	
5. Building Stone	*Kessler, Daniel W.	
6. Concreting Materials	Blaine, Raymond L.	1929–
7. Constitution and Microstructure	McMurdie, Howard F.	1928–
8. Chemistry of Mineral Products	*Wells, Dr Lansing S.	
X. BUILDING TECHNOLOGY	Parsons, Douglas E. Thompson, George N. (Assistant)	
1. Structural Engeering	Parsons, Douglas E.	
2. Fire Protection	*Mitchell, Nolan D.	1922–52
3. Heating and Air Conditioning	Dill, Richard S.	
4. Exterior and Interior Coverings	Snoke, Dr Hubert R.	1920–60
5. Codes and Specifications	Thompson, George N.	
XI. APPLIED MATHEMATICS	*Curtiss, Dr John H. Cannon, Dr Edward W. (Assistant)	1946–53 1946–
1. Numerical Analysis	*Rosser, Dr J. Barkley	1949–51
2. Computation Laboratory	Alt, Dr Franz L.	1948–
3. Statistical Engineering	Eisenhart, Dr Churchill	1946–
4. Machine Development	Cannon, Dr Edward W.	
XII. COMMODITY STANDARDS	*Ely, Edwin W. Reynolds, Floyd W. (Assistant)	
1. Metal and Ceramic Products	Schuster, George	
2. Textiles and Apparel	Ehrman, H. A.	
3. Mechanical Equipment	Medley, J. W.	
4. Packaging	Braithwaite, William E.	
5. Chemical Products	Reynolds, Floyd W.	

*Krynitsky, retired, 1950.
*Denison, to Diamond Ordnance Fuze Laboratories, 1953.
*Kessler, to Kessler Stone Research Laboratory as materials engineer, 1952; NBS consultant, 1952 to date.
*Wells, died 1954.
*Mitchell, retired, September 1952; NBS consultant, 1952 to date.
*Curtiss, assistant to Director, April 1946; National Applied Mathematics Laboratories, 1947; to Institute of Mathematical Science and adjunct professor of math, New York University, 1953.
*Rosser, to Army Ordnance, 1951.
*Ely, NBS liaison with Commodity Standards Division, Department of Commerce, 1947–50; transferred with division to Office of Technical Services, Department of Commerce, 1950.

XIII. ELECTRONICS AND ORDNANCE	Astin, Dr Allen V.	
Assistant Chief for Ordnance	*Hinman, Wilbur S. Jr.	
Assistant Chief for Aerophysics	Skramstad, Dr Harold K.	1935–
Electronics Consultant	Huntoon, Dr Robert D.	
Electronics Consultant	Page, Dr Chester H.	
Electronics Standards Laboratory	(Vacant)	
1. Engineering Electronics	*Reid, J. Gilman Jr.	1937–54
2. Electron Tubes	White, Dr John E.	1946–
3. Electronic Computers	Alexander, Samuel N.	1946–
Ordnance Development Laboratory.	Hinman, Wilbur S. Jr.	
4. Ordnance Research	*Goldberg, Dr Harold	1947–
5. Ordnance Mechanics	*Rabinow, Jacob	
6. Ordnance Electronics	Guarino, P. Anthony	1948–
7. Ordnance Engineering	Domsitz, M. G.	1942–
8. Ordnance Tests	*Godfrey, Theodore B.	
Guidance Missile Laboratory	Lamm, Ralph A.	1947–
9. Missile Dynamics	Skramstad, Dr Harold K.	
10. Missile Intelligence	Atchison, Dr F. Stanley	1942–
11. Missile Engineering	Lamm, Ralph A.	
12. Missile Instrumentation	Wildhack, William A.	1935–
13. Technical Services	McLean, J. D.	
XIV. CENTRAL RADIO PROPAGATION LABORATORY	*Smith, Dr Newbern	1935–54
Assistant Chief	McNish, Alvin G.	1946–
Assistant Chief	Norton, Kenneth A.	1946–
Microwave Research Consultant	Carroll, T. J.	
Ionospheric Research Laboratory		
1. Upper Atmosphere Research	McNish, Alvin G.	
5. Ionospheric Research	Bateman, Ross	
7. Field Operations	Hutchison, H. P.	
Systems Research Laboratory		
3. Regular Propagation Services	Chadwick, Walter B.	
4. Frequency Utilization Research	Norton, Kenneth A.	
6. Tropospheric Propagation Research	Herbstreit, Jack W.	
Measurements Standards Laboratory		
8. High Frequency Standards	George, William D.	
9. Microwave Standards	*Lyons, Dr Harold A.	1941–55

*Hinman, to Diamond Ordnance Fuze Laboratories, September 1953.
*Reid, to private industry, January 1954.
*Goldberg, and most of the Ordnance Development and Guidance Missile staffs, transferred to Diamond Ordnance Fuze Laboratories, 1953.
*Rabinow, to Diamond Ordnance Fuze Laboratories, 1953.
*Godfrey, to Diamond Ordnance Fuze Laboratories as division chief, 1953.
*Smith, N., to full-time technical work, Aug. 29, 1953, Dr Brode replacing him as division chief; resigned 1954.
*Lyons, resigned, May 1951.

FIELD STATIONS

Brookline, Mass. (Electricity and Optics—Lamp Inspection)

Clearing, Ill. (Metrology—Master Scale Depot)

Allentown, Pa. (Mineral Products—Cement Testing and Inspection)

Riverside, Calif. (Mineral Products—Cement Testing and Inspection)

Permanente, Calif. (Mineral Products—Cement Testing and Inspection)

Seattle, Wash. (Mineral Products—Cement Testing and Inspection)

Denver, Colo. (Mineral Products—Cement and Concrete Materials)

San Francisco, Calif. (Mineral Products—Materials Testing Station)

Los Angeles, Calif. (Applied Mathematics—Institute for Numerical Analysis)

LaPlata, Md. (Electronics—Blossom Point Proving Ground)

Tuckerton, N.J. (Electronics—Warren Grove Test Field)

Anchorage, Alaska (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Point Barrow, Alaska (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Guam Island (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Puunene Maui, Hawaii (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Honolulu, Hawaii (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Puerto Rico (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Trinidad, British West Indies (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Las Cruces, N. Mex. (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Fort Belvoir, Va. (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Sterling, Va. (Central Radio Propagation Laboratory—Radio Propagation Field Station)

Beltsville, Md. (Central Radio Propagation Laboratory—Radio Propagation Field Station)

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of October 1, 1954

DIRECTOR	**Astin, Dr Allen V.**	
Associate Director for Chemistry	*Brode, Dr Wallace R.	
Associate Director for Physics	Huntoon, Dr Robert D.	
Associate Director for Testing	McPherson, Dr Archibald T.	
Associate Director for Administration	*Golovin, Nicholas E.	
Consultants to the Director	Crittenden, Dr Eugene C.	
	Curtiss, Dr Leon F.	
	Page, Dr Chester H.	
	*Souder, Dr Wilmer	
	McNish, Alvin G.	
OFFICE OF SCIENTIFIC PUBLICATIONS	Brode, Dr Wallace R.	
OFFICE OF WEIGHTS AND MEASURES	Bussey, William S.	
Assistant	Jensen, Malcolm W.	1951–
Consultant	Smith, Ralph W.	
OFFICE OF BASIC INSTRUMENTATION	Wildhack, William A.	
I. ELECTRICITY AND ELECTRONICS	*Silsbee, Dr Francis B.	
	*Stansbury, Carroll (Assistant)	1948–59
1. Resistance and Reactance	Thomas, Dr James L.	
2. Electron Tubes	Marsden, Dr Charles P. Jr.	1949–
3. Electrical Instruments	Defandorf, Dr Francis M.	
4. Magnetic Measurements	Cooter, Irving L.	1930–
5. Process Technology	*Tuckerman, Lucien P.	1949–56

*Brode, Science Advisor to Secretary of State, 1958.
*Golovin, to White Sands Proving Ground as Chief Scientist, 1958.
*Souder, retired, 1954.
*Silsbee, retired, July 31, 1959; NBS consultant.
*Stansbury, retired for reasons of ill health, October 1958.
*Tuckerman, transferred to Diamond Ordnance Fuze Laboratory, July 1, 1956.

I. ELECTRICITY AND ELECTRONICS—Continued		
6. Engineering Electronics	*Selgin, Dr Paul J.	1947–55
7. Electronic Instrumentation	Stansbury, Carroll	
8. Electrochemistry	Hamer, Dr Walter J.	1935–
II. OPTICS AND METROLOGY	*Gardner, Dr Irvine C.	
	*Gibson, Dr Kasson S. (Assistant)	
1. Photometry and Colorimetry	Gibson, Dr Kasson S.	
2. Optical Instruments	Washer, Dr Francis E.	1935–
3. Photographic Technology	*Davis, Raymond	
4. Length	*Judson, Dr Lewis V.	
5. Engineering Metrology	Fullmer, Irwin H.	1917–
III. HEAT AND POWER	*Brickwedde, Dr Ferdinand G.	
1. Temperature Measurements	Brickwedde, Dr Ferdinand G.	
2. Thermodynamics	Beckett, Dr Charles W.	1950–
3. Cryogenic Physics	Hudson, Dr Ralph P.	1951–
4. Engines and Lubrication	Swindells, James F.	1927–
5. Engine Fuels	Howard, Dr Frank L.	
6. Free Radicals Research (1956–59)	*Broida, Dr Herbert P.	1949–59
IV. ATOMIC AND RADIATION PHYSICS	Taylor, Dr Lauriston S.	
Atomic Physics Laboratory	(Vacant)	
1. Spectroscopy	*Meggers, Dr William F.	
2. Radiometry	Plyler, Dr Earle K.	1945–63
3. Mass Spectroscopy	Mohler, Dr Fred L.	
4. Solid State Physics	*Breckenridge, Dr Robert G.	1949–55
5. Electron Physics	Marton, Dr Ladislaus L.	
6. Atomic Physics	Branscomb, Dr Lewis M.	1951–
Radiation Physics Laboratory	Wyckoff, Dr Harold O.	
8. Nuclear Physics	Fano, Dr Ugo	
9. Radioactivity	Mann, Dr Wilfrid B.	
10. X Rays	Wyckoff, Dr Harold O.	
11. Betatron	Koch, Dr Herman W.	
12. Nucleonic Instrumentation	Costrell, Louis	1946–

*Selgin, resigned to take up private consultant work, continuing part-time work with NBS.
*Gardner, retired, July 8, 1959.
*Gibson, retired, January 1955.
*Davis, retired, April 1958; NBS consultant.
*Judson, transferred to Office of Weights and Measures, Mar. 22, 1959.
*Brickwedde, to Pennsylvania State University as dean of College of Chemistry and Physics, February 1957.
*Broida, succeeded by Dr Arnold M. Bass, July 1, 1959; program terminated Oct. 1, 1959; returned as senior research fellow 1961–62.
*Meggers, retired, July 31, 1958; NBS consultant.
*Plyler, retired, Oct. 7, 1963.
*Breckenridge, resigned, May 1, 1955.

IV. ATOMIC AND RADIATION PHYSICS—Continued		
13. Radiological Equipment	Smith, Dr Scott W.	
14. Radiation Instruments Branch, AEC	Butenhoff, Robert L.	
V. CHEMISTRY	Wichers, Dr Edward Hoffman, Dr James I. (Assistant)	
1. Organic Coatings	Howard, Paul T.	1922–
2. SurfaceChemistry	Hoffman, Dr James I.	
3. Organic Chemistry	*Smith, W. Harold	
4. Analytical Chemistry	*Bright, Harry A.	
5. Inorganic Chemistry	Gilchrist, Dr Raleigh	
6. Electrodeposition	Brenner, Dr Abner	1930–
7. Gas Chemistry	*Weaver, Elmer R.	
8. Physical Chemistry	*Smith, Dr Edgar R	
9. Thermochemistry	Prosen, Edward J.	1936–
10. Spectrochemistry	Scribner, Bourdon F.	
11. Pure Substances	Saylor, Dr Charles P.	1931–
VI. MECHANICS	*Ramberg, Dr Walter Souder, Dr Wilmer (Consultant)	
1. Sound	Cook, Dr Richard K.	
2. Mechanical Instruments	Lloyd, Edward C.	1954–
3. Fluid Mechanics	Schubauer, Dr Galen B.	
4. Engineering Mechanics	Wilson, Bruce L.	
6. Mass and Scale	Tate, Douglas R.	
7. Capacity, Density, and Fluid Meters	*Bean, Howard S.	
8. Combustion Controls	*Fiock, Dr Ernest F.	
VII. ORGANIC AND FIBROUS MATERIALS	Kline, Dr Gordon M. *Appel, William D. (Assistant)	
1. Rubber	Wood, Dr Lawrence A.	
2. Textiles	Appel, William D.	
3. Paper	Hobbs, Dr Robert B.	1930–
4. Leather	*Wallace, Everett L.	
5. Testing and Specifications	Stiehler, Dr Robert D.	
6. Polymer Structure	Bekkedahl, Dr Norman P.	1931–

*Smith, W. H., retired, Feb. 1, 1957; NBS consultant; died Apr. 14, 1959.
*Bright, retired, Feb. 29, 1960; died May 22, 1961.
*Weaver, retired, May 31, 1957.
*Smith, E. R., retired, June 30, 1957.
*Ramberg, to U.S. Embassy in Rome, Department of State, as scientific officer, Mar. 1, 1959.
*Bean, retired, July 1, 1958.
*Fiock, to Rocket Fuels Division, Phillips Petroleum Co., Texas, as technical director, March 1956.
*Appel, retired, Jan. 31, 1959.
*Wallace, retired, Jan. 1, 1955.

VII. ORGANIC AND FIBROUS MATERIALS—Continued		
7. Organic Plastics	Reinhart, Frank W.	1937–
8. Dental Research	Sweeney, William T.	1922–
VIII. METALLURGY	*Thompson, Dr John G.	
1. Thermal Metallurgy	Digges, Thomas G.	
2. Chemical Metallurgy	Wyman, Leroy L.	1953–
3. Mechanical Metallurgy	Bennett, John A.	1936–
4. Corrosion	Ellinger, George A.	
IX. MINERAL PRODUCTS	Schoonover, Dr Irl C. Hahner, Clarence H. (Assistant)	
1. Porcelain and Pottery	*Geller, Roman F.	
2. Glass	Hahner, Clarence H.	
3. Refractories	*Heindl, Raymond A.	
4. Enameled Metals	Harrison, William N.	
6. Concreting Materials	Blaine, Raymond L.	
7. Constitution and Microstructure	McMurdie, Howard F.	
X. BUILDING TECHNOLOGY	Parsons, Douglas E. *Thompson, George N. (Assistant) Roeser, William F. (Consultant)	
	*McBurney, John W. (Consultant)	1935–56
1. Structural Engineering	Parsons, Douglas E.	
2. Fire Protection	Robertson, Dr Alexander F.	1950–
3. Heating and Air Conditioning	*Dill, Richard S.	
4. Floor, Roof, and Wall Coverings	*Snoke, Dr Hubert R.	
5. Codes and Specifications	Thompson, George N.	
XI. APPLIED MATHEMATICS	Alt, Dr Franz L. Cannon, Dr Edward W. (Assistant)	
1. Numerical Analysis	*Todd, John	1949–57
2. Computation Laboratory	*Abramowitz, Dr Milton	1942–58
3. Statistical Engineering	Eisenhart, Dr Churchill	
4. Mathematical Physics	Cannon, Dr Edward W.	

*Thompson, J. G., retired, February 1956.
*Geller, retired, December 1955; NBS consultant.
*Heindl, retired, July 1955; NBS consultant.
*Thompson, G. N., retired, June 30, 1955.
*McBurney, retired, May 1956.
*Dill, died 1957.
*Snoke, retired, July 31, 1960.
*Todd, to California Institute of Technology as professor of mathematics, September 1957.
*Abramowitz, died July 5, 1958.

XII. DATA PROCESSING SYSTEMS	Alexander, Samuel N.	
1. Components and Techniques	Holt, A. W.	
2. Digital Circuitry and Devices	Elbourn, Robert D.	1947–
3. Digital Systems	Leiner, A. L.	
4. Analog Systems	Skramstad, Dr Harold K.	
80. BOULDER LABORATORIES		
Director	Brown, Dr Frederick W.	1954–
81. Cryogenic Engineering	Scott, Russell B.	
1. Cryogenic Equipment	Birmingham, Bascom W.	1951–
2. Cryogenic Processes	VanderArend, Peter C.	1951–
3. Properties of Materials	Reynolds, Martin M.	
4. Gas Liquefaction	Johnson, Victor J.	1950–
82. Radio Propagation Physics	Slutz, Dr Ralph J.	1949–
1. Upper Atmosphere Research	Gautier, Thomas N. Jr.	1942–
2. Ionospheric Research	Bateman, Ross	
3. Regular Propagation Services	Chadwick, Walter B.	
83. Radio Propagation Engineering	Norton, Kenneth A.	
4. Frequency Utilization Research	Norton, Kenneth A.	
6. Tropospheric Propagation Research	Herbstreit, Jack W.	1946–
84. Radio Standards	*Thomas, Dr Harold A.	1947–56
	*Lyons, Dr Harold (Assistant)	
High Frequency Standards Branch	George, William D.	
1. High Frequency Electrical Standards	Selby, Myron C.	1941–
2. Radio Broadcast Service	Morgan, Alvin H.	1946–
3. High Frequency Impedance Standard	(Vacant)	
Microwave Standards Branch	Lyons, Dr Harold	
6. Extreme High Frequency and Noise	Kerns, Dr David M.	1946–
7. Microwave Frequency and Spectroscopy	Birnbaum, George	1946–
8. Microwave Circuit Standard	Beatty, Robert W.	1944–

FIELD STATIONS

Brookline, Mass. (Optics and Metrology: Lamp Inspection)
Arcata, Calif. (Optics and Metrology: Visual Landing Aids)
Clearing, Ill. (Mechanics: NBS Master Track Scale Depot)
Allentown, Pa. (Mineral Products: Concreting Materials Section)
Denver, Colo. (Mineral Products: Concreting Materials Section)
San Francisco, Calif. (Mineral Products: Concreting Materials Section)

*Thomas, to John Jay Hopkins Laboratory for Pure and Applied Science (San Diego), General Dynamics Corporation, December 1956.

*Lyons, to staff of Microwave Laboratory, Hughes Aircraft Co., July 1955.

84. Radio Standards—Continued

FIELD STATIONS—Continued

Seattle, Wash. (Mineral Products: Concreting Materials Section)
Kansas City, Mo. (Mineral Products: Concreting Materials Section)
Anchorage, Alaska (Boulder: Radio Propagation Field Station)
Point Barrow, Alaska (Boulder: Radio Propagation Field Station)
Guam Island (Boulder: Radio Propagation Field Station)
Puunene Maui, Hawaii (Boulder: Radio Propagation Field Station)
Puerto Rico (Boulder: Radio Propagation Field Station)
Bluie West-1, Greenland (Boulder: Radio Propagation Field Station)
Panama Canal Zone (Boulder: Radio Propagation Field Station)
Colorado Springs, Colo. (Boulder: Radio Propagation Field Station)
Fort Belvoir, Va. (Boulder: Radio Propagation Field Station)
Sterling, Va. (Boulder: Radio Propagation Laboratory)
Beltsville, Md. (Boulder: Radio Transmitting Station)
Front Royal, Va. (Boulder: Radio Noise Recording Station)

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL STAFF CHIEFS

as of December 1, 1960

DIRECTOR	**Astin, Dr Allen V.**	
Deputy Director	Huntoon, Dr Robert D.	
Associate Director for Physics	Huntoon, Dr Robert D.	
Associate Director for Engineering	McPherson, Dr Archibald T.	
Associate Director for Chemistry	Wichers, Dr Edward	
	Souder, Dr Wilmer (Consultant)	
Associate Director for Planning	Schoonover, Dr Irl C.	
Associate Director for Administration	Walleigh, Robert S.	
Associate Director for Boulder Laboratories	Brown, Dr Frederick W.	
NBS Reactor Program	Muehlhause, Dr Carl O.	
Special Research Assistant to Director	Fano, Dr Ugo	
Special Development Assistant to Director	Wildhack, William A.	
Consultant to the Director	*Curtiss, Dr Leon F.	
	Schuler, Dr Kurt E.	1955–
Director Emeritus	Briggs, Dr Lyman J.	
OFFICE OF WEIGHTS AND MEASURES	Bussey, William A.	
Assistant	Jensen, Malcolm W.	
Consultant	Smith, Ralph W.	
OFFICE OF TECHNICAL INFORMATION	Tilley, William R.	1946–
Assistant	Gautier, William K.	1947–
I. ELECTRICITY	Page, Dr Chester H.	
1. Resistance and Reactance	Thomas, Dr James L.	
2. Electrochemistry	Hamer, Dr Walter J.	
3. Electrical Instruments	Defandorf, Dr Francis M.	
4. Magnetic Measurements	Cooter, Irving L.	
5. Dielectrics	Hoffman, Dr John D.	1942–
II. METROLOGY	McNish, Alvin G.	
	Judd, Dr Deane B. (Assistant)	1927–
1. Photometry and Colorimetry	Barbrow, Louis E.	1927–

*Curtiss, retired, June 30, 1961.

II. METROLOGY—Continued		
2. Refractometry	Washer, Dr Francis E.	
3. Photographic Research	McCamy, Calvin S.	1952–
4. Length	*Page, Benjamin L.	1918–61
5. Engineering Metrology	Fullmer, Irwin H.	
6. Mass and Scale	Peiser, H. Steffen	1957–
7. Volumetry and Densimetry	Collett, Charles T.	1943–
III. HEAT	Herzfeld, Dr Charles M.	1955–
	Beckett, Dr Charles W. (Assistant)	1950–
1. Temperature Physics	Swindells, James F.	
2. Heat Measurements	Ginnings, Dr Defoe C.	1929–
3. Cryogenic Physics	Hudson, Dr Ralph P.	
7. Equation of State	Hilsenrath, Joseph	1948–
8. Statistical Physics	Green, Dr Melville S.	1954–
IV. RADIATION PHYSICS	Taylor, Dr Lauriston S.	
Scientific Assistant	Ney, Wilbert R.	
AEC Coordinator	Taylor, Dr Lauriston S.	
1. X Ray	Wyckoff, Dr Harold O.	
2. Radioactivity	Mann, Dr Wilfrid B.	
3. Radiation Theory	Spencer, Dr Lewis V.	
4. High Energy Radiation	Koch, Dr Herman W.	
5. Radiological Equipment	Smith, Dr Scott W.	
6. Nucleonic Instrumentation	Costrell, Louis	
7. Neutron Physics	Caswell, Dr Randall S.	1952–
V. ANALYTICAL AND INORGANIC CHEMISTRY	Schoonover, Dr Irl C.	
	Bates, Dr Roger G. (Assistant)	1939–
	Saylor, Dr Charles P. (Consultant)	
1. Pure Substances	*Howard, Dr Frank L.	1937–63
2. Spectrochemistry	Scribner, Bourdon F.	
3. Solution Chemistry	Bates, Dr Roger G.	
4. Analytical Chemistry	Hague, John L.	
5. Inorganic Chemistry	Gilchrist, Dr Raleigh	
VI. MECHANICS	Wilson, Bruce L.	
	Brombacher, Dr William G. (Consultant)	
	Frankland, Dr John M. (Consultant)	
	Lloyd, Edward C. (Consultant)	
1. Sound	Cook, Dr Richard K.	
2. Pressure and Vacuum	Johnson, Dr Daniel P.	1935–
3. Fluid Mechanics	Schubauer, Dr Galen B.	

*Page, retired, 1961.
*Howard, died Oct. 15, 1963.

VI. MECHANICS—Continued		
4. Engineering Mechanics	Irwin, Lafayette K.	1949–
5. Rheology	Marvin, Dr Robert S.	1949–
8. Combustion Controls	Caldwell, Frank R.	1920–
VII. ORGANIC AND FIBROUS MATERIALS	Kline, Dr Gordon M.	
1. Rubber	Wood, Dr Lawrence A.	
2. Textiles	Schiefer, Dr Herbert F.	1929–
3. Paper	Hobbs, Dr Robert B.	
4. Leather	Kanagy, Dr Joseph R.	1930–
5. Testing and Specifications	Stiehler, Dr Robert D.	
6. Polymer Structure	Bekkedahl, Dr Norman P.	
7. Plastics	Reinhart, Dr Frank W.	
8. Dental Research	Sweeney, William T.	
VIII. METALLURGY	*Hoffman, Dr James I. *Digges, Thomas G. (Assistant)	
1. Thermal Metallurgy	Digges, Thomas G.	
2. Chemical Metallurgy	Wyman, Leroy L.	
3. Mechanical Metallurgy	Bennett, John A.	
4. Corrosion	Ellinger, George A.	
5. Metal Physics	Kushner, Dr Lawrence M.	1948–
6. Electrodeposition	Brenner, Dr Abner	
IX. MINERAL PRODUCTS	Franklin, Dr Allan D. Hahner, Clarence H. (Assistant) Geller, Roman F. (Consultant) Lippincott, Dr Ellis R. (Consultant)	1955–
1. Engineering Ceramics	Burdick, Milton D.	1931–
2. Glass	Hahner, Clarence H.	
3. Refractories	(Vacant)	
5. Crystal Growth	Ordway, Dr Frederick	1948–
7. Constitution and Microstructure	McMurdie, Howard F.	
X. BUILDING RESEARCH	Parsons, Douglas E. *Roeser, William F. (Consultant)	
1. Structural Engineering	Watstein, David	1930–
2. Fire Research	Robertson, Dr Alexander F.	
3. Mechanical Systems	Achenbach, Paul R.	1937–

*Hoffman, retired, 1962.
*Digges, retired, 1962.
*Roeser, died June 17, 1964.

X. BUILDING RESEARCH—Continued		
4. Organic Building Materials	Walton, Dr William W.	1929–
5. Codes and Safety Standards	*Lloyd, Richard L.	1941–62
6. Heat Transfer	Robinson, Henry E.	1937–
7. Inorganic Building Materials	Blaine, Raymond L.	
9. Metallic Building Materials	Harrison, William N.	
XI. APPLIED MATHEMATICS	Cannon, Dr Edward W.	
	Alt, Dr Franz L. (Assistant)	
	Youden, Dr William J. (Consultant)	1948–
1. Numerical Analysis	Davis, Dr Philip J.	1952–
2. Computation	Mittleman, Dr Don I.	1951–
3. Statistical Engineering	Eisenhart, Dr Churchill	
4. Mathematical Physics	Pell, Dr William H.	1956–
5. Operations Research	Goldman, Dr Alan J.	1961–
XII. PROCESSING SYSTEMS	Alexander, Samuel N.	
	Skramstad, Dr Harold K. (Assistant)	
	Rafferty, John F. (SEAC)	
1. Components and Techniques	Elbourn, Robert D.	
2. Digital Circuitry	Greenwald, Sidney	1947–
3. Digital Systems	Alexander, Samuel N.	
4. Analog Systems	Skramstad, Dr Harold K.	
5. Applications Engineering	Glaser, Ezra	
XIII. ATOMIC PHYSICS	Branscomb, Dr Lewis M.	
	*Mohler, Dr Fred L. (Consultant)	
1. Spectroscopy	Kessler, Dr Karl G.	1948–
2. Radiometry	*Plyler, Dr Earle K.	
4. Solid State Physics	Frederikse, Dr Hans P. R.	1953–
5. Electron Physics	Marton, Dr Ladislaus L.	
6. Atomic Physics	Smith, Dr Stephen J.	1954–
XIV. INSTRUMENTATION	Montgomery, G. Franklin	1946–
1. Engineering Electronics	Shapiro, Gustave	1947–
2. Electron Devices	Marsden, Charles P.	
3. Electronic Instrumentation	Montgomery, G. Franklin	
4. Mechanical Instruments	Wexler, Arnold	1941–
5. Basic Instrumentation	Stern, Joshua	1951–
XV. PHYSICAL CHEMISTRY	Wallenstein, Dr Merrill B.	1953–55, 1959–
1. Thermochemistry	Prosen, Edward J.	
2. Surface Chemistry	(Vacant)	
3. Organic Chemistry	Isbell, Dr Horace S.	1927–

*Lloyd, to Underwriters' Laboratories, New York, 1962.
*Mohler, retired, 1960; NBS consultant.
*Plyler, retired, Oct. 8, 1963.

XV. PHYSICAL CHEMISTRY—Continued

4. Molecular Spectroscopy	Mann, Dr David E.	1951–
5. Molecular Kinetics	Ferguson, Dr Robert E.	1952–
6. Mass Spectroscopy	Dibeler, Dr Vernon H.	1942–
7. Molecular Structure and Radiation Chemistry	Buckley, Floyd	1943–

80. BOULDER LABORATORIES—

Director	Brown, Dr Frederick W.	
CRPL Liaison and Progress Development	Shapley, Alan H.	1947–
Mathematical-Analysis and Computation Facility Group	Sopka, Dr John J.	1959–
Consultant in Mathematical Physics	Brown, Edmund H.	1952–
Consultant in Statistics	Crow, Dr Edwin L.	
Consultant in Astrophysics	Thomas, Dr Richard N.	
Consultant in Radio Wave Propagation	Wait, Dr James R.	
81. Cryogenic Engineering	Scott, Russell B. Birmingham, Bascom W. (Assistant)	
1. Cryogenic Equipment	Jacobs, Dr Robert B.	1951–
2. Cryogenic Processes	Birmingham, Bascom W.	
3. Properties of Materials	Corruccini, Dr Robert J.	1944–
4. Gas Liquefaction	Johnson, Victor J.	

CENTRAL RADIO PROPAGATION LABORATORY—BOULDER

82. Ionosphere Research and Propagation	Smith, Dr Earnest K. Jr.	1951–
	Gautier, Thomas N. Jr. (Assistant)	
	Bailey, Dana K. (Consultant)	1948–
1. LF and VLF Research	Jean, Arthur G. Jr	1949–
2. Ionosphere Research	Davies, Dr Kenneth	1958–
3. Prediction Services	Chadwick, Walter B.	
4. Sun-Earth Relationships	Knecht, Robert W.	1949–
5. Field Engineering	Sellery, Harry G.	1946–
6. Radio Warning Services	Lincoln, J. Virginia	1942–
83. Radio Propagation Engineering	Norton, Kenneth A.	
	Herbstreit, Jack W. (Assistant)	
	Florman, Edwin F. (Consultant)	1946–
1. Data Reduction Instrumentation	Johnson, Walter E.	1953–
4. Radio Noise	Crichlow, William Q.	1946–
5. Tropospheric Measurements	Peterson, Charles F.	1952–
6. Tropospheric Analysis	Rice, Philip L.	1949–

83. Radio Propagation Engineering—Continued

7. Propagation-Terrain Effects	Kirby, Robert S.	1947–
8. Radio-Meteorology	Bean, Bradford R.	1950–
9. Lower Atmosphere Physics	Thompson, Dr Moody C. Jr.	1947–
84. Radio Standards Laboratory	Richardson, Dr John M.	1952–
Assistant Chief for Radio Frequencies	George, William D.	
Assistant Chief for Microwave Frequencies	Kerns, Dr David M.	1946–
Assistant Chief for Technical Planning and Coordination	Wolzien, Eldred C.	
Consultant	Brown, W. W.	
Consultant	Wacker, Dr Paul F.	1944–
1. High Frequency Electrical Standards	Selby, Myron C.	1941–
2. Radio Broadcast Service	Morgan, Alvin H.	1946–
3. Radio and Microwave Materials	Dalke, John L.	1947–
4. Atomic Frequency and Time Interval Standards	Mockler, Dr Richard C.	1954–
5. Electronic Calibration Center	Lance, Harvey W.	1948–
7. Millimeter-Wave Research	Culshaw, Dr William	1956–
8. Microwave Circuit Standards	Beatty, Robert W.	
85. Radio Systems	Kirby, Richard C.	1948–
	Patterson, Donald W. (Assistant)	1958–
	Haydon, George W. (Consultant)	1959–
1. High Frequency and VHF Research	Silberstein, Richard	1941–
4. Modulation Research	Koch, J. Wesley	1957–
5. Antenna Research	Cottony, Herman V.	1941–
6. Navigation Systems	Hefley, Gifford	1949–
7. Space Telecommunications	Coombs, William C.	1959–
87. Upper Atmosphere and Space Physics	Little, Dr C. Gordon	1958–
	Gates, Dr David M. (Asst.)	1957–
	Slutz, Dr Ralph J. (Cons.)	
	Bailey, Dana K. (Cons.)	
1. Upper Atmosphere and Plasma Physics	Gallet, Roger M.	1955–
5. Ionosphere and Exosphere Scatter	Bowles, Dr Kenneth L.	1955–

87. Upper Atmosphere and Space Physics—Continued

7. Airglow and Aurora	Roach, Dr Franklin E.	1954–
8. Ionospheric Radio Astronomy	Lawrence, Robert S.	1948–

FIELD STATIONS, NBS

Anchorage, Alaska (Central Radio Propagation Laboratory)
Koloa, Kauai, Hawaii (Central Radio Propagation Laboratory)
Antarctica and Kolb Stations, Boulder (Central Radio Propagation Laboratory)
Barrow, Alaska (Central Radio Propagation Laboratory)
Lima, Peru (Central Radio Propagation Laboratory)
Douglas, Wyo. (Central Radio Propagation Laboratory)
Lafayette, Colo. (Central Radio Propagation Laboratory)
Colorado Springs, Colo. (Central Radio Propagation Laboratory)
Havana, Ill. (Central Radio Propagation Laboratory)
Fort Belvoir, Va. (Central Radio Propagation Laboratory)
Puunene, Maui, Hawaii (Central Radio Propagation Laboratory)
Rollinsville, Colo. (Central Radio Propagation Laboratory)
Puerto Rico (Central Radio Propagation Laboratory)
Front Royal, Va. (Central Radio Propagation Laboratory)
Schickley, Nebr. (Central Radio Propagation Laboratory)
Lanham, Md. (Radio Standards Laboratory)
Puuenene, Maui, Hawaii (Radio Standards Laboratory)
Brookline, Mass. (Metrology: Lamp Inspection)
Arcata, Calif. (Metrology: Visual Landing Aids Field Laboratory)
Clearing, Ill. (Metrology: Master Railway Track Scale Depot)
Allentown, Pa. (Building Technology: Concreting Materials Section)
Denver, Colo. (Building Technology: Concreting Materials Section)
San Francisco, Calif. (Building Technology: Concreting Materials Section)
Seattle, Wash. (Building Technology: Concreting Materials Section)

APPENDIX K

NBS Publications representing RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY, 1901–1951

Abbreviations

NBS PUBLICATIONS

S	Scientific Paper
T	Technologic Paper
RP	Research Paper
C	Circular
H	Handbook
M	Miscellaneous Publication
BMS	Building Materials and Structures Report
LC	Letter Circular
TNB	Technical News Bulletin

NON-NBS PUBLICATIONS

Am. Mach.	American Machinist
ASTM Bull.	American Society for Testing Materials Bulletin
Am. Soc. Testing Mater. Proc.	Proceedings of the American Society for Testing Materials
Anal. Chem.	Analytical Chemistry
Ann. N.Y. Acad. Sci.	Annals of the New York Academy of Sciences
Elec. Eng.	Electrical Engineering
Horological Inst. Am. J.	Horological Institute of America Journal
Ind. Eng. Chem.	Industrial and Engineering Chemistry
J. Am. Dental Assoc.	Journal of the American Dental Association
J. Am. Ceram. Soc.	Journal of the American Ceramic Society
J. Appl. Phys.	Journal of Applied Physics
J. Dental. Res.	Journal of Dental Research
J. Opt. Soc. Am.	Journal of the Optical Society of America
J. Wash. Acad. Sci.	Journal of the Washington Academy of Sciences
Mech. Eng.	Mechanical Engineering
Natl. Adv. Comm. Aeron. Tech. Note	National Advisory Committee for Aeronautics Technical Note
Natl. Adv. Comm. Aeron. Tech. Rep.	National Advisory Committee for Aeronautics Technical Report

Natl. Adv. Comm. Aeron. Rep.	National Advisory Committee for Aeronautics Report
Phys. Rev.	Physical Review
Proc. Am. Phil. Soc.	Proceedings of the American Philosophical Society
Proc. IRE	Proceedings of the Institute of Radio Engineers
Proc. Natl. Acad. Sci.	Proceedings of the National Academy of Sciences
Rev. Sci. Instr.	Review of Scientific Instruments
Scripta Math.	Scripta Mathematica
Trans. ASME	Transactions of the American Society of Mechanical Engineers
Trans. AIEE	Transactions of the American Institute of Electrical Engineers
Trans. Soc. Motion Picture Eng.	Transactions of the Society of Motion Picture Engineers

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1901–1910

1. ELECTRICITY

Coffin, Construction and calculation of absolute standards of inductance (S29, 1906)

Brooks, The deflection potentiometer: a new p. for the measurement of emf and current (S33, 1906)

Austin, Detector for small alternating currents and electrical [radio] waves (S22, 1905)

Rosa & Dorsey, A new determination of the ratio of the electromagnetic to the electrostatic unit of electricity (S65 and S66, 1907)

Wolff, The principles involved in the selection and definition of the fundamental electrical units to be proposed for international adoption (S102, 1909)

Burrows, A new permeameter for determination of magnetic induction in straight bars (S117, 1909)

2. WEIGHTS & MEASURES

Osborne & Veazey, New methods for testing glass volumetric apparatus (S92, 1908)

——— Standard density and volumetric tables (C19, 1909)

3. HEAT & THERMOMETRY

Waidner & Burgess, Optical pyrometry (S8 and S11, 1904)

Burgess, Radiation from platinum at high temperatures (S24, 1905; S124, 1909)

Burgess, Melting points of the iron-group elements by a new radiation method (S62, 1907)

Wensel, Roeser, Barbrow & Caldwell, The Waidner-Burgess standard of light (Elec. World, 52, 625, 1908; RP325, 1931)

Burgess, The estimation of the temperature of copper by means of optical pyrometers (S121, 1909)

Buckingham, On the definition of the ideal gas (S136, 1910)

4. OPTICS

Nutting, Some new rectifying effects in conducting gases [Development with Sperling of the first neon sign tubing] (S6, 1904)

Coblentz, A vacuum radiomicrometer [A new form of radiometer] (S46, 1906)

Bates, A quartz compensating polariscope with adjusting sensibility (S86, 1908)

Nutting, The resolving power of objectives (S122, 1909)

5. CHEMISTRY

Stokes & Cain, On the colorimetric determination of iron with special reference to chemical reagents (S53, 1907)

Noyes, The atomic weight of hydrogen (S77, 1908)

Douty, Bursting strength. The conditions which influence this test of paper considered (Paper Trade J. 50, 271, 1910)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1911–1916

1. ELECTRICITY

Agnew, A study of the current transformer . . . [Pioneer analysis of the performance of current transformers] (S164, 1911)

Dellinger, High-frequency ammeters [Measurement of high-frequency radio current] (S206, 1914)

Vinal & Bates, Comparison of the silver and iodine voltameters and the determination of the value of the faraday [Precise determination of the faraday] (S218, 1914)

Curtis, Insulating properties of solid dielectrics (S234, 1915)

Rosa & McCollum, Electrolysis and its mitigation (T52, 1915; Logan, C450, 1945)

Kolster, A direct-reading instrument for measuring the logarithmic decrement and wave length of electromagnetic waves [The Kolster decremeter] (S235, 1915)

Brooks & Weaver, A variable self and mutual inductor (S290, 1917)

Rosa & Vinal, Summary of experiments on the silver voltameter . . . and proposed specifications (S285, 1916)

2. WEIGHTS & MEASURES

Gray, Hidnert & Souder, Development of precision micrometric thermal expansion equipment (J. Wash. Acad. Sci. 2, 248, 1912; S219, 1914; S276, 1916; S410, 1922; S524, 1926)

——— U.S. standard tables for petroleum oils (C57, 1916; C154, 1924; C410, 1936–37)

3. HEAT & THERMOMETRY

Waidner & Burgess, On the constancy of the sulphur boiling point (S149, 1911)

Buckingham & Dellinger, On the computation of the constant c_2 of Planck's equation by an extension of Paschen's method of equal ordinates (S162, 1911)

Harper, Thermometric lag (S185, 1912)

Burgess, A micropyrometer (S198, 1913)

Dickinson & Mueller, New calorimetric resistance thermometers (S200, 1913; Sligh, S407, 1922)

Dickinson, Harper & Osborne, Latent heat of fusion of ice (S209, 1914)

Burgess & Crowe, Critical ranges A2 and A3 of pure iron (S213, 1914; Thompson & Cleaves, RP1226, 1939)

Waidner & Mueller, Industrial gas calorimetry [First comprehensive study of methods of measuring heating value of gases] (T36, 1914)

Burgess & Foote, Characteristics of radiation pyrometers (S250, 1915)

Buckingham, Model experiments and the forms of empirical equations [in fluid mechanics] (Trans. ASME, 37, 263, 1915)

Dickinson, Combustion calorimetry and the heats of combustion of cane sugar, benzoic acid and naphthalene (S230, 1915)

Waidner, Dickinson, et al., Wheatstone bridges for resistance thermometry (S241, 1915; S288, 1917)

Foote & Fairchild, Luminosity of a black body and temperature (S270, 1916)

4. OPTICS

Coblentz, Measurements on standards of radiation in absolute value [Standards of radiant flux and thermal radiation] (S227, 1915; Coblentz and Stair, RP578, 1933)

Coblentz, A comparison of stellar radiometers and radiometric measurements on 110 stars [Use of vacuum thermopiles with calcium "getter" bulb] (S244, 1915)

Coblentz & Emerson, Studies of instruments for measuring radiant energy in absolute value: an absolute thermopile (S261, 1916)

Coblentz, Present status of the determination of the constant of total radiation from a black body [Use of filters in combination with thermopiles] (S262, 1915)

Bates & Jackson, Constants of the quartz-wedge saccharimeter and the specific rotation of sucrose (S268, 1916)

5. CHEMISTRY

McBride, Weaver, et al., Determination of sulphur in illuminating gas [Development of apparatus and methods of gas analysis] (T20, 1913; T110, 1918)

——— Standards for gas service [First compilation of rules and regulations relating to standards for gas service of public utilities] (C32, 1912; 4th ed., 1920)

——— Standard methods of gas testing [Fuel gas testing and performance testing of gas appliances] (C48, 1914; 2d ed., 1916)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1917–1919

1. ELECTRICITY

Kolster, The radio direction finder and its application to navigation (1917; S428, 1922)

Wenner, [Construction of a high precision bridge] . . . for the comparison of precision standard resistors (1918; RP1323, 1940)

Silsbee, Note on electrical conduction in metals at low temperatures [The Silsbee hypothesis, relating critical current and critical magnetic field in superconductors] (S307, 1918)

Lowell & Willoughby, Underwater antenna for submerged submarines (NBS Radio Laboratory Report, Nov 1918)

Ould, [Standard variable condenser for radio] (reported in C74, 2d ed., 1918)

2. WEIGHTS & MEASURES

Stillman, A portable cubic-foot standard for gas (T114, 1918)

Van Keuren, Manufacture of Hoke precision gages . . . (Mech. Eng. 41, 289, 1919; Am. Mach. 50, 625, 1919)

3. HEAT & THERMOMETRY

Osborne & Van Dusen, The specific heat of liquid ammonia (S313, 1918)

Mueller & Burgess, H. A., Standardization of the sulphur boiling point (S339, 1919)

4. OPTICS

Jackson, The saccharimetric normal weight and specific rotation of dextrose (S293, 1917)

——— Method for slip casting large refractory pots; wartime production of optical glass; design of new types of optical glass (1917–18; Gardner & Hahner, M194, 1949)

Coblentz & Kahler, Some optical and photoelectric properties of molybdenite (S338, 1918)

Coblentz, The spectrophotoelectric sensitivity of thalofide [New infrared detection devices] (S380 and S398, 1920)

Gibson, Photoelectric spectrophotometry by the null method [First photoelectric spectrophotometer] (S349, 1919)

Bates & Bearce, New Baumé scale for sugar solutions (T115, 1918)

5. CHEMISTRY

Edwards, A specific gravity balance for gases [First commercial specific gravity balance for gases] (T89, 1917)

Edwards, Effusion method of determining gas density [Instruments and method for determinating gas density] (T94, 1917)

Weaver & Weibel, New forms of instruments for showing the presence and amount of combustible gas in the air (S334, 1919)

8. METALLURGY

Merica, Waltenberg & Scott, The heat treatment of duralumin [First explanation of the phenomenon of age hardening of metals] (S347, 1919)

9. CLAY PRODUCTS

Silsbee, Honaman, et al., [Development of a new type of porcelain for aviation spark plugs] (Natl. Adm. Comm. Aeron. Rep. 53, 1919)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1920–1930

1. ELECTRICITY

Breit, High-frequency resistance of inductance coils (S430, 1922)

Lowell, An electron-tube amplifier using sixty-cycle alternating current to supply power for the filaments and plates [First a.c. radio set] (S450, 1922)

Dunmore & Engel, Directive radio transmission on a wavelength of 10 meters [First aural radio beacon] (S469, 1923)

Hund, Theory of determination of ultra-radio frequencies by standing waves on wires [Standard of wavelength] (S491, 1924)

——— Standard frequency and time interval broadcasts (no publ., 1925–1937)

Pratt & Diamond, Receiving sets for aircraft beacon and telephony [Development of stub antenna for aircraft] (RP19, 1928; Diamond & Davies RP313, 1931)

Dunmore, Design of tuned reed course indicators for aircraft radio beacon (RP28, 1928)

Wenner, A new seismometer . . . (RP66, 1929)

Diamond and Kear, A 12-course radio range for guiding aircraft . . . (RP154, 1930)

Diamond & Gardner, Engine ignition shielding for radio reception in aircraft (RP158, 1930)

Thomas, A new design of precision resistance standard (RP201, 1930)

Diamond & Dunmore, A radiobeacon and receiving system for blind landing of aircraft (RP238, 1930)

2. WEIGHTS & MEASURES

Souder & Peters, An investigation of the physical properties of dental materials [A new dental interferometer for measuring expansion of dental amalgams] (T157, 1920)

Danielson & Souder, The causes and control of fish scaling of enamels for sheet iron and steel (J. Am. Ceram. Soc. 4, 620, 1921)

Peters & Boyd, Interference methods for standardizing and testing precision gage blocks (S436, 1922)

——— Testing sieves by projection methods (LC72 and LC74, 1922; LC584, 1940)

Bearce, A fundamental basis for measurements of length (S535, 1926)

Bean, Buckingham & Murphy, Discharge coefficients of square-edged orifices for measuring the flow of air (RP49, 1929)

Bean, An apparatus and method for determining the compressibility of a gas and the correction for "supercompressibility" (RP170, 1930)

3. HEAT & POWER

——— Tables of thermodynamic properties of ammonia (C142, 1923)

Osborne, Stimson, Sligh & Cragoe, Specific heat of superheated ammonia vapor (S501, 1924)

Kanolt, Nonflammable liquids for cryostats (S520, 1925)

Burgess and Stimson, The International Temperature Scale (RP22, 1928; RP1962, 1948)

Osborne, Stimson & Fiock, A calorimetric determination of thermal properties of saturated water and steam from 0° to 270° C. (RP209, 1930)

4. OPTICS

Jackson & Silsbee, C. G., The solubility of dextrose in water (S437, 1922)

Meggers, Kiess & Stimson, Practical spectographic analysis (S444, 1922)

Gibson & Tyndall, The visibility of radiant energy (S475, 1923)

Judd, Contributions in colorimetry to the development of the ICI standard observer (1924; J. Opt. Soc. Am. 23, 359, 1933)

Gardner & Bennett, A modified Hartman test based on interference (J. Opt. Soc. Am. 11, 441, 1925)

Gardner & Case, Camera for photographing the interior of a rifle barrel (J. Opt. Soc. Am. 12, 159, 1926)

Jackson, C. G. Silsbee & Proffitt, The preparation of levulose (S519, 1925)

Peters & Phelps, Color [and color nomenclature] in the sugar industry (T338, 1926)

Gardner, Application of the algebraic aberration equations to optical design (S550, 1926)

Meggers & Burns, Hyperfine structures of lanthanum lines (J. Opt. Soc. Am. 14, 449, 1927)

Davis & Walters, Sensitometry of photographic emulsions and a survey of the characteristics of plates and films of American manufacture (S439, 1922)

Davis, A special camera for photographing cylindrical surfaces (S517, 1925)

Davis, Artificial sunlight for photographic sensitometry (Trans. Soc. Motion Picture Eng. 12, 225, 1928)

Taylor, Analysis of diaphragm system for the X-ray standard ionization chamber (RP119, 1929; Taylor & Singer RP211, 1930)

Taylor, The precise measurement of X-ray dosage [The first X-ray dosage standards] (RP56, 1929)

Mohler, Relative production of negative and positive ions by electron collisions (Phys. Rev. 26, 614, 1926)

Mohler & Boecker, Photo-ionization of caesium by line absorption (RP186, 1930)

5. CHEMISTRY

Holler, A method of studying electrode potentials and polarization ((S504, 1924; Darnielle, RP1336, 1940)

Palmer & Weaver, [First U.S. publication of] Thermal-conductivity method for the analysis of gases (T249, 1924)

Weaver, Relation between the heating value of gas and its usefulness to the customer (T290, 1925)

——— First industrial recording instrument based on thermal conductivity (constructed for Navy plant at Indian Head, Md., 1924 — no publ.)

Weaver, Eiseman & Shawn, [First program based on] A method for testing gas appliances to determine their safety from producing carbon monoxide (T304, 1926)

Swanger, [First analytical methods for] The analysis of dental gold alloys (S532, 1926)

Souder et al., [First standards and certification system for dental materials] (J. Dental Res. 7, 173, 1927; C433, 1942)

Coleman, Physical properties of dental materials [First accurate determination of casting shrinkage of dental inlay gold] (RP32, 1928)

Washburn, Bruun & Hicks, Apparatus and methods for the separation, identification, and determination of the chemical constituents of petroleum (RP45, 1929)

Washburn, On the determination of the empirical formula of a hydrocarbon (RP236, 1930)

6. ENGINEERING PHYSICS

Eckhardt, Karcher & Keiser, Electron tube drive for tuning forks (Phys. Rev. 17, 535, 1921)

Heyl & Briggs, The earth inductor compass (Proc. Am. Phil. Soc. 61, 15, 1922)

Tuckerman, [The Tuckerman optical strain gage] (Am. Soc. Testing Mater. Proc. 23, 602, 1923)

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Quayle, Spark photography and its application to some problems in ballistics [First spark shadow photographs of bullets in flight] (S508, 1924)

Zobel & Carroll, A hot-wire anemometer for measuring air flow through engine radiators (T287, 1925)

Briggs, Hull & Dryden, Aerodynamic characteristics of airfoils at high speeds (Natl. Adv. Comm. Aeron. Tech. Rep. 207, 1924; Natl. Adv. Comm. Aeron. Tech. Rep. 319, 1929; Natl. Adv. Comm. Aeron. Tech. Rep. 365, 1930)

Tuckerman, Keulegan & Eaton, A fabric tension meter for use on aircraft [for testing rigid airship envelopes] (T320, 1926)

Buckingham, Theory and . . . experiments on the transmission of sound through partition walls (S506, 1925)

Dryden, Heald, et al., Investigations in turbulence in wind tunnels (Natl. Adv. Comm. Aeron. Tech. Rep. 231, 1926; Natl. Adv. Comm. Aeron. Tech. Rep. 342, 1930, et seq.)

Whittemore, Petrenko, et al., Proving rings for calibrating testing machines (patents, 1926; C454, 1946)

Heyl, A redetermination of the constant of gravitation (RP256, 1930)

Tuckerman, Whittemore & Petrenko, A new dead-weight testing machine of 100,000 pounds capacity (RP147, 1930)

Dryden & Hill, [Studies of wind pressure on structures] (Proc. Natl. Acad. Sci., Nov 1930; RP301, 1931; RP545, 1933)

7. ENGINEERING, STRUCTURAL & MISC. MATERIALS

Holt & Wormeley, Dynamometer [equipment and] tests of automobile tires (T240, 1923)

Holt & Wormeley, [Equipment for] Endurance tests of tires (T318, 1926)

Holt, Wormeley, et al., The testing of rubber goods (C38, 5th ed., 1927)

Kline & Acree, Consumption of nitric acid in the oxidation of xylose (Ind. Eng. Chem. 22, 975, 1930)

Kline & Acree, A study of the method for titrating aldose sugars with standard iodine and alkali (RP247, 1930)

8. METALLURGY

Merica & Waltenberg, [Pioneer work on the] Malleability and metallography of nickel (T281, 1925)

French & Klopsch, Initial temperature and mass effects in quenching ,T295, 1925; French & Hamill, RP103, 1929)

French & Tucker, Flow in a low-carbon steel at various temperatures [Pioneer work on creep of metals at elevated temperatures] (T296, 1925; Geil & Carwile, RP2329, 1952)

Jordan & Eckman, Gases in metals [Pioneer work on the effects of oxygen and hydrogen on the properties and behavior of metals] (S514, 1925)

Herschman, Air-hardening rivet steels (T358, 1927)

Rawdon, [The prevention of corrosion in duralumin] Natl. Adv. Comm. Aeron. Tech. Note 284, 1928)

Saeger and Ash, [Practical methods of determining the quality of metals in the foundry] (LC252, 1928; RP399, 1932)

Logan, Soil-corrosion studies [First explanation of the mechanism of corrosion in soils] (RP95, 1929)

French & Digges, Turning with shallow cuts at high speeds [and method for testing high-speed tool steels] (RP120, 1929)

Freeman, Scherer & Rosenberg, Reliability of fusible tin boiler plugs in service [Cause and remedy for their failure in marine boilers] (RP129, 1930; see also Burgess & Merica, T53, 1914)

9. CERAMICS

Finn, Making the glass disk for a 70-inch telescope reflector [The first reflector this large made in the United States] (RP97, 1929)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1931–1940

1. ELECTRICAL

Sanford, A method for the standardization of permeameters at high magnetizing forces (RP279, 1931)

Kear & Wintermute, A simultaneous radiotelephone and visual range beacon for the airways (RP341, 1931)

Diamond, The cause and elimination of night effects in radio range-beacon reception (RP513, 1933)

Brooks, The standard-cell comparator [Design and construction of a specialized potentiometer for exact comparison of standard cells] (RP586, 1933)

Harris, A new cathode-ray oscillograph and its application to the study of power loss in dielectric materials (RP636, 1934)

Dunmore, Unicontrol radio receiver for ultra high frequencies, using concentric lines as interstage couplers (RP856, 1935)

Dellinger, Sudden disturbances of the ionosphere [Discovery of the Dellinger effect] (RP1016, 1937)

Curtis, Moon & Sparks, An absolute determination of the ohm (RP857, 1936; RP1137, 1938)

Brooks, Defandorf & Silsbee, An absolute electrometer for the measurement of high alternating voltages (RP1078, 1938)

Diamond, Hinman, Dunmore, et al., A method for the investigation of upper-air phenomena and its application to radio meteorography [The radiosonde] (RP1082, 1938; RP1329, 1940)

Dunmore, An electric hygrometer and its application to radio meteorography (RP1102, 1938; RP1265, 1939)

Astin, Measurement of relative and true power factors of air capacitors (RP1138, 1938)

George, Production of accurate one-second time intervals (RP1136, 1938)

Curtiss, Astin, et al., An improved radio meteorograph on the Olland principle (RP1169, 1939)

2. WEIGHTS & MEASURES

——— Design of flexible steel gages for control of mesh size of gill nets (LC372, 1933)

Peffer, Device for testing haemacytometers and other pipettes of small capacity [The Peffer pipette tester] (RP1019, 1937)

Knoop, Peters & Emerson, A sensitive pyramidal-diamond tool for indentation measurements [The Knoop hardness indenter] (RP1220, 1939)

3. HEAT & POWER

Roeser, Caldwell & Wensel, The freezing point of platinum (RP326, 1931)

Van Dusen & Shelton, Apparatus for measuring thermal conductivity of metals up to 600° C (RP668, 1934)

Wensel, Judd & Roeser, Establishment of a scale of color temperature (RP677, 1934)

Wensel, International Temperature Scale and some related physical constants (RP1189, 1939)

Osborne, Stimson & Ginnings, Thermal properties of saturated water and steam (RP1229, 1939)

4. OPTICS

Taylor, L. S., X-ray protection [The first X-ray protection code] (H15, 1931; H20, 1936, et seq.)

Davis & Gibson, Filters for the reproduction of sunlight and daylight and the determination of color temperature [International standards for converting artificial light to daylight quality and for determining color temperature] (M114, 1931)

Taylor, International comparison of X-ray standards (RP397, 1932)

Mohler, Collisions of the first and second kind in the positive column of a caesium discharge (RP485, 1932)

Boeckner & Mohler, Scattering of electrons by ions and the mobility of electrons in a caesium discharge (RP535, 1933)

Taylor, Radium protection [The first radium protection code] (H18, 1934; H23, 1938, et seq.)

Tilton & J. K. Taylor, Refractive index and dispersion of normal and heavy water (RP703, 1934)

Curtiss, Deflection of cosmic rays by a magnetic field (RP509, 1932)

Hoffman & Scribner, Purification of gallium by fractional crystallization of the metal (RP823, 1935)

Gardner, Design and construction of eclipse apparatus [Application of telephoto lenses to eclipse photography] (1936; reported in Nat. Geo. Soc. Solar Expedition Papers, No. 2, 1942, pp. 4, 95)

Gardner & Case, Precision camera for testing lenses (RP984, 1937)

Mohler, Cesium discharge under conditions of nearly complete ionization (RP1150, 1938)

Gardner, Relation of camera error to photogrammetric mapping (RP1177, 1939)

Saunders, Improved interferometric procedure with application to expansion measurements (RP1227, 1939)

Gibson & Haupt, Standardization of the luminous-transmission scale used in the specification of railroad signal glasses (RP1209, 1939)

Judd & Kelly, Method of designating colors [Development of the ISCC–NBS method of designating colors] (RP1239, 1939; C553, 1955)

Washer & Gardner, Studies of the resolving power of camera lenses (1939–1950; C428, 1940; RP1636, 1945; C533, 1953)

Scribner, Spectrographic detection of rare earths in plants (Proc. 6th Summer Conf. on Spectroscopy, 1939, pp. 10–13)

Curtiss, Astin, et al., Cosmic-ray observations in the stratosphere with high-speed counters (RP1254, 1939)

Judd, Hue, saturation, and lightness of surface colors with chromatic illumination (RP1285, 1940)

Carroll & Hubbard, The photographic emulsion . . . (RP340, 1931 . . . RP622, 1933)

5. CHEMISTRY

Smith, W. H., Saylor & Wing, The preparation and crystallization of pure ether-soluble rubber hydrocarbon (RP544, 1933)

Washburn, Standard states for bomb calorimetry (RP546, 1933)

Washburn, E. R. Smith & Frandsen, The isotopic fractionation of water (RP601, 1933)

Gilchrist, Methods for the separation of platinum, palladium, rhodium, and iridium [First systematic method of separating the platinum metals] (RP655, 1934)

Washburn, E. R. Smith & F. A. Smith, Fractionation of the isotopes of hydrogen and of oxygen in a commerical electrolyzer (RP729, 1934)

Hoffman, Preparation of pure gallium (RP734, 1934)

Brickwedde, Scott, & H. S. Taylor, The difference in vapor pressures of ortho- and paradeuterium (RP841, 1935)

Brenner, Magnetic method for measuring the thickness of nickel coatings on non-magnetic base metals [The Magnegage] (RP994, 1937)

Knowlton & Rossini, Method and apparatus for the rapid conversion of deuterium oxide into deuterium (RP1050, 1937)

Gilchrist, New procedure for the analysis of dental gold alloys (RP1103, 1938)

Wildhack & Goerke, Formulas for diaphragm and diaphragm capsules (Natl. Adv. Comm. Aeron. Tech. Note 738, 1939; Natl. Adv. Comm. Aeron. Tech. Note 876, 1942)

Thompson, Methods of measuring pH in alkaline cyanide plating baths (RP1291, 1940)

6. MECHANICS & SOUND

Lyon, Whittemore, et al., Strain measurement in reinforcement . . . [The Whittemore hand strain gage] (RP268, 1931)

Snyder, An automatic reverberation meter for the measurement of sound absorption (RP457, 1932)

Peterson & Womack [The aviation superheat meter] (Natl. Adv. Comm. Aeron. Tech. Rep. 606, 1937)

Cordero, A vibrometer for measuring amplitude in a single frequency (patent, 1934)

Heald, [Ground effect tests and air forces on automobiles] (RP748 and RP749, 1934)

Snyder, Recent sound-transmission measurements [Threshold standards for audiometry] (RP800, 1935)

Wright, [Pioneer hydraulic model studies] (RP907, 1936; Keulegan, RP1488, 1942)

Heyl & Cook, The value of gravity at Washington (RP946, 1936)

Briggs, [The flight performance of golf balls and baseballs] (TNB, No. 252, 1938; RP1624, 1945)

Keulegan & Beij, Studies of turbulent flow in pipes and open channels (RP965, 1937; RP1110, 1938; RP1151. 1938; RP1488, 1942)

Golden & Hunter, Backflow prevention in over-rim water supplies [Cross-connection flow in plumbing systems] (BMS28, 1939)

Greenspan, Approximation to a function of one variable from a set of its mean values [Method of measurement of strain at a point] (RP1235. 1939)

Keulegan & Patterson, Mathematical theory of irrotational translation waves [Research on the theory of wave motion] (RP1272, 1940; RP1544, 1943)

7. ORGANIC & FIBROUS MATERIALS

Schiefer & Best, Carpet wear testing machine (RP315, 1931)

Schiefer, The flexometer . . . for evaluating the flexural properties of cloth and similar materials (RP555, 1933)

Schiefer, The compressometer . . . for evaluating the thickness . . . and compressional resilience of textiles and similar materials (RP561, 1933)

Becker, Spectral reflectance of . . . abacá [manila rope] fiber (RP628, 1933)

Schiefer & Appel, Hosiery testing machine (RP679 and LC466, 1934)

Carson, A sensitive instrument for measuring the air permeability of paper and other sheet materials (RP681, 1934)

Bekkedahl, [Volume dilatometer for studying phase changes in liquids and solids] (RP717, 1934; RP2016, 1949)

Kline & Malmberg, Suitability of various plastics [especially cellulose acetate butyrate] for use in airplane dopes (RP1098, 1938)

Taylor, R. H., & Holt, Small inertia-type machine for testing brake lining (RP1297, 1940)

Launer, Apparatus for the study of the photochemistry of sheet materials (RP1300, 1940)

8. METALLURGY

Rosenberg & Jordan, Influence of oxide films on the wear of steels (RP708, 1934)

Buzzard & Wilson, Anodic coating of magnesium alloys [for aircraft use] (RP964, 1937)

Krynitsky & Saeger, Elastic properties of cast iron [Optical method for measuring deflection of cast iron bars under pressure] (RP1176, 1939)

9. CLAY & SILICATE PRODUCTS

Geller & Creamer, "Moisture expansion" of ceramic white ware [Discovery of effect of moisture expansion on crazing of glasses] (RP472, 1932)

Kessler & Sligh, Physical properties and weathering characteristics of slate (RP477, 1932)

Swenson, Wagner & Pigman, Effect of the granulometric composition of cement on the properties of pastes, mortars, and concretes [New method for determining fineness of Portland cement] (RP777, 1935)

Theuer, Effect of temperature on the stress-deformation of concrete [Sonic methods for measurement of modules of elasticity of concrete] (RP970, 1937)

Stull & Johnson, Relation between moisture content and flow-point pressure of plastic clay [First comprehensive study of cause of white-coat plaster failures] (RP1186, 1939)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1941–1945

1. ELECTRICITY

——— [Development of workable perchloric and fluoboric acid batteries] (1941; TNB 30, 76, 1946)

Astin, Radio reporters for proximity fuse testing [Telemetering from missiles in flight] (Classified NDRC Rep. A–53, 1942)

Hinman & Brunetti, Radio proximity fuze design (1941; RP1723, 1946)

Silsbee, Static electricity [Nature, origins, and mitigation of static electricity in industrial processes] (C438, 1942)

——— [Development of first guided missile, the BAT] (1944; TNB 31, 30, 1947)

——— Code for protection against lightning (H40, 1945)

Franklin, NBS casting resin for potting electronic circuitry (1945; TNB 31, 78, 1947)

2. WEIGHTS & MEASURES

Hidnert, Thermal expansion of electrolytic chromium [Explanation of cracking of chromium plating] (RP1361, 1941)

——— Absolute collimeter for testing range and height finders (no publ., 1942)

Schoonover & Dickson, [Development of mold lining material for processing resin dentures] (J. Am. Dental Assoc. 29, 1349, 1942)

Schoonover, Souder & Beall, [First explanation of delayed] Excessive expansion of dental amalgam (J. Am. Dental Assoc. 29, 1825, 1942)

——— [Development of] Elastic dental impression compounds with an alginate base (J. Am. Dental Assoc. 30, 565, 1943)

Peters, Nefflen & Harris, Diamond cutting by an electric arc (RP1657, 1945)

4. OPTICS

Scribner, Spark spectrographic analysis of commercial tin (RP1451, 1942)

Coblentz & Stair, A daily record of ultraviolet solar and sky radiation in Washington, 1941 to 1943 (RP1593, 1944)

Scribner & Mullin, Carrier-distillation method for spectrographic analysis and its application to the analysis of uranium-base materials (Manhattan Project Report A-2907, Sep 1945; RP1753, 1946)

Washer, Region of usable imagery in airplane-camera lenses (RP1636, 1945)

Gibson, Haupt & Keegan, Specification of railroad signal colors and glasses (RP1688, 1946)

Meggers, Microscopy, past, present, and future (J. Opt. Soc. Am. 36, 431, 1946)

5. CHEMISTRY

Branham, Shepherd & Schuhmann, Critical study of the determination of carbon monoxide by combustion over platinum . . . [First sensitive colorimetric indicator for carbon monoxide] (RP1396, 1941)

Mair, Glasgow & Rossini, Separation of hydrocarbons by azeotropic distillation (RP1402, 1941)

Gilchrist, Analytical separations by means of controlled hydrolytic precipitation (RP1519, 1943)

Flint, Clarke, et al., Extraction of alumina from clays and high-silica bauxites (RP1691, 1945–46; Hoffman, Leslie, et al., RP1756, 1946)

6. MECHANICS & SOUND

Hunter, Water-distributing systems for buildings (BMS79, 1941)

Heyl & Chrzanowski, A new determination of the constant of gravitation (RP1480, 1942)

Wildhack & Iberall, [Linear flowmeter for measuring oxygen regulator characteristics] (TNB 28, 68, 1944)

Cordero, Waterproof and shockproof standby compass (no publ., 1943)

Ramberg & Osgood, Description of stress-strain curves by three parameters (Natl. Adv. Comm. Aeron. Tech. Note 902, 1943)

McPherson, Adaptor for measuring principal strains with Tuckerman strain gage (Natl. Adv. Comm. Aeron. Tech. Note 898, 1943)

Keulegan, Laminar flow at the interface of two liquids [Research on density currents] (RP1591, 1944)

Brueggman, Mayer & Miller, Devices for testing thin sheet metals in compression tests (Natl. Adv. Comm. Aeron. Tech. Note 931, 1944; Natl. Adv. Comm. Aeron. Tech. Note 1022, 1946)

Tate, Solenoid compensating device for hardness testing machines (patent, 1944)

Womack & Orbach, [Carbon monoxide indicators for aircraft] (1941; TNB 30, 73, 1946)

Womack & Cordero, Yaw meter for aircraft (no publ., 1945)

Greenspan & Sweetman, A transfer strain gage for [measurement of] large strains (RP 1658, 1945)

Cook & Chrzanowski, Absorption and scattering by sound-absorbent cylinders [Acoustic impedance of the human ear] (RP1709, 1946)

Ramberg, Vacuum-tube acceleration pickup (RP1754, 1946)

Womack & Cordero [A portable wind speed and direction indicator] (TNB 31, 97, 1947)

7. ORGANIC & FIBROUS MATERIALS

Dreby, The planoflex . . . for evaluating the pliability of fabrics (RP1434, 1941)

Kline & Schiefer, An instrument for estimating tautness of doped fabrics on aircraft [Tautness meter] (Natl. Adv. Comm. Aeron. Tech. Note 729, 1942)

Schiefer, Mizell & Mosedale, [Thermal transmission apparatus for testing textiles] (RP1528, 1943)

Dreby, A friction meter for determining the coefficient of kinetic friction [in testing the smoothness] of fabrics (RP1562, 1943)

Kanagy, Charles, et al., [Prevention of mildew of leather] (RP1713, 1946)

——— Plastic housing for binoculars (TNB 28, 30, 1944)

Schiefer, Machines and methods for testing cordage fibers (RP1611, 1944)

——— Standard fading lamp (LC785, 1945)

8. METALLURGY

Ellinger, Bissell & Williams, [Development of] The tee-bend test to compare the welding quality of steels (RP1444, 1942)

9. CLAY & SILICATE PRODUCTS

Geller, A resistor furnace . . . [Development of ceramic oxide resistors for high-temperature furnaces] (RP1443, 1941)

Harrison & Moore, [Mechanism of] Weather resistance of porcelain-enameled iron structural units (RP1476, 1942)

Hoffman, J. I., Leslie, et al., Development of a hydrochloric acid process for the production of alumina from clay (RP1756, 1946)

Harrison, Moore & Richmond, Ceramic coatings for high-temperature protection of steel (RP1773, 1947)

NATIONAL BUREAU OF STANDARDS

RESEARCH HIGHLIGHTS IN SCIENCE AND TECHNOLOGY—1946–1951

1. ELECTRICITY & OPTICS

Washer & Scott, Influence of the atmosphere upon the precision of telescope pointing (RP1829, 1947)

Washer, Sources of error in and calibration of the f-number of photographic lenses (RP1927, 1948)

Gardner & Hahner, Research and development in applied optics and optical glass at the NBS (M194, 1949)

Washer & Case, Calibration of precision airplane mapping cameras (RP2108, 1950)

——— Electrochemical constants: a symposium (C524, 1953)

——— Optical image evaluation: a symposium (C526, 1954)

2. METROLOGY

Peters, Emerson, et al., Electrical methods for diamond-die production (RP1787, 1947)

Bowman, An automatic correction-computing chronograph [A method for making precision isochronism measurements] (Horological Inst. Am. J. 6, 13, 1951)

——— Frequency-monitoring device for interval timers (TNB 33, 99, 1949)

——— Gravity waves: a symposium (C521, 1952)

3. HEAT & POWER

Woolley, Scott & Brickwedde, Compilation of thermal properties of hydrogen in its various isotopic and ortho-para modifications (RP1932, 1948)

Scott, [New helium liquefier for studies in superconductivity] (TNB 33, 13, 1949)

——— Low-temperature physics: a symposium (C519, 1952)

——— Mechanical properties of metals at low temperatures: a symposium (C520, 1952)

——— Energy transfer in hot gases: a symposium (C523, 1954)

4. ATOMIC & RADIATION PHYSICS

Singer, Braestrup & Wyckoff, Absorption measurements for broad beams of 1- and 2-million-volt X-rays [Use of concrete as a high-energy radiation shield] (RP1735, 1946)

Meggers & Westfall, Lamps and wavelengths of mercury 198 [New standard of length, the Hg198 lamp] (TNB 31, 133, 1947; Sci. Mo. 68, 3, 1949; RP2091, 1950)

Marton & Belson, Tracer micrography [with radioactive isotopes] (Science, 106, 2742, 1947)

——— A non-magnetic radio-frequency mass spectrometer (TNB 32, 1, 1948)

Marton & Lachenbruch, Electron optical observation of magnetic fields [The electron optical shadow method for field mapping] (RP2033, 1949)

Curtiss & Carson, Reproducibility of photo-neutron standards (Phys. Rev. 76, 1412, 1949)

Hipple, Sommer & Thomas, A precise method of determining the faraday by magnetic resonance [The omegatron] Phys. Rev. 76, 1877, 1949)

Thomas, Driscoll & Hipple, Measurement of the proton moment in absolute units (Phys. Rev. 75, 902, 1949; RP2104, 1950)

Driscoll, Thomas & Hipple, The absolute value of the gyromagnetic ratio of the proton (Phys. Rev. 78, 339, 1950)

Huntoon & Fano, Atomic definition of primary standards (Nature, 166, 167, 1950)

——— Electron physics: a symposium (C527, 1954)

——— Mass spectroscopy in physics research: a symposium (C522, 1953)

5. CHEMISTRY

Shepherd, Analysis of a standard sample . . . [First nation-wide effort to standardize gas analysis] (RP1704, 1946)

Brenner & Riddell, Nickel plating on steel by chemical reduction (RP1725, 1946)

Rossini, Pitzer, et al., Tables of selected values of properties of hydrocarbons (C461, 1947)

Glasgow, Murphy, et al., Purification, purity, and freezing points of 31 hydrocarbons of the API–NBS series (RP1734, 1946)

Schwab & Wichers, [Benzoic acid cells as thermometric standard] (TNB 31, 116, 1947)

Brenner, Couch & Williams, Electrodeposition of alloys of phosphorus with nickel or cobalt (RP2061, 1950)

Scribner & Corliss, Emission spectrographic standards (Anal. Chem. 23, 1548, 1951)

——— Electrodeposition research: a symposium (C529, 1953)

6. MECHANICS

Carson & Worthington, Apparatus for determining water-vapor permeability of moisture barriers (C453, 1946)

Wildhack & Goalwin, [Compact liquid-to-gas oxygen converter] (TNB 33, 65, 1949)

Wexler, Divided flow, low-temperature humidity test apparatus [for radiosonde hygrometers] (TNB 32, 11, 1948; RP1894, 1948)

Levy, A. E. McPherson & Hobbs, Calibration of accelerometers [for aircraft] (RP1930, 1948)

Cordero, Johnson & Womack [Development of the Pfund sky compass] (TNB 33, 53, 1949)

Cordero, Stick-force indicator for aircraft (TNB 34, 6, 1950)

French, Stack venting of plumbing fixtures (BMS118, 1950)

——— Characteristics and application of resistance strain gages: a symposium (C528, 1954)

7. ORGANIC & FIBROUS MATERIALS

Schiefer, et al., Solution of problem of producing uniform abrasion and its application to the testing of textiles (RP1807, 1947; RP1988, 1949)

Holt, Knox & Roth, Strain test for rubber [Vulcanizates] (RP1907, 1948)

Axilrod, Thiebeau & Brenner, Variable-span flexure test jig for plastic specimens (ASTM Bull. 148, 96, 1947)

Hobbs, [Luggage testing and fatigue tester for luggage handles] (TNB 32, 134, 1948)

Hanks & Weissberg [The osmometer] (1948; RP2377, 1952)

Newman, Borysko & Swerdlow, Ultra-microtomy by a new method (RP2020, 1949)

O'Leary, et al., Paper from glass fibers (TNB 35, 177, 1951; TNB 39, 82, 1955)

——— Polymer degradation mechanism: a symposium (C525, 1953)

8. METALLURGY

Digges, Reinhart, et al., Influence of boron on some properties of experimental and commercial steels [Substitution of boron for carbon in hardening steels] (RP1815, 1947; RP1938, 1948)

Rosenberg & Darr, Stabilization of austenitic stainless steel [Prevention of corrosion in certain stainless steels] (RP1878, 1948)

9. MINERAL PRODUCTS

——— [Preparation of very thin] Ceramic dielectrics for electronic signal devices (TNB 33, 142, 1949)

Harrison, Moore & Richmond, Ceramic coatings for high-temperature protection of steel (RP 1773, 1947)

11. APPLIED MATHEMATICS

Lowan, The computation laboratory of the NBS [Mathematical tables program, 1930–1950] (Scripta Math. 15, 33, 1949)

13. ELECTRONICS & ORDNANCE DEVELOPMENT

Brunetti & Curtis, NBS printed circuit techniques (TNB 31, 1946; C468, 1947)

Rabinow, Magnetic fluid clutch (TNB 32, 54, 1948)

——— Computer development at the NBS [SEAC, SWAC, and DYSEAC] (C551, 1955)

14. CENTRAL RADIO PROPAGATION LABORATORY

——— Ionospheric radio propagation [Basic radio propagation predictions] (C462, 1947)

Husten & Lyons, Microwave frequency [measurements and standards] (Elec. Eng. 67, 436, 1948)

Kerns, Determination of efficiency of microwave bolometer mounts from impedance data (RP1995, 1949)

Lyons, et al., The atomic clock: an atomic standard of frequency and time (TNB 33, 17, 1949)

Lyons, Microwave spectroscopic frequency and time standards [The atomic clock] (Elec. Eng. 68, 251, 1949)

Birnbaum, A recording microwave refractometer (Rev. Sci. Instr. 21, 169, 1950)

Greene & Solow, Development of very-high-frequency field-intensity standards (RP2100, 1950)

Birnbaum, Kryder & Lyons, Microwave measurements of the dielectric properties of gases (J. Appl. Phys. 22, 95, 1951)

Selby, Radio-frequency micropotentiometer [and measurement of accurate rf microvoltages] (TNB 35, 33, 1951; Trans. AIEE 72, 158, 1953)

Huston, Improved NBS ammonia clock (Proc. IRE 39, 208, 1951)

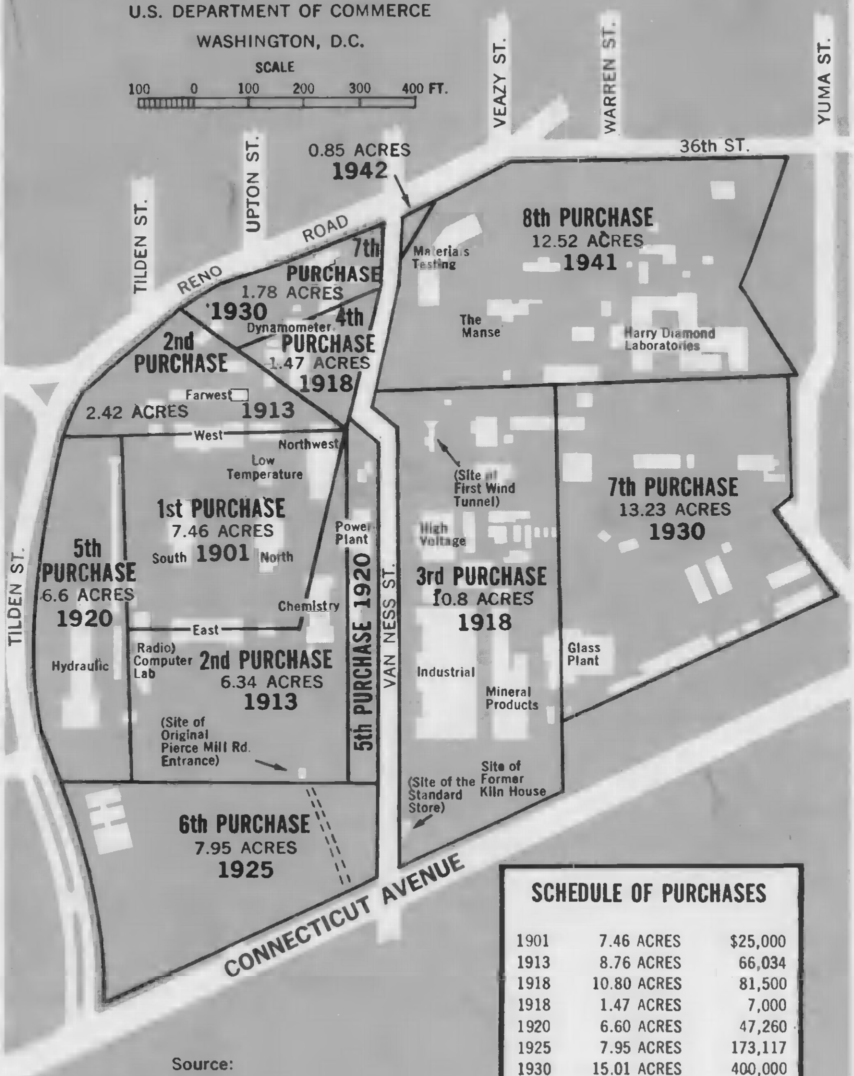
Lyons, Spectral lines as frequency standards [NBS Model III of the ammonia clock] (Ann. N.Y. Acad. Sci. 55, 831. 1952)

LAND PURCHASES

for the National Bureau of Standards

U.S. DEPARTMENT OF COMMERCE

WASHINGTON, D.C.



SCHEDULE OF PURCHASES

1901	7.46 ACRES	$25,000
1913	8.76 ACRES	66,034
1918	10.80 ACRES	81,500
1918	1.47 ACRES	7,000
1920	6.60 ACRES	47,260
1925	7.95 ACRES	173,117
1930	15.01 ACRES	400,000
1941	12.52 ACRES	125,000
1942	.085 ACRES	

Source:

PLANT DIVISION, NBS

APPENDIX M

SAMUEL WESLEY STRATTON

Founder and First Director of the National Bureau of Standards [1]

It is no exaggeration to say that Dr. Stratton's whole life was the National Bureau of Standards and that every formative influence in his early years was a preparation for his founding and direction of the Bureau. The Bureau is his monument, and the ideals of service that Stratton built into the edifice he raised in the age of commerce and industry survive intact into the present space age.

The name "Stratton" goes back to 12th-century Scotland, the surname of families who dwelt in a walled village by a paved road. The first Stratton on record in this country came from England in 1628. Dr. Stratton himself is believed to have descended from a Thomas Stratton who received a patent of land in Pittsylvania County, Va., in 1764. Thomas's great grandson Robertson Stratton moved from Virginia to Kentucky, where his fifth child, the father of Samuel Wesley Stratton, was born in 1832.

Upon the death of Robertson in 1832, his widow and children moved to Illinois. Dr. Stratton's father, Samuel, grew up in Litchfield, Ill., went into stock farming and later lumbering, and married a widow, Mrs. Mary Webster Philips. It was on the farm just outside Litchfield that Samuel Wesley was born on July 18, 1861.

Young Samuel Wesley grew up with little taste for farm life or for the stocks of Jersey cattle, Shetland ponies, Brahma chickens, and other new breeds of farm animals introduced into the State by his father as a result of periodic trips East and one voyage he made for new stock to England and the Channel Islands. Instead, he took an early interest in tinkering with the farm machinery, clocks, and other devices in the house, and in devising mechanical ways of taking the drudgery out of soapmaking, making apple butter, and similar farm chores. An annual treat was the stock show in St. Louis, 50 miles away, where his father exhibited his livestock and where young Samuel explored the exhibits of farm machinery, tools, and new mechanical inventions on display.

Determined on more education than provided by the district school and the high school in Litchfield, 2 miles away, Stratton sold a colt he had raised and announced his intention of going for a year to the Illinois Industrial University at Urbana, the future University of Illinois. In 1880 land-grant Illinois Industrial was almost 12 years old, a citadel of learning offering courses in "such branches of learning as are related to agriculture and the mechanic arts, and military studies, without excluding other scientific and practical studies."

The course Samuel Wesley set his heart on was that in "Machine shop practice," and he persuaded the registrar to let him take it in his freshman year. He was then 19,

[1] Except as otherwise noted, the present sketch is based on the manuscript fragment of a biography of Stratton written by Dr. Samuel C. Prescott of the Massachusetts Institute of Technology in 1933–34 and on the materials collected for that biography that now comprise the Stratton Papers in the Archives Library at M.I.T. The biographical fragment and other documents in that collection used in this sketch have been reproduced for the NBS Historical File.

Samuel W. Stratton at 21, probably early in his 3d year at Illinois Industrial University, about the time he entered the home of Dr. Peabody, president of the university.

Stratton as brevet captain, "Co. C., I.I.U. Battalion, Champagne, Ill., 2/25–84," as he wrote on the back of the picture. Fourteen years later, his fledgling moustache fully grown, he was in uniform again, serving under Commodore Remey during the Spanish-American War.

a stockily built boy of slightly less than average height, with gray-blue eyes and light brown hair, his serious face concealing a shyness that, except in the company of close friends, was to last all his life.

With little money from home, he found work in the college machine shops where he repaired farm machinery at 10 cents an hour. He also, with a wet-plate camera he had brought from home, took pictures of the buildings and classrooms for sale to students and visitors, and in the absence of satisfactory textbooks, began blueprinting the notes of professors at the university, at 2 cents a sheet. The notes, which he copied neatly from often illegible scrawls and then printed, sold well and enabled him to continue into his second year. That second year also he secured a room rent free in the chemical laboratory building in exchange for serving as fireman and janitor.

Stratton's last 2 years at the university were assured when the president and head of the department of mechanical engineering, Dr. Delim H. Peabody, offered him room, board, and a small salary in exchange for tending the farm and grounds of the president's house and acting as a sort of personal secretary. He became, a daughter of Dr. Peabody later recalled, a member of the family, and the training he received in the social graces, in household management, and in meeting and entertaining visitors and guests of the university was to prove almost the most valuable part of his college education.

It was about this time that he seems to have felt his youthful appearance belied his new responsibilities, for in his 22d year he began to grow the short, full mustache he wore the rest of his life.

Beginning in his second year, young Stratton took "Military," as required in State-supported universities, and demonstrated marked skill as a drillmaster. Of his other studies a contemporary was to say that his scholarship was fair but not brilliant, but "in some matters he did excel—shop work, draughtsmanship, and work in the physics laboratory * * * his work a model of neatness and accuracy."

Upon his graduation in 1884, Stratton received a completion certificate for his work in mathematics, physics, and mechanical engineering, his grades, according to the college record, consistently those expected of a "superior student"; a commission as brevet captain in the State military; and an invitation to return to the university as a member of the faculty. He presented his thesis, "The design of a heliostat," in 1886 and received his B.S. degree that year.

In his only extant autobiographical fragment, a four-page note on his military and naval service, Stratton said he once asked President Peabody why he been selected to teach at the university. The president replied that he had observed Stratton at drill and was impressed with the fact that he seemed to know how to get along with men. "I enjoyed the systematic way of doing things," Stratton commented, "and that experience. especially the discipline, has been of great value to me in most of the things I have been called upon to do later."

After a summer of engineering work in a Chicago factory, Stratton began instructing in mathematics and physics in the preparatory department of the university. He continued in the rank of instructor until 1889, when he was made assistant professor of physics. Upon his organization of a course in electrical engineering a year later, he occupied the chair of professor of physics and electrical engineering. In 1892, through a member of the faculty who preceded him, Stratton was called to the new University of Chicago as assistant professor of physics.[2]

The Ryerson Physical Laboratory at Chicago was under construction and Prof. Albert A. Michelson, brought from Clark University to head the new department, spent most of that year at the International Bureau of Weights and Measures outside Paris. There he demonstrated the practicability of a wavelength (light wave) standard, which was destined to replace the standard meter bar as the standard of length.

Stratton, as senior in Michelson's absence, therefore had the principal task of organizing the department and overseeing the construction and equipping of the new physics laboratory. He was then 26.

Stratton's 7 years under Michelson served him well, for the highly irascible master of the spectroscope and interferometer was a stickler for perfection and champion of the sixth decimal point. Disciplined in the measurement method of science, Michelson did not foresee its replacement by mathematical and theoretical physics, and like many of his scientific colleagues he continued to believe that the future of physics was strictly a matter of further precision and improved instrumentation.

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[2] Stratton's salary of $2,000 was $500 less than that of Amos Alonzo Stagg (1862–1965), brought to the university that same year as athletic director and given the rank of associate professor. Time, Mar. 26, 1965, p. 45.

Sometime after settling into the routine of teaching and research with Michelson, Stratton was asked by Michelson, who had a strong interest in the Navy, to assist in organizing a volunteer naval militia at Chicago. A naval vessel on the Great Lakes was available for training in the operations of a warship, and Stratton accepted command of one of the four units constituting the naval militia battalion that was formed. At full strength his unit comprised a hundred men, consisting of trained engineers as officers and skilled artisans as crew.

At the outbreak of the war with Spain in the spring of 1898, Stratton was commissioned a lieutenant, put in charge of the battalion, expanded with additional volunteers to 705 men, and all were formally inducted into the U.S. Navy. The battalion was sent to Key West where it was distributed among the ships preparing to put to sea. Stratton saw most of his original unit detailed to the battleship *Oregon* when it arrived in late May after its famous 16,000-mile voyage around the Horn.

Many of his men saw action, but not Stratton. He had from the beginning of his naval service demonstrated marked executive ability and could not be spared. He was first attached to the naval base, then as watch and division officer on Commodore George C. Remey's flagship at the base, and finally attached to the battleship *Texas*, sister ship of the *Maine*, when she came north after the battle of Santiago. Mustered out in November 1898, Stratton kept up his naval connections, and from 1904 to 1912 held the rank of Commander in the District of Columbia Naval Militia. The Bureau laboratories were never to be without research projects for the Navy and he maintained a strong attachment to that service all his life.

His trip to the Nation's Capital late in 1898, to invite Admiral Dewey and Secretary of the Treasury Gage to give talks at the University of Chicago, led to Stratton's survey of the Office of Weights and Measures in the Coast Survey and the invitation to form and head the new National Bureau of Standards.[3]

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[3] The originals of the Treasurv Department appointment of Dr. Stratton as Inspector of Standards, effective date of oath Oct. 28, 1899, and the U.S. Civil Service certificate formally appointing him Inspector, dated Dec. 12, 1899, are in the Stratton Papers, MIT, Box 11.

A communication from Dr. Leonard B. Loeb, emeritus professor of physics, University of California, who studied and later taught under Michelson at Chicago, to Mrs. Dorothy Michelson Stevens, daughter of the great physicist, suggests that Michelson himself was very much interested in the position as Director of the new Bureau and, as plans for its establishment matured, hoped Stratton would make that known in Washington. Stratton had been Inspector of Standards for 6 months, working on the bill to be presented to Congress, when on Apr. 25, 1900, Michelson telegraphed Stratton asking him to return at once to Chicago, to help reorganize the local naval militia. Stratton, he said, was to be his chief of staff. (Telegram in Stratton Papers, MIT, copy in NBS Historical File.) But Stratton was now fully committed to his task in Washington.

One of Stratton's first duties upon becoming Director on Mar. 3, 1901, was to recommend to Secretary of the Treasury Lyman J. Gage suitable members for the Visiting Committee to the Bureau. A letter in April 1901 to Stratton from Dr. Henry S. Pritchett, former head of the Coast and Geodetic Survey who had recently become President of MIT, agreed with Stratton on the wisdom of asking Elihu Thomson, as well as Michelson, to join the Visiting Committee. "I think it wise to ask Michelson also as a member * * * because of his reputation and standing; no doubt we shall be able to keep him in good order." (Letter, Apr. 13, in Stratton Papers, Box 5.) The letter of invitation to Michelson was sent on June 6, 1901. No answer has been found. The letters

Prior to his appointment in March 1901 as the Bureau Director, Stratton lived at a boardinghouse at the corner of 18th and I Streets. Later that year he moved into an apartment in The Farragut, then nearing completion, a block away on 17th Street. His famous perfect and faithful maid Cordelia who came at this time was to run his bachelor household and delight his frequent dinner guests with her good cooking for the next 25 years in Washington and in Cambridge.

As Director of the Bureau, Dr. Stratton had considerable entertaining to do and learned to do it well. He streamed with charm and even his slight air of haughtiness was engaging. If he was somewhat formal and shy with strangers and acquaintances, with those who became friends he was wholly at ease, merry, and playful. He enjoyed most of all friends with large families, whose children he could spoil with presents and confections. They were sometimes unusual presents, such as the piglet he brought to one house, the great white goose he carried to another. As a treat for the Parris children on P Street, one of whom, Morris, was many years later to become his personal secretary and assistant at MIT, Stratton on one occasion secured the private car of the president of the Washington Railway & Electric Co. and for an afternoon and evening took them and a swarm of their friends on a picnic trip around the city and out into the suburbs.

Without a family, he made the Bureau family his own, presiding over their welfare, their education, and even their marriages, a number of which were held in his home at the Farragut. As the Bureau grew and the children of the staff members multiplied, Stratton began his custom of putting on elaborate Christmas parties and summer games and picnics for them. At the annual summer party in June, each child was weighed and measured and the new figures compared with those previously recorded. For their amusement he had swings erected on the Bureau lawn, brought up an organ grinder and monkey, a merry-go-round with a caliope, and hired a clown, and ponies to ride. There was a toy for each child, balloons were everywhere, and all the ice cream, lemonade, cake, and cookies the youngsters could eat. And to keep their parents happy out on Connecticut Avenue, Stratton held frequent receptions for their entertainment and arranged dances, lectures, and musicals, the latter often by members of the staff—events unheard of in a Government bureau before that time.[4]

He tried golf briefly and occasionally played tennis during his first years at the Bureau but never really cared for such organized exercise. The tennis ended when in 1905 Stratton and Louis A. Fischer, his chief of weights and measures, bought a 25-foot motor launch which they kept moored at a boat club on the Potomac. They spent many evenings and Sundays on the river, and made new friends along the waterway, among them James C. Courts, clerk of the Appropriations Committee, who became a great help to Stratton in getting Bureau bills through Congress. Not that he needed much help, for Stratton had a way with Congress, of interesting and exciting its committees in the research work of the Bureau, that was famous. As commander of the District Naval Militia, Stratton also had access to the monitor *Puritan* and a steam yacht, the

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to those who were to form the first Visiting Committee, including both Thomson and Pritchett, were sent on June 18 (see ch. II, p. 61).

Mrs. Stevens, Michelson's daughter, presently engaged in writing a biography of her father, acknowledges that the introspective physicist, with his almost complete lack of interest in adminstration, would probably not have been happy as Director of the Bureau. But that his standing as a scientist and metrologist made him unquestionably the best qualified man in the Nation, and otherwise the obvious choice, for the position is beyond question.

[4] G. K. Burgess, "Dr. Samuel Wesley Stratton," The Tech Engineering News (MIT), 3, 146 (1922).

Scenes at the summer picnics that Dr. Stratton planned and presided over on the Bureau lawn between North and South buildings. Dr. Stratton appears in two of the scenes. The picture with the cameraman is dated 1922; the others are probably somewhat earlier.

Oneida, the latter a training ship whose crews on weekend outings and picnics frequently included some of Stratton's friends.

As Director of the Bureau and also a highly eligible bachelor, Stratton was in constant demand at official functions and private dinners. He was a frequent guest at the White House, beginning with the McKinleys. Later, the houseful of young Roosevelts became a recurring delight, as were his visits to the home of Commerce Secretary Hoover with its two enterprising youngsters. But his entertainment ranged far beyond official circles. For an inherently shy person Stratton had, Dr. Burgess was to say, "probably as wide an acquaintance among men of science, industry, engineering, and business as any single American."[5] Among his hundreds of acquaintances and friends, the two most intimate and longlasting were, not surprisingly, in the instrument industry, John Bashear, the great instrumentmaker, and Ambrose Swasey, manufacturer of machine tools and astronomical instruments, including the Lick, Naval Observatory, and Yerkes telescopes.

One chore that Dr. Stratton had all his professional life and could not evade was making speeches. Through the years he was called on more and more for talks and dedications and addresses, yet never learned to enjoy the prospect or effort. Even late in his career the thought of making an informal speech at the Bureau, on the occasion of its 25th anniversary, was daunting. As he wote to Dr. Burgess, "Of course, you know speaking is rather difficult for me."[6]

As the Bureau grew larger and the responsibilities greater, Dr. Stratton took less and less time off, until the yearly trips to Paris, mostly for meetings at the International Bureau of Weights and Measures, often became his only real vacation. It was during one of these Atlantic crossings shortly after World War I that he met Francis R. Hart of Boston, banker and member of the executive committee of the Massachusetts Institute of Techology, who is said to have submitted Stratton's name to the committee when that institution was looking for a new president.[7] He was invited to Cambridge in the spring of 1922 but deferred the decision to accept the office until he had discussed it with Secretary Hoover. Besides his concern for the Bureau, he had just bought an old house in Georgetown and was in the midst of remodeling it. Friends of 20 years were in Washington and its environs, and his roots were deep in the Bureau he had founded. But more visits to Cambridge followed, and on January 2, 1923, after receiving with the Hoovers at their annual New Year's day reception, Stratton arrived at the president's house on Charles River Road in Cambridge to stay.

Returning to the Bureau late in 1926 to take part in the celebration of its 25th anniversary, Stratton recalled as the greatest accomplishments of the Bureau under his direction, not its many achievements in science and technology, but its impact on American industry. Its most significant accomplishments for the advance of industry, promised when the Bureau was founded, were "the influence upon manufacturers, of the introduction of scientific methods of measurements and methods of research * * * [and] the training of men for industry."[8] They were also the objectives he had raised to new heights in his administration of MIT.

Dr. Stratton was summering at the home of friends in Manchester, Mass., in June 1927 when Gov. Alvan T. Fuller asked President Abbott Lawrence Lowell of Harvard University, Judge Robert A. Grant of the Probate Court of Suffolk County, and Dr.

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[5] Ibid.
[6] Letter, Oct. 28, 1926 ("General Correspondence files of the Director, 1945–1955").
[7] Undocumented account in Prescott's manuscript. Hart may have been partly instrumental, but for a better documented account of the invitation, see ch. V, pp. 233–235.
[8] Speech, Dec. 4, 1926 (NBS Blue Folder Box 3, APW301c).

The Bureau of Standards Orchestra, fostered by Dr. Stratton to keep his staff happy, played at all social functions and from time to time attempted concerts.

Dr. Paul D. Foote, a regular member of the group, recalls "with embarrassment" that this picture was taken during the performance on the evening of April 17, 1918, when "the rendition of a quartet encore [of 'Moment Musicale'] failed to indicate sufficient coordination and practice."

Identified in the ensemble are Mr. and Mrs. W. F. G. Swann, C. G. Peters, P. D. Foote, H. F. Stimson, R. F. Jackson, W. F. Meggers F. L. Mohler, W. Skogland, L. E. Whittemore, J. H. Dellinger, O. Lytle, Miss G. Neidig, and P. McNicholas.

Stratton to serve on an advisory committee in the Governor's investigation of the Sacco-Vanzetti case.

Seven years before, in May 1920, Nicolò Sacco and Bartolomeo Vanzetti, one a shoe worker, the other a fish peddler, were arrested and subsequently charged with the murder of a shoe factory paymaster and his guard at South Braintree, near Boston. They bore the stigma of being unnaturalized foreigners, wartime draft dodgers, admitted anarchists and atheists. These crimes might have convicted them but in truth they were tried for murder and on July 14, 1921, found guilty.

Immediately after their arrest, Socialist and anarchist friends formed a Sacco-Vanzetti Defense Committee that was soon joined by a civil liberties committee and many of the dissident groups that flourished in the troubled years after the war. For 6 years the committee delayed execution of the sentence by successive motions for new trials, and created a worldwide cause célèbre in which law professors and students, lawyers, college professors, editors, journalists, preachers, poets, playwrights, publicists, authors, labor unions, church councils, the radical press, volunteer agitators, and simple citizens, labored in the atmosphere of the hysteria provoked by the case.

Two respites were granted by Governor Fuller after the sentence of execution, pronounced on April 9, 1927, was set. On June 1 the Governor appointed his advisory committee of three to make a final review of the evidence. Lowell, Grant, and Stratton studied the amassed records and held hearings and interviews with Judge Webster Thayer, the district attorney, the defense attorneys, the jury members, police, and many of the witnesses. A recommendation for commutation of the death sentence would have relieved them from the threats of violence and the abuse they were to suffer, but in their report to the Governor on July 27 they unanimously adjudged the trial fair and upheld the jury's verdict that the defendents were guilty beyond a reasonable doubt. Sacco and Vanzetti were executed on August 23, 1927.

It was a harrowing experience. Tempers were high and threatening letters bombarded the committee. An armed guard sat in Dr. Stratton's office at the State House and in his car wherever he went. At Manchester a policeman followed his car and another patroled his house at night. When the ordeal was over Stratton sailed for Europe under secrecy imposed by the uneasy steamship company. He spent the hours before sailing in the port captain's office and boarded the ship only at the last minute. His name was omitted from the passenger list. In London the American Embassy took over, and in that city and in Paris there were demonstrations, but Stratton was not recognized and he continued his tour without event.

Stratton's trips to Europe by then had become frequent, and besides visiting the friends he had everywhere, he spent much time in antique shops, collecting old silver in shops in Glasgow and at Mallets in Bath, rare china in Kings Street, London, old furniture in Rubgy, tapestries wherever they were to be found in France, and new pieces of china from the Sèvres factory outside Paris and in the Rive Gauche. No new or idle pastime, this connoisseurship was quite in keeping with his long years of interest in ceramics, in textiles, and metalworking.

His love of fine instruments and working with tools never diminished. As he had furnished a workshop next to his office at the Bureau, so one of the first things he set up in Cambridge was a nearly perfect shop, with great stores of material and extra tools, in the basement below his office at the Institute. Only slightly less complete was another shop downstairs in the president's house. His zeal for acquisition of "stock," as he called it, extended to his food supplies and linens for the house, to clothing and everything else that could be bought ahead.

He was as lavish, within his means, toward others as toward himself, and never made a visit without a shower of presents for his hosts and their children. After visiting the American consul and his wife in Dresden one summer he mailed them great hampers of food unobtainable in postwar Germany. To friends he visited on Norway's North Cape he sent two barrels of fruit. Besides his good company, he was always a welcome and useful guest, for he willingly mended toys and broken household machines brought to his attention.

A poor sleeper and avid reader from youth onward, Stratton carried books with him when he visited and collected them abroad. At home he kept his bedroom shelves filled with current scientific periodicals and books and often read from midnight to 3 or 4 in the morning.

In his 8 years at MIT he introduced at that institution many of the innovations he had set going at the Bureau, extending its research in engineering and industrial processes, in pure science, and expanding the Institute's work into new fields of applied science. Under him new laboratories and dormitories rose, lecturers were brought from the universities of Europe to make available the best research and teaching in science and technology abroad, and advisory committees of men eminent in professional or business life were appointed to counsel the departments of the Institute.

As at the Bureau, Stratton was everywhere overseeing, counseling, and directing the affairs of the Institute and the student body, and as his 70th birthday approached the effort became overtaxing. Acting on his suggestion, the corporation of MIT divided the heavy administrative responsibility in 1930, making Dr. Stratton chairman of the corporation. Dr. Karl T. Compton, who had been head of the physics department at Princeton, came to assume the presidency of the Institute.

Stratton's birthday on July 18, 1931, was celebrated by an avalanche of letters, almost 200 of them later mounted in a great gleaming leather birthday book. Beginning with a warm letter from Herbert and Lou Hoover, the book remains a remarkable index to the world circle of Stratton's friends and acquaintances.

Four months before his birthday, Stratton, still hale, in excellent health, and full of memories of his years at the Bureau, came as guest of honor to a party held in East building to celebrate the 30th anniversary of its founding. On the evening of October 18, 3 months after his birthday and a week after returning from England where he had attended the international Faraday celebration, he died suddenly of a coronary occlusion at his home in Beacon Street. He was dictating a tribute to Thomas Edison, whose death had occurred that same morning, when his own came.

Dr. Stratton's greatest achievement was in founding and establishing the National Bureau of Standards and gaining for it international respect and fame. It was a superlative feat and called for a high and specialized talent. Dr. Compton of the Institute spoke for all in paying tribute to those distinguishing traits of Dr. Stratton's that had served the Bureau and the Institute and marked the man: his fundamental kindness of character, his wholehearted absorption in his work, and the consistency of his life and thought in pursuit of his ideals and objectives. Unsympathetic perhaps and certainly impatient with people or things that ran contrary to his ideal, he gave the full measure of his support and force to that which advanced his ideal, first of the Bureau and later of the Institute. Few men's lives have been so consistent, straightforward, and unswerving in their devotion to public service as Stratton's, and with so complete an absence of self-interest.

The intense admiration that Dr. Stratton inspired in his friends led two of them to attempt his biography. Shortly after his death, Morris A. Parris, his personal secretary, and Prof. Samuel C, Prescott, his closest friend at the Institute, chairman of the Department of Biology and Public Health, and soon to become Dean of Science, began collecting records, reminiscences, and memoranda for the biography. The materials gathered over the next 3 years were to form the shelf of Stratton papers located in the Archives Library at MIT.

Several outlines of the proposed work and preliminary drafts of three chapters, through Stratton's early teaching career at Urbana, were completed when certain difficulties arose. Sufficient details and documents of Stratton's forebears could not be found and the early pages were thin. The complete absence of self-interest, and hence self-revelation, in Stratton's life and career gradually became evident. Then Parris left the Institute and Prescott assumed the additional duties of Dean of Science. But almost certainly the crowning difficulty, stifling further work on the biography, was the prospect of attempting to record the history of Stratton's directorship of the Bureau.[9]

Professor Prescott undoubtedly relinquished his project under the pressure of his administrative and teaching duties, but it is more than likely that he also came to realize that the heart of any possible biography of Dr. Stratton could not be a record of his life so much as a history, the history of his greatest single accomplishment, the National Bureau of Standards.

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[9] The final correspondence in Prescott's search for biographical materials is that with Dr. Briggs of the Bureau in December 1934, which resulted in Prescott receiving nine items. These included copies of extracts from the report of the Electrical Conference of 1884, a chart of the funds and staff of the Bureau since its founding, the Bureau's brief biographical sketch of Dr. Stratton, and the program of the Bureau's farewell reception for him.

APPENDIX N

BOOKS by Staff Members of the National Bureau of Standards

1912–1960*

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Cleaves, Harold E., and J. G. Thompson, The metal-iron. New York & London: Published for the Engineering Foundation by McGraw-Hill, 1935, 574 p.

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*Only books that had their inception or were largely or entirely written or revised while the author was a member of the staff, or were written in retirement, appear in this compilation. Books edited by Bureau members or to which Bureau members contributed, unless theirs was the major contribution, have been omitted.

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Hamer, Walter Jay, The structure of electrolytic solutions. New York: Wiley, 1959, 441 p.

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Harris, Forest K., Electrical measurements. New York: Wiley, 1952, 784 p.

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APPENDIX O

BUILDINGS AND STRUCTURES of the National Bureau of Standards [1]

Washington, D.C.

Bldg. No.	Name	Year Built	Construction Cost	Estimated Replacement Cost—1947	Estimated Replacement Cost—1960
1	South	1905	$400,000 (1 and 3 together)	$864,000	$1,620,000
3	North	1905–32 [2]		323,000	1,430,000
2	East	1914	430,000	767,000	1,906,000
4	West	1910	350,000	665,000	1,538,000
5	Chemistry	1918	386,000	750,000	1,932,000
6	Power Plant	1930	200,000	330,000	845,000
7	Northwest	1919	285,750	540,000	1,656,000
8	Dynamometer	1919–33	96,480	197,400	828,000
9	Hydraulic Lab.	1932	350,000	705,000	2,200,000
10	Radio (later Computer Lab.)	1919–42	200,000	300,000	825,000
11	Industrial	1920	1,090,000	1,600,000	5,636,000
12	High Voltage	1939	400,000	550,000	1,282,000
13	Materials Testing	1942	540,000	900,000	2,168,000
14	Kiln House (later Mineral Products)	1920	116,500	171,000	1,461,000
15	Glass Plant	1941	100,000	145,000	650,000
16	Service (later Electronics)	1942–45	70,000	100,000	855,900
17	The Manse	[3]	[3]	40,000	150,000
18	Low Temperature	1906	23,375	71,000	261,000
19	South Wind Tunnel	1918	16,440	31,500	60,000
20	Far West	1915–42	96,300	374,000	480,000
21	Utility (later Stucco)	1918–47	105,000	94,000	300,000
22	Sound	1921–44	[4]	63,000	120,000
23	Reverberation	1929	4,000	5,600	35,000
24	Meter Rating	1914	16,240	53,700	75,000
25	Lamp Test	1941–49	10,000	10,000	30,000
26	Telephone	1914–23–41	[4]	30,870	40,000
27	Chemistry Annex	1924–45–48	[4]	21,900	75,000
28	Scale House	1939	6,000	9,300	50,000
29	Utility (later Boiler Test)	1943	[4]	7,500	20,000
30	Sterrett House	[3]	[3]	7,500	35,000
31	Test Bungalow (later Plasma Res.)	1941	[4]	52,000	80,000
32	Fuel Synthesis #1 (later Surface Chem.)	1945	15,336	20,000	28,000

Footnotes at end of table.

Bldg. No.	Name	Year Built	Construction Cost	Estimated Replacement Cost—1947	Estimated Replacement Cost—1960
33	Fuel Synthesis #2	1943	(4)	4, 500	12, 000
34	Oil Storage	1925	(4)	11, 000	12, 800
35	Refrig. Plant	1925–45	(4)	14, 000	60, 000
36	Dynamometer Annex	1925–47	(4)	11, 500	65, 000
[5] 37	West Guard Office	1950	....	2, 000	10, 000
38	Plant Div. Storage (later Central Guard Office)	1929–52	4, 460	7, 100	10, 000
39	Plant Div. Storage	1933	(4)	....	....
40	Greenhouse	1946	1, 513	2, 200	10, 000
41	Radio Annex (later Microwave Spectroscopy)	1943	(4)	2, 200	9, 800
42	Utility Quonset	1943	4, 300	7, 500	75, 000
43	Utility Quonset	1943	4, 300	6, 250	75, 000
44	Central Guard Off.	1927	1, 500	1, 500	4, 000
45	Volatile Liquid Vault #1	1943	6, 520	8, 200	12, 500
46	Northwest Annex	1945	....	1, 260	....
47	East Guard Office	1942	....	(6)	....
48	Combustion Res.	....	(4)	(7)	....
49	Storage Battery	1943–44	(4)	27, 500	60, 000
50	Storage (later Corrosion Lab. Annex)	....	(4)	1, 000	3, 500
[8] 51	Construction Off.	1941	....	(7)	....
[8] 52	Supply Warehouse	1944	25, 219	34, 000	200, 000
[8] 53	Std. Sample Storage	1943	....	3, 750	25, 000
[8] 54	Shipping Warehouse	1943	....	3, 750	24, 000
[8] 55	Storage Warehouse #1	1942	....	18, 000	....
56	North Guard Off.	1942	....	(7)	....
57	Chemistry Storage	1944	(4)	(7)	....
58	Quartz Storage Ann.	1944	24, 974	(7)	....
59	Utility (later Ultra Centrifuge Lab.)	....	(4)	3, 900	6, 800
60	Volatile Liquid Vault #2	1944	....	7, 000	5, 000
61	Utility (later Mineral Products Shop)	1926	8, 000	13, 100	20, 000
62	Utility (later Heat Transfer Lab.)	1925	8, 000	10, 000	24, 000
63	Warehouse (later Plant Div. Shops)	1945	17, 000	17, 000	125, 000
64	Fire Resistance Lab #1	1929	111, 000	177, 000	97, 000
65	Fire Resistance Lab #2	1924–27–58	(4)	30, 500	80, 000
66	Paint Storage	....	(4)	1, 500	5, 000
67	Fire Resist. Lab #3	1943	(4)	12, 500	45, 000
68	Fire Resist. Lab #4	1930	(4)	20, 000	77, 000
69	Fire Resistance	1925–30	3, 800	(7)	....
70	Storage	....	1, 500	(7)	....
71	Storage	....	600	(7)	....

Footnotes at end of table.

Bldg. No.	Name	Year Built	Construction Cost	Estimated Replacement Cost—1947	Estimated Replacement Cost—1960
72	High Voltage Annex	1939	100, 000	155, 500	130, 000
73	North Wind Tunnel	1944	110, 000	142, 000	215, 000
74	Open Wind Tunnel	1923	20, 000	(7)	....
75	Storage (Bomb Shelter)	1942	1, 500	(7)	....
76	Hangar (later Supersonic Wind Tunnel)	1930	15, 000	24, 700	81, 000
77	Barracks	....	....	(7)	....
78	Canteen	....	....	2, 000	19, 000
79	Volatile Liquid Vault #3	1944	7, 000	9, 000	10, 000
80	Electronics Lab. Annex	1930–44	9, 500	22, 500	25, 000
81	Test Shed	....	....	(7)	....
82	Explosives Vault	....	....	600	800
[5] 83	Electronics Lab. (later Ordnance Hqs.)	1944–52	40, 141	52, 000	....
[5] 84	Electronic Tube Lab.	1944	20, 812	27, 000	....
[5] 85	Optical Test Lab.	....	(4)	21, 000	....
[5] 86	Test Shed	....	....	(7)	....
[5] 87	Alumina Res. Bldg.	(3)	(3)	15, 000	....
[5] 88	Explosive Components	1944–58	5, 195	6, 400	....
89	Grounds Maintenance	....	....	200	22, 650
90	Fire Prevention	....	....	400	3, 500
91	Utility Quonset #3	1944	....	15, 000	115, 000
[5] 92	Ordnance Laboratory	1939–43	513, 000	795, 000	....
93	Fire Resist. Lab. #5	1939	(4)	3, 000	15, 000
94	Hydrogenation Vault	1947	3, 300	4, 500	10, 000
95	Vibration Test	1946	2, 935	3, 700	75, 000
.....	Pipe Tunnels	....	....	194, 000	....
96	Combustion Research	1947	15, 722	17, 500	86, 000
97	Fire Resistance	1947	1, 000	(7)	....
98	Storage shed	....	400	(7)	....
99	Ordnance Refrigeration	....	....	....	....
100	Storage Warehouse #2	1948	19, 664	....	67, 000
101	Storage Warehouse #3	1948	19, 708	....	67, 000
102	Carpenter shop	1948	32, 798	....	85, 000
[5] 103	Ordnance Annex #1	1948	20, 000	....	....
104	Betatron	1949	282, 000	....	375, 000
[5] 105	Ordnance Annex #2	1949	6, 500	....	....
106	Battery Shelter	1949	2, 557	....	800
107	Labor Office	1949	7, 184	....	10, 000
108	Radio Systems Lab.	1949	20, 000	....	80, 000
111	Aggregate Storage	1951	5, 000	....	15, 000
[5] 112	Air Gun Bldg.	1951–58	32, 000	....	....
[5] 113	Refrigeration	1951	6, 800	....	....
114	Ordnance Rd. Guard Office	1950	2, 000	....	4, 000
115	Acoustics Lab.	1950	19, 300	....	35, 000

Footnotes at end of table.

Bldg. No.	Name	Year Built	Construction Cost	Estimated Replacement Cost—1947	Estimated Replacement Cost—1960
[5] 116	Ordnance Plating Shop	1950	5,000	....	....
118	Timber Storage	1951	5,000	....	45,000
119	Sand Bins	1950	2,000	....	9,500
120	Tire Test	1952	20,000	....	175,000
121	Polymer Lab.	1952	22,000	....	95,000
122	Gamma Ray Lab.	1953	55,000	....	85,000
[5] 123	DOFL Storage	1956–58	....	....	....
124	High Pressure Test	1956	13,485	....	20,000
[5] 126	Fuze Laboratory	1957	....	....	....
127	Pneumatics Annex	1958	1,500	....	6,000
129	Tempo A	1957	8,000	....	14,000
130	Tempo B	....	200	....	1,000
[5] 132	New Guard Hq.	1957	24,761	....	....
[5] 133	Regional Training Center	1959	50,209	....	....
[5] 134	Industrial Engineering Laboratory	1959	40,800	....	....
[5] 135	Radioactive Material Storage	1959	16,990	....	....
136	Plasma Power Supply	1961	10,495	....	....
137	Gas Viscosity Lab.	1955	14,156	....	18,000
138	Gas Cylinder Storage	1961	5,529	....	....

[1] Based on Public Buildings Administration (FWA) appraisal dated July 11, 1947, correlated with Public Buildings Administration survey data of Oct. 1, 1948; NBS Plant Division inventory of 1960; and addenda supplied by Plant Division, January 1963 (NBS Historical File). Note.—Original construction costs in the chart are in some instances higher than those reported in the history since they include special facilities, equipment, structural changes, and other costs above the original appropriation.

[2] Second date indicates major modification or addition to the structure. The additional story on North Building, for example, cost $138,687.

[3] Acquired with land.

[4] Experimental structure, erected with research project funds.

[5] Occupied by Diamond Ordnance Fuze Laboratories (DOFL), 1953.

[6] Razed 1948.

[7] Razed.

[8] Erected by Reconstruction Finance Corporation and transferred to NBS.

BIBLIOGRAPHIC NOTE

Predecessors of this history have been the formal study of the administration of the Bureau by Gustavus A. Weber, *The Bureau of Standards: Its History, Activities and Organization* (1925), a sound reference book about the Bureau during its first quarter century, and the highly readable popularization by John Perry, in *The Story of Standards* (1955). The more complex plan of the present history and the range of its sources require some description of its documentation.

Following the bibliographical information given here for each work is the page reference to its first citation in the text. The latter I have given not only as a convenience to the interested reader seeking to track the abbreviated form of subsequent citations to their source, but in some instances to direct the bibliographic-minded to such additional information about the work as its location or library catalog number.

PUBLISHED SOURCES

NBS PUBLICATIONS

The range of Bureau publications and a brief account of their history of publication appear in the notes to appendix I. Detailed information on the publications from 1901 to 1947 is given in NBS Circular 460, from 1947 to 1957 in the Supplement to C460, and from 1957 to 1960 in NBS M240.

The Annual Reports of the Bureau (since 1958 entitled Research Highlights of the National Bureau of Standards) provide an indispensable guide to the framework of the history. I have however kept in mind the natural inclination to prepossession and party spirit inherent in any such publication, wherever issued. The Annual Reports of the Bureau are complete except for the years 1943–45, when manuscript copies only, noted on p. 369n, were prepared.

A number of useful summary histories of the work of the Bureau, of weights and measures, laws relating to weights and measures, and the development of standards and standardization in industry, appear in NBS Miscellaneous Publications. Included in this series is the excellent survey of Bureau research during World War I (M46, 1921), but not Dr. Briggs's 188-page report on World War II research, which is available only in multilith form (copy in NBS Historical File).

A complete set of NBS publications is maintained in the NBS Library, as are the files of mimeographed Bureau Orders, Director's Memoranda to Division and Section Chiefs, Administrative Bulletins, and Administrative Memoranda. An exception are the NBS Letter Circulars, presently located in the Office of Technical Information and Publications (see p. 251n, above).

OTHER GOVERNMENT DOCUMENTS

No series of Government documents has been more important to the animation of the history than the annual hearings before the Subcommittee of the House Committee on Appropriations (first cited on p. 46n), on which occasions the Director of the Bureau seeks to justify his requests for funds and support for his research programs, new construction, additional staffing, and the housekeeping operations of the Bureau. The give and take of the sessions provides valuable insights into the personalities of the participants and a wealth of informal information on Bureau affairs nowhere else to be found. Except for those preceded by the word "Senate" in brackets (p. 130n), all hearings cited are those of the House.

Extensive use has also been made of a half-century of House and Senate reports and of their miscellaneous and executive documents, of hearings before special committees of both the House and Senate, and of the Congressional Record. They have provided much primary source material, particularly concerning the progress of science in the Federal Government.

Consulted for material pertinent or peripheral to the operations of NBS have been the annual reports and other publications of the Department of Commerce, its Coast and Geodetic Survey, Census Bureau, and its Office of Publications Management (formerly Bureau of Publications); also of the Treasury Department, Department of the Interior, Department of Labor, the Interstate Commerce Commission, the National Aeronautics and Space Administration (formerly National Advisory Committee for Aeronautics), and the Council of National Defense, 1917–19.

Two other series of annual reports may be mentioned here, those of the Smithsonian Institution, and the reports from the Bureau's counterpart in Great Britain, the National Physical Laboratory. Both series have furnished important and useful information.

BACKGROUND SOURCES

Histories: The history of the Bureau could not be written without tracing the progress of science and of American business and industry in the 20th century, and relating it to the social and political climate of the nation. Set pieces, evoking the local and national scene, have been resorted to, often illuminated by recollections of Bureau staff members, as background for the changing activities of the Bureau. For these pieces, as well as for direct and indirect information on Bureau operations and research, my indebtedness to histories of science, industry, and the social scene is extensive. The histories that I have quoted or paraphrased, with the page reference to their first appearance in the text, include:

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Besides the manuscript memoirs of Bureau staff members noted below in Unpublished Sources, two splendidly frank autobiographies are available in print, those of William W. Coblentz and Harvey L. Curtis. Although his recollections of the Bureau are brief, another former staff member, George C. Southworth, offers good background material in his published memoirs. Five Secretaries of Commerce have left memoirs with commentaries on their terms of office: William C. Redfield, Herbert C. Hoover, Daniel C. Roper, Jesse H. Jones, and Lewis L. Strauss. These and other biographical and autobiographical works providing primary sources for the history of the Bureau, with the page reference to their first citation in the text, are as follows:

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Periodicals and Newspapers: The periodical literature of science, social and political affairs, philosophy, and current events that has been consulted is so extensive that reference can only be made to its direct citation in the history. Singled out, however, must be the magazine *Science*, scarcely a single issue of which since its founding in 1883 has not had a reference to weights, measures, or standards, and which since 1900 has reported every event of note relating to individual members of the Bureau staff and to the affairs of the Bureau itself.

The New York *Times* and the Washington, D.C., newspapers have since the turn of the century, provided useful background details of NBS and Department of Commerce concerns, and with other newspaper accounts of Bureau events (many of them preserved in the NBS correspondence files in the National Archives) give useful sidelights on the scientific and social milieu of the Bureau.

UNPUBLISHED SOURCES

ARCHIVAL COLLECTIONS

The National Archives is the repository for the main body of NBS correspondence since the founding of the Bureau. Located in National Archives Record Group (NARG) 167, the correspondence for the years 1901–45 fills 512 consecutively numbered boxes, each box containing approximately a thousand document sheets, or more than half a million pages of document history. The first citation to these boxes appears on p. 5 of the history.

NARG 167 also includes the Blue Folder collection of Bureau correspondence (first cited on p. 40), comprising 87 boxes, for the years 1902–52. Containing correspondence about significant transactions of recurring interest and identified, for ready reference, by blue folders, these files have been kept until recently at the Bureau.

In contrast to the amount of material in these two correspondence files, of which full use was made, little that was pertinent to the history of the Bureau was found in the special collection in NARG 167 of 57 volumes of the correspondence of the Office of Standard Weights and Measures for the years 1830–1900. With a few exceptions (i.e., p. 30), other sources adequately covered this background material.

Seventeen other collections of NBS records in NARG 167, comprising a total of 1,703 boxes, volumes, and trays, and containing miscellaneous papers relating to weights and measures, manuscripts of research papers, computations, laboratory notebooks, and test records were surveyed for possible papers or marginalia of historical interest. The sampling indicated that the amount to be found would not justify the time required for a full search.

Much useful information was found in the General Records of the Department of Commerce, located in NARG 40, particularly the correspondence of the Office of the Secretary of Commerce (first cited on p. 135), that of the Secretary's Visiting Committee to the Bureau (p. 311), and in the general records of the Department of Commerce (p. 314).

Correspondence of the Secretary of the Treasury relating to the early history of the Bureau appears in NARG 56 (p. 61), of the Secretary of Agriculture in NARG 16 (p. 152), that of the Bureau of the Budget in NARG 51 (p. 307), and of the Office of Scientific Research and Development (OSRD) in NARG 227 (p. 369).

Employment records of former Bureau staff members were made available by official transcript from the Federal Records Center in St. Louis, Mo. Biographical files on former members, which also contain news releases on their careers, records of achievement, copies of their publications, and other memorabilia, were forwarded on loan from the Federal Records Center at Alexandria, Va.

One other archival collection, the Stratton Papers (p. 49), comprising more than 25 boxes of materials, is located in the Archives Library at the Massachusetts Institute of Technology. The preservation and availability of these Papers made possible the biographical sketch of Dr. Stratton in the appendix of the history.

DIRECTOR'S FILES

A recent assembly of correspondence and other materials, long maintained in the Office of the Director, is that temporarily designated "General Correspondence Files of the Director, 1945–55" (first cited on p. 62). The dates are misleading, since the material includes correspondence of as long ago as 1902 and as recently as 1960.

Much of this material comprises NBS policy memoranda, correspondence of recurring interest and importance, and papers of historical concern. The equivalent of almost 30 National Archives boxes, it is presently being organized in the NBS Office of Records Management for transfer to the National Archives.

Other Bureau correspondence to which I have had access, and similar in nature to the "General Corespondence," is that currently maintained in the Office of the Director and so designated where cited in the history.

NBS HISTORICAL FILE

The assemblage of historical documents and other materials by members of the Bureau staff beginning in 1956 and extended by the author and his assistants during the course of research for the history forms the basis for the NBS Historical File. It will be maintained provisionally in the NBS Library at Gaithersburg.

Of special interest in the File are the brief manuscript memoirs by N. Ernest Dorsey (p. 65) and Hobart C. Dickinson (p. 240), and the manuscript memoir-histories of Elmer R. Weaver (p. 114), Raleigh Gilchrist (p. 175), J. Howard Dellinger (p. 292), William W. Coblentz (p. 338), and Galen B. Schubauer (p. 376).

Besides two extended historical accounts of Bureau administration and operations prepared by the individual section and division chiefs in 1949 and again in 1961, the NBS Historical File also contains the records of more than fifty personal interviews or conversations which I held with former and present members of the staff. My correspondence with other than Bureau members that is cited in the history will also be found in this File.

Letters and documents reproduced from the Stratton Papers at MIT, with other Stratton materials collected at the Bureau, have been designated in the NBS Historical File as the NBS Stratton Papers. Similar collections of materials not available in archival records have been tentatively set up and designated by reason of their principal source as the Briggs Papers, Condon Papers, Gilchrist Papers, Crittenden Papers (scarce publications and personal correspondence he preserved), Lowell Papers (relating to NBS patent history), and Silsbee Papers (largely concerning electrical matters).