MEASURES FOR PROGRESS

A HISTORY OF THE NATIONAL BUREAU OF STANDARDS

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First printing: 1966
Second printing: 1974

NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
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fere with business or to aid it, and its concept of the public welfare remained nebulous to the end of the century.

The golden years of unregulated private enterprise were abruptly interrupted almost singlehandedly by Teddy Roosevelt, who became President following the assassination of McKinley at the Pan-American Exposition on September 6, 1901. After a century of unfettered enterprise, a quarter century of trusts and monopolies, Roosevelt's mediation in the anthracite coal strike of 1902, the indictment of the meat-packing trust in 1905, the passage of the Pure Food and Drug Act in 1906, and his victory over Morgan's steel trust in 1907 came as unprecedented and incredible intrusions by the Government.

The fight against monopoly in business and industry, buttressed as they were by their special franchises, tax privileges, tariffs, and patents, would continue in the new century. But while the maverick President established the Government's right to regulate, and to mediate between big business and the public, he did not deny the very real benefits of the corporations in the industrialization of the Nation. With curbs, they were destined to be tolerated and even aided by the Government that had subdued them.

LOOKING BACK

Except for the recognition by the committee of the National Academy of Sciences that areas of investigation existed in the realm of "exact science" that were Federal responsibilities, little in the Office of Weights and Measures in the year 1884 recommended it as the nucleus of a physical laboratory in the proposed Department of Science.

In charge of weights and measures and of gravimetric studies in the Coast Survey at that time was Charles S. Peirce (1839–1914), a brilliant scientist, philosopher, and logician, lecturer at Harvard, and a member of the National Academy of Sciences, who spent 20 years of his life with the Coast Survey. Long before the necessary precision instruments were available he made the first attempt to use the wavelength of a light ray as a standard unit of measure. He is deservedly the subject of one of the longest and most interesting memoirs in the Dictionary of American Biography.[23]

Testifying before the Allison Commission—the question of a department of science had already been disposed of—Peirce was asked about the work of his office. "The office of weights and measures at present is a very slight affair, I am sorry to say," he had to admit, "* * * a nonentity, having hardly any legal existence." It consisted of himself and two assistants, and

[23] See also Victor F. Lenzen, "The contributions of Charles S. Peirce to metrology," Proc. Am. Phil. Soc. 109, 29 (1965).

was maintained only "to keep up the supply of standards and balances" to the States, territories, and the country's agricultural schools, as required by law, and to "take occasion to verify any standard that is referred to us." The latter service was of questionable value since in most instances "we want the means of executing the verifications asked of us." [24]

The full title of Peirce's agency in appropriation acts at that time was the Office of Construction of Standard Weights and Measures, indicating its limited scope in the eyes of Congress.[25] Its history reflects the century-long hestitation of the Federal Government to exercise even that most elementary degree of control in the affairs of the individual citizen—the imposition of a discipline of weights and measures—and the failure of the States to exercise it in the absence of Federal regulation.

The provision in article 9 of the Articles of Confederation (1777–78) granting Congress "the sole and exclusive right and power of * * * fixing the standard of weights and measures throughout the United States" was repeated in article I, section 8, clause 5 of the Constitution (1789), its principal purpose to make "all Duties, Imposts and Excises * * * uniform" throughout the colonies. Without direct taxation, funds to maintain the Government depended largely on these imposts. Yet excises on flour, sugar, and other imported commodities, as well as the tonnage tax on vessels, the Government's other principal source of income, depended upon guesswork of a low order so long as barrel sizes and their contents and the weight of a ton met no uniform definition or standard. For over a hundred years it was to prove as difficult to legislate standards as it was to determine them.

President Washington in his annual messages in 1790 and 1791, Secretary of State Thomas Jefferson in an elaborate report to Congress in 1790, President James Madison in his eighth annual message in 1816, and Secretary of State John Quincy Adams in a report in 1821 that has been called "a classic in weights and measures literature," all urged the establishment by law of uniform and reliable standards in weights and measures.[26] To allay public fears and lessen the inconveniences attending the introduction of uniform standards, when determined, Jefferson recommended that they be introduced first in the customhouses, to familiarize merchants with them, then among merchants and traders in foreign commodities, and finally offered to the

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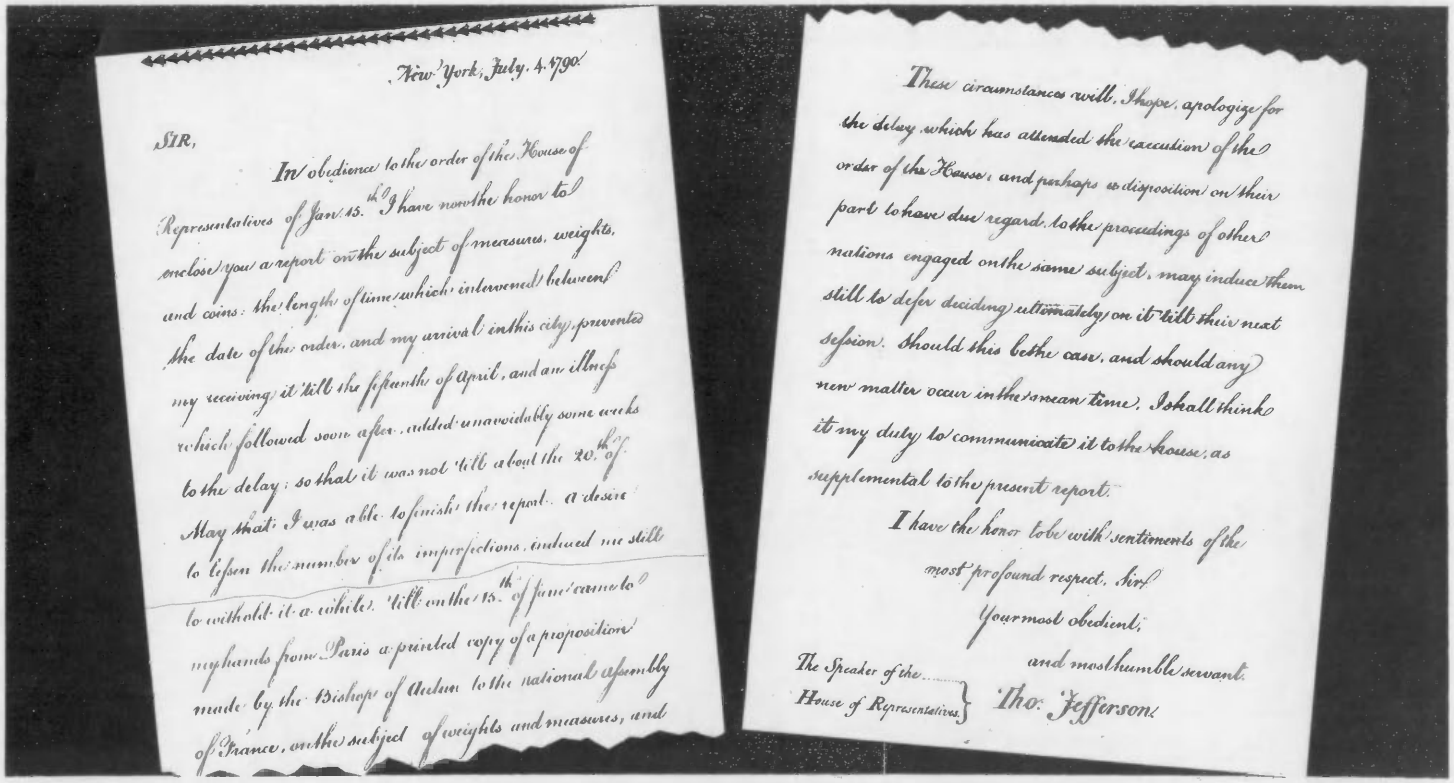
[24] Allison Commission, Testimony, p. 370.

[25] The Appropriation Act of Aug. 5, 1882 (22 Stat. 230) first designated the agency as the Office of Construction of Standard Weights and Measures. The name continued in appropriation acts until 1901, although after 1891 the agency was otherwise officially designated the Office of Standard Weights and Measures.

[26] Source references for these documents appear in Ralph W. Smith's "The Federal basis for weights and measures," NBS C593 (1958). For a recent study of Jefferson's report see The Papers of Thomas Jefferson, ed. Julian P. Boyd (Princeton University Press, 1961), XVI, 602–675.



New York, July. 4. 1790.

SIR,

In obedience to the order of the House of Representatives of Jan. 15.th I have now the honor to enclose you a report on the subject of measures, weights, and coins: the length of time which intervened between the date of the order, and my arrival in this city, prevented my receiving it till the fifteenth of April, and an illness which followed soon after, added unavoidably some weeks to the delay; so that it was not till about the 20.th of May that I was able to finish the report. A desire to lessen the number of its imperfections, induced me still to withold it a while. till on the 15.th of June came to my hands from Paris a printed copy of a proposition made by the Bishop of Autun to the national assembly of France, on the subject of weights and measures, and

These circumstances will, I hope, apologize for the delay which has attended the execution of the order of the House, and perhaps no disposition on their part to have due regard to the proceedings of other nations engaged on the same subject, may induce them still to defer deciding ultimately on it till their next session. Should this be the case, and should any new matter occur in the mean time, I shall think it my duty to communicate it to the house, as supplemental to the present report.

I have the honor to be with sentiments of the most profound respect, Sir,

Your most obedient,

and most humble servant.

The Speaker of the House of Representatives } Tho: Jefferson.

A fragment of Jefferson's letter of transmittal accompanying his report to Congress on measures, weights, and coins in 1790, shortly before he became Secretary of State. The original of the copperplate transcription of Jefferson's message is in the National Archives, Record Group 59.

general public. Adams suggested that public officials such as custom officers, public land surveyors, and postmasters be the first required to adopt the new standards, when devised, with general enforcement of them left to the individual States.[27]

Scientists, statesmen, and business men throughout the first quarter century of the Republic repeatedly called for such legislation, and House and Senate committees were appointed in 1791, 1795, 1798, 1804, 1808, 1816, 1819, 1821, and 1826 to fix on a uniform plan of standards for adoption by Congress. None denied their necessity, but a majority invariably bridled at the thought of general enforcement. A standard of coinage was another matter, and on April 2, 1792, Congress established without a demur the decimal system for the money of the United States. Weights of coins, on the other hand, fared little better than commodity weights until in 1828 Congress adopted the British troy pound of 1758 as the standard for American coinage.

Troy weight had been more or less "standard" since colonial days, and continued to be even after Great Britain reformed her system of weights and measures in 1824, at which time she adopted new imperial standards, including a new avoirdupois pound. Nevertheless, in 1827 Albert Gallatin, Secretary of the Treasury from 1801 to 1814 and at that time American Minister to Great Britain, secured a brass copy of the old troy pound. It was deposited with the Director of the Mint at Philadelphia and the next year additional copies were made and supplied to all U.S. mints as the basis for the weight of a pound of gold.

But as Charles Peirce pointed out to the Allison Commission more than 50 years later, the troy pound at the mint was not suitable for precision weights of any kind. For one thing, it had never been weighed in a vacuum to determine its true weight, and in point of fact, the Government had no balance that could do that. Moreover, since the destruction of its prototype when the Houses of Parliament burned in 1834, there was no way of telling how much that brass pound at Philadelphia really weighed, except in terms of the British avoirdupois pound. In other words, said Peirce, the weight of the American pound "is not known." [28] Nevertheless, this pound remained the standard for coinage until 1911 when it was replaced by weights certified by the National Bureau of Standards in terms of the platinum-iridium kilogram.[29]

But coinage was not alone in dealing with unknown quantities. The history of weights and measures in this country had more than its share.

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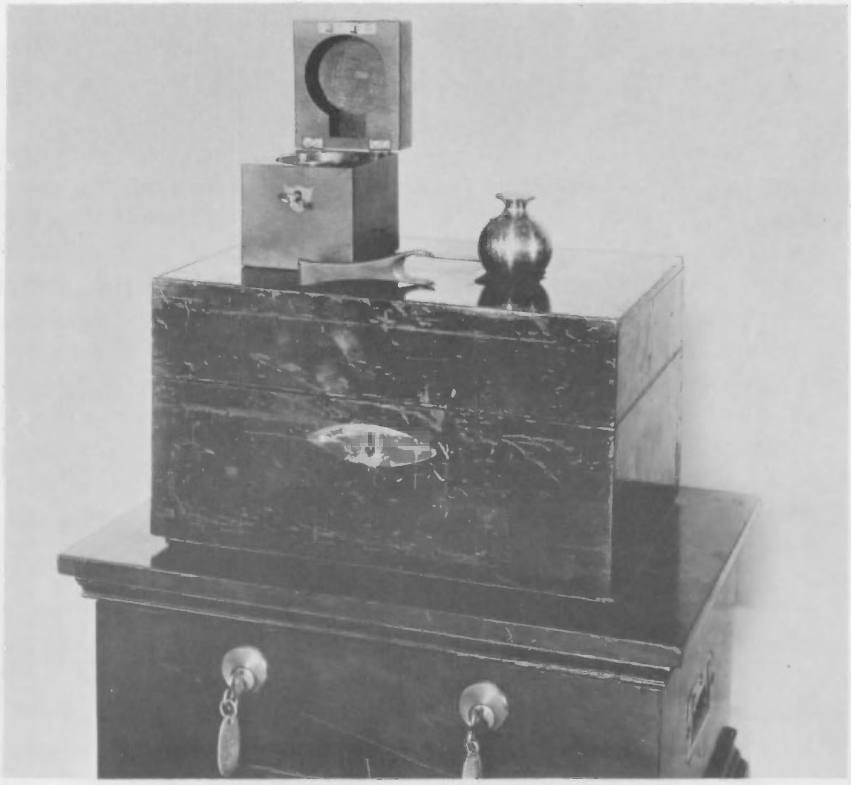
[27] Gustavus A. Weber, The Bureau of Standards: Its History, Activities, and Organization (Institute for Government Research, Service Monograph No. 35, Baltimore: The Johns Hopkins Press, 1925), pp. 2, 3, 9.

[28] Allison Commission, Testimony, pp. 372–374.

[29] NBS Annual Report 1910, p. 7; Annual Report 1911, p. 11.



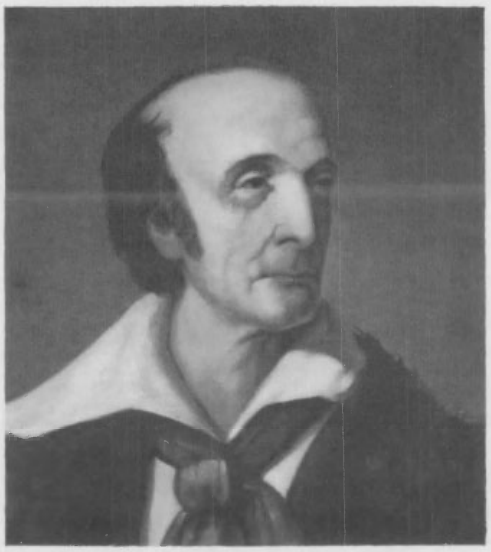
The troy pound of the U.S. Mint at Philadelphia, with the nested packing cases in which it was shipped to the United States in 1827. An exact copy of the imperial troy pound, this standard for coinage virtually became the fundamental standard of the United States, from which the avoirdupois pound in common use was derived.

The first real effort to provide accurate, if nonlegal, standards of weights and measures was made by Ferdinand Rudolph Hassler (1770–1843), a Swiss engineer and metrologist who emigrated to this country at the age of 35. Upon the establishment of the Coast Survey in the Treasury Department, Hassler became its first superintendent, holding that office from 1807 to 1818. When in 1830, acting on complaints of unsatisfactory customs collections at the ports, a Senate resolution directed the Secretary of the Treasury to make an examination of the standards used in the customhouses, Hassler, then 60, was called back to Washington to undertake the investigation. Two years later he was reappointed superintendent of the Coast Survey.[30]

He collected the standards then in use in the various Government departments, the weights and measures used at the customhouses, and as

[30] See app. A for a biographical sketch of Hassler.

many more as he could obtain from other domestic and foreign sources, and presented his findings in two reports on January 27 and June 29, 1832. As had Secretary of State Adams in 1820, Hassler found no two customhouses in the country where the pound or bushel were the same, the great discrepancies producing "inequalities in the duties levied at the different ports." In fact, "hardly any custom houses have actual standards. All equally refer, for weights and measures of any kind, to the city sealers of the place or those



Ferdinand Rudolph Hassler, first Superintendent of Weights and Measures, from a painting made probably sometime between 1830 and 1840, by Capt. William G. Williams of the Topographical Corps, U.S. Army.

According to a long inscription pasted on the back of the canvas, the recollection of Mary Hassler Newcomb, granddaughter of Hassler and wife of Prof. Simon Newcomb, the portrait hung for many years after its completion on a bare brick wall in the Lee home in Arlington, Va. In April 1864 it came into the hands of Prof. Louis Agassiz, who gave it to the National Academy of Sciences, to keep "as a forerunner of portraits of our noted scientists."

It was hung for several years in the west end of the Smithsonian, then disappeared until 1874, when Professor Newcomb, going "to the tower of the Smithsonian to see after the working of the artificial transit of Venus," found it there covered with dust and somewhat damaged. Hassler's granddaughter claimed it and plans were made to send it to the Coast Survey. In concert with Prof. Joseph Henry, Prof. Julius E. Hilgard, and Prof. Charles S. Peirce, Mrs. Newcomb had the painting restored at Mr. Hein's studio for $20.

Either the Coast Survey refused the portrait or Mrs. Newcomb decided to keep it, for it has remained in the Hassler family since. In 1965 its present owner, Dr. Hassler Whitney of Princeton, N.J., had the painting restored once more and presented it to the Coast and Geodetic Survey, to be hung in its new quarters at Rockville, Md.

appointed by the respective States." And most customhouses, like the city sealers, used "coarse iron, or other weights * * * which * * * on account of their great mass, could not be adjusted but upon common balances." [31]

While Congress debated, the Secretary of the Treasury directed Hassler to secure apparatus and a shop and prepare copies of the standards he recommended in his reports. The Treasury Department at least, with its coinage and customhouse functions, had to adopt something like uniform standards. Thus in 1832, "with the President's approbation," Secretary Louis McLane preempted a corner in the United States Arsenal in Washington, and "with all the exactness that the present advanced state of science and the arts will afford," Hassler set to work on his standards.[32]

He adopted brass for their construction, as did most European countries, because it was "the cheapest metal, not subject to prompt very evident oxidation," and its ordinary expansion was "too minute to have any effect upon the practical application to standards within the limits of magnitude they generally have." Platinum, despite its less destructible nature, was not well enough known, he said, and might have unsuspected differences greater than brass.[33]

The units as defined by Hassler were not new but were those most widely used in the United States. By defining them, he gave them an authority they had not had previously. The standards which he constructed were the best then obtainable, and to them Hassler gave precise and reproducible values so that careful copies derived from them would at least assure uniformity in the offices of the Treasury throughout the nation.

His standard of length was an 82-inch brass bar, made for the Coast Survey in 1813 by Edward Troughton, the best of the London instrument-makers, and brought to this country by Hassler himself 2 years later. The yard measure on this bar was between the 27th and 63d inch marks and was supposed to be identical with the English standard at 62° F, although it had never been directly compared with that standard. The standard of weight remained the troy pound, that made by the English metrologist, Captain Kater, for the United States Mint in 1827, and from it Hassler derived the avoirdupois pound in common use, the ratio of the avoirdupois to the troy pound precisely defined as 7,000 grains to 5,760 grains.

The gallon, based on the English wine gallon of 1703, was a vessel with a volume of 231 cubic inches (holding 8.3389 pounds avoirdupois of distilled water, or 58,372.2 standard grains) when weighed in air at 30 inches

[31] [Hassler,] "Weights and Measures", Report from the Secretary of the Treasury, July 2, 1832 (22d Cong., 1st sess., H. Doc. 299), pp. 1, 95.

NOTE.—By common balances Hassler meant ordinary commercial scales, since precision balances were not yet made or available in this country.

[32] Ibid., pp. 1–2.

[33] Ibid., p. 16.

barometric pressure and 62° F. The bushel, based on the old English Winchester bushel, established in the reign of Henry VII, was a measure with a volume of 2,150.42 inches (holding 77.6274 pounds avoirdupois of distilled water or 543,391.89 grains), weighed at the same barometric pressure and temperature as the gallon.[34]

Two years after the Treasury's adoption of Hassler's weights and measures, the 1758 originals of the Troughton yard and Kater pound were irreparably damaged by fire. Despite the fact that their prototypes were lost, Congress recognized the merit and enormous convenience of the new standards. If it could not bring itself to legalize them, it could at least approve them, and in 1836—the generally accepted date of the establishment of an Office of Weights and Measures in the Treasury—a joint resolution of Congress directed the Secretary of the Treasury to make copies of Hassler's standards,

> 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 a uniform standard of weights and measures may be established throughout the United States.[35]

Arbitrary and without any authority but Hassler's (except that Congress had been fully informed of Hassler's choice of units), these were in most instances promptly adopted by the States as their sole legal standards, thus becoming the first nationwide standards in this country.

Two years later another congressional resolution directed that a standard balance be made "under the superintendence of Hassler" for each State. Resolutions, however, are not statutory laws, but further than that Congress would not go.

Constructing these weights and measures with all their multiples and submultiples was slow and difficult work, and not until 1838 were sets of the weights delivered to the States. The customhouses received them a year later. When Hassler died in November 1843 at the age of 73, only half the capacity measures and a third of the measures of length had been completed, and work on the balances had just begun.

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[34] [Hassler,] "Weights and Measures", p. 12; Louis A. Fischer, "History of the standard weights and measures of the United States," NBS M64 (1925), pp. 7–10. NOTE.—M64 refers to the numbered series of Miscellaneous Papers of the NBS, as C designates its series of Circulars.

The British abolished the wine gallon of 1703 and the Winchester bushel in 1824 when imperial measures were adopted. The imperial gallon was considered as 277.274 cubic inches of distilled water (10 pounds of water), the imperial bushel 2218.19 cubic inches (8 gallons of water), both at 62° F and 30 inches barometric pressure. Thus as Peirce testified in 1885, the English and American gallons and bushels differed by about 17 percent and 3 percent, respectively, as they do today. Apothecaries' weights in the two countries differ by almost 10 percent.

[35] Quoted in NBS M64, pp. 10–12.

In 1856, 13 years later, a report by Alexander D. Bache, Hassler's successor as superintendent of the Coast Survey and in charge of the Office of Weights and Measures, said that full sets of weights, measures, and balances for the States had at last been completed and nearly all delivered. Most of the hundred or more customhouses were now equipped with weights, but only 91 standard gallons, 24 sets of their subdivisions, 22 standard yards, and 11 standard bushel measures had been completed and sent to them.[36] A decade later, as the last of Hassler's measures was dispatched, the metric system arrived in America.

Established in 1791, the French metric system had been adopted during the past century by most civilized countries, with the notable exception of Great Britain and the United States.[37] Then in 1864 Great Britain, compromising with science and commerce, authorized the use of the metric system concurrently with its imperial system. Two years later, on July 28, 1866, Congress in a singular gesture legalized the use of the metric system in this country—something our common system of weights and measures has not achieved to this day. However, use of the metric system was neither then nor later made compulsory, but by legalizing the relationship between the yard and meter (construing the meter as 39.37 inches), Congress sanctioned continued use of the common system based on Hassler's adaptation of the British imperial yard and pound.

Implementing the new law, a joint resolution of Congress that same year authorized the Secretary of the Treasury to furnish each State with a set of metric weights and measures. Until replaced at the end of the century by new international metric standards, a brass meter brought by Hassler to this country in 1805 and a brass copy of a platinum kilogram obtained by Gallatin in 1821 were the basis for the sets made by the Office of Weights and Measures. By 1880 practically all the States had sets of metric standards.[38] What became of these, as well as Hassler's standards distributed earlier, was, as we shall see, disclosed during an investigation begun shortly after the founding of the present National Bureau of Standards.

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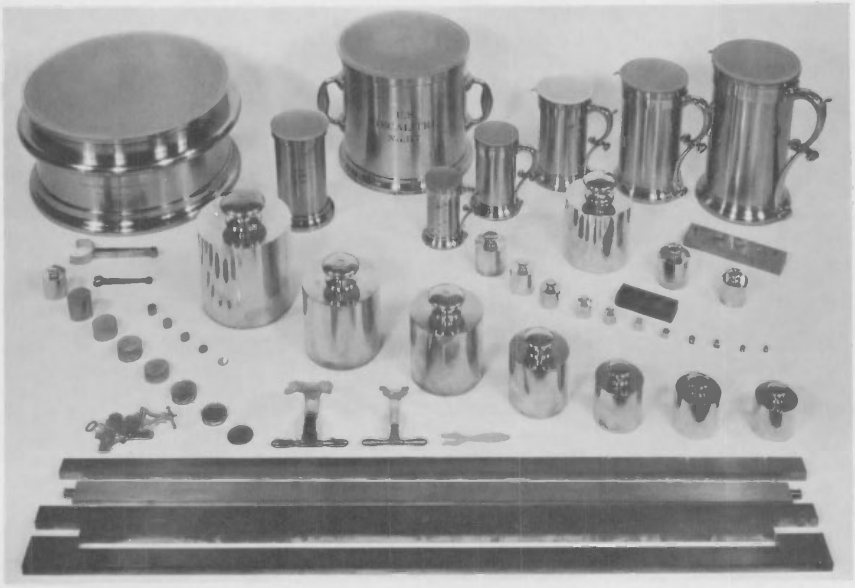
[36] [Bache,] Report of the Secretary of the Treasury on the Construction and Distribution of Weights and Measures (34th Cong., 3d sess., S. Ex. Doc. 27), Washington: A. O. P. Nicholson, 1857, pp. 2–8.

Long current has been the legend that in July 1864 when Jubal Early's army crossed at Harper's Ferry and approached Washington, the Troughton yard, Bronze yard No. 11, Troy pound of 1827, Imperial pound of 1855, Arago kilogram and other standards collected by Hassler and his successor were sent into the Vermont countryside for safekeeping (letter, F. S. Holbrook, May 23, 1936, and attached correspondence, NBS Box 400, IW).

[37] See app. B for a brief history of the metric system.

[38] NBS M64, pp. 16–19. See also metric legislation in app. C.



Prototypes of the weights and measures distributed to the States at the direction of Congress in 1836 and 1866. The newly established Office of the Construction of Weights and Measures fashioned these sets modeled after British standards (1836) and the metric measures of France (1866). From top to bottom are complete sets of standards of capacity, mass, and length, and their handling equipment. The standard of flatness, a quartz disk, did not become a standard provided to the States until many years later.

Meanwhile, the simple and logical metric system had been found wanting. In 1867 serious differences in metric measurements came to light in France while carrying out a series of geodetic surveys. The metric system was based on a natural concept which assumed the meter to be one ten-millionth part of a meridional quadrant of the earth. Investigation disclosed that realization of the concept in the adopted meter was erroneous, and further, that the original standards, kept in the Archives of France, had simply not been constructed with the degree of precision possible three-quarters of a century later.

With the United States participating, the series of international conferences that were held in 1872–73 to construct new metric standards led to the selection of a graduated line standard as a new basis for the metric system. Rejection of a natural basis for the meter made international agreement necessary in order to maintain the validity of this artificial meter. The conferees therefore agreed to the establishment of a permanent International Bureau of Weights and Measures, to be located at Sèvres, near Paris, which would not only keep custody of the new prototype meter and

kilogram when constructed, but make comparisons between them and the fundamental standards of nonmetrical weights and measures in other countries. The convention was signed on May 20, 1875, by representatives of 17 countries, including the United States, and ratified by President Rutherford B. Hayes, on the advice of the Senate, on September 27, 1878.[39]

In 1889, after more than 10 years of labor, the instrumentmakers at Sèvres completed the new metric standards. From among 30 carefully constructed meters and 40 kilograms, all of platinum-iridium, a committee selected an International Meter and International Kilogram as prototypes. The remaining standards were then distributed to the contributing countries, the United States receiving meter Nos. 21 and 27 and kilogram Nos. 4 and 20.[40] The Coast Survey's Office of Weights and Measures accepted custody of them the next year. Subsequently two other meter bars designated Nos. 4 and 12, made of an earlier platinum composition, the alloy of 1874, as it was called, were secured.

On April 5, 1893, Thomas C. Mendenhall, then superintendent of the Coast Survey and its Office of Weights and Measures, adopted with the approval of the Secretary of the Treasury the new meter and kilogram as the fundamental standards of length and mass in the United States, deriving from them the common yard as $\frac{3600}{3937}$ meter and the avoirdupois pound as 0.453 592 427 7 kilogram.[41] In doing so Mendenhall assumed, as did Hassler, considerably more authority than he had, since he changed the value slightly for the kilogram from that given in the law of 1866, on the basis of more recent comparisons made between the kilogram and the English pound.

From the beginning, use of the metric system in Government agencies as elsewhere was a matter of choice, except for laws passed in 1866 and 1872 requiring balances marked in metric grams for all post offices, and an order of 1894 enjoining use of the metric system in requisitioning medical supplies for the War Department. Though extensively used in scientific and technological research, the metric system made very meager inroads into ordinary government or commercial transactions in this country.

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[39] A contemporary account of the organization of the International Bureau appears in Statement of Professor J. E. Hilgard before the Committee on Coinage, Weights and Measures, May 8 and June 3, 1878 (45th Cong., 2d sess., H. Misc. Doc. 61). Julius E. Hilgard (1825–91), a Bavarian geodesist hired by Bache, was with the Coast Survey from 1834 to 1885, succeeding Bache as superintendent in 1881.

[40] Letter, B. A. Gould to Secretary of State James G. Blaine, Nov. 4, 1889. In Correspondence of the Office of U.S. Standard Weights and Measures, vol. V, pp. 436–449 (National Archives, Record Group 167).

[41] "Fundamental standards of length and mass," Coast and Geodetic Survey Bull. 26 (1893); NBS C593 (1958), pp. 15–16.

Without the force of law the two sets of weights and measures deposited in the National and State capitals, one based on British standards, the other on French, tended to gather dust. Special legislation or departmental orders were necessary to enforce their use in Federal agencies, and for want of direction and centralized authority Federal and State statute books became crowded with acts setting up still other standards. Many of these were freely conceived, merely expedient, and as often as not limited in application to a single agency.

Among the plethora of Federal standards alone were those enacted between 1825 and 1875 for the Treasury Department and Commissioner of Internal Revenue specifying the kinds of hydrometers to be used to determine the proof of distilled spirits, defining the term "proof gallon," the number of pounds of grain in bushel measures used in distilleries, and the number of gallons to a barrel. In 1868 a standard gage for bolts, nuts, and screw threads, adopted by the Secretary of the Navy, became mandatory in all Navy Yards but nowhere else.

Other acts between 1789 and 1880 established the measurement of vessel tonnage, prescribed rules and measures for surveying public lands, and fixed procedures for examining and testing steam engines used by the Government. Periodically, revised acts specified the number of pounds in a bushel of grain, peas, and similar commodities for estimating import duties, defined the weight and measure of a ton of coal or a cord of wood when bought for Federal agencies, and authorized Treasury standards for the quality of imported sugar. Still another act provided funds for investigating the physical properties of wool and other animal fibers, and one even imposed the use of proper weights and measures (without defining them) for determining the provisions served to American seamen.

This year to year legislation in measurement, operating nowhere below the Government level, became increasingly unsatisfactory and was of no use to science or industry. By 1884 the telephone and electric light had become commercial realities, the first commercial electric trolley car was a year away, the first commercial electric power plant 2 years away. These and other electrical developments would continue to advance by wasteful trial and error methods, for lack of definitions and measurements that neither scientific institutions nor industry were qualified to provide. That Congress recognized its responsibility seems evident from the appropriation it made underwriting the conference of electrical workers and scientists that met at the Franklin Institute in Philadelphia in the autumn of 1884.[42]

In complete agreement on the necessity for Federal intervention, the conference appointed a committee headed by Prof. Monroe B. Snyder to make a strong recommendation to Congress for "the establishment of a

[42] See above, p. 18.

Bureau of Standards * * * charged with the duty of examining and verifying instruments for electrical and other physical measurements [and] * * * to determine and reproduce all the physical standards with relation to each other." [43] That was the year the National Academy of Sciences proposed a Department of Science in the Federal Government.

By 1893 some sort of agreement on electrical measurements had become imperative, and an international electrical congress held at the Columbian Exposition in Chicago that summer adopted values for the basic units of electricity. In December, Mendenhall, in one of his last acts as superintendent of the Coast Survey, issued a bulletin announcing their formal adoption by the Office of Weights and Measures. On July 12, 1894, Congress enacted the definitions and values of these units into law. The founders of electrical science were honored by using their names for the units, and by international agreement the *ohm* was designated the unit of resistance, the *ampere* the unit of current, the *volt* the unit of electromotive force, the *coulomb* the unit of quantity, the farad or *faraday* the unit of capacity (now, capacitance), the *joule* the unit of work, the *watt* the unit of power, and the *henry* the unit of induction (inductance).

Congress also charged the National Academy of Sciences with prescribing and publishing such specifications as might be "necessary for the practical application of the definitions of the ampere and volt," from which all the other electrical units could be derived. The next year Dr. Frank A. Wolff, Jr., in the Office of Weights and Measures, was directed to begin preliminary experiments and tests on certain specifications adopted by the Academy.

But as Peirce pointed out a decade earlier, the metrological work of that office had little standing and less legal status; nor was it, for lack of funds, to be notably enhanced upon assumption of this new responsibility. From 1832 until 1870 the expenses of the Office were met out of general appropriations made to the Treasury Department and later to the Coast Survey. Then in 1870 Congress for some reason made all its appropriations for the Coast Survey specific that year, leaving no funds whatever for weights and measures.

The Office languished until the Appropriation Act of March 3, 1873, for the first time included an explicit appropriation in Coast Survey funds "for construction and verification of standard weights and measures for the customhouses and for the several States, and of metric standards for the States, $12,000." The first recognition of the Office by name and as a separate agency, in any legislative act, occurred in the Appropriation Act of August 5, 1882. But except for the addition of the clause in 1890, "and for such

[43] Report of the Electrical Conference at Philadelphia, September 1884 (reprinted in 49th Cong., 1st sess., S. Ex. Doc. 45, 1886), pp. 45–48.

necessary repairs and adjustment * * * to the standards furnished to the several States and Territories * * * [and] Customhouses," the functions of the Office, as quoted, remained unchanged until 1901.[44]

Little wonder that Peirce declared that "an office of weights and measures in the sense in which it exists in every other country * * * which should be prepared to make exact verification of all sorts of standards and certify officially to them, does not exist in the United States." Asked what his office should be equipped to do to fulfill reasonably public and Federal requirements, Peirce, in keeping with the mood of Congress, replied modestly that besides acquiring units of electrical measurement it should be ready to verify the legal units of length and weight, "say the yard, the meter, the pound, and the kilogram," and be prepared to verify speedily and certify officially for the public the multiples and submultiples of these units of mass and length. More importantly, in order to carry out these responsibilities, it should be given legal recognition and support. This would permit the Office to act with authority at home and to work for international agreement on the imperial measures shared by the United States, Russia, and Great Britain.[45]

Such a program, said Peirce, could be carried out with an increase of nine members in the Office, making a total of twelve, who would confine themselves to supplying and verifying standards within the scope he had outlined. Ignoring the fine work in astronomy then being done by Simon Newcomb at the Naval Observatory, Peirce rejected the idea of basic research in his Office, or in any government agency, for that matter. "A bureau of of the government cannot very properly be expected to do original scientific work," said Peirce. "Its natural functions are to do routine work. * * * It is hardly to be expected that scientific investigation undertaken incidentally by a Bureau of the Government should, in the long run, be of the very highest character." No one contradicted him.

A further natural limit to the scope of work of the Office, declared Peirce, was that "it need not enter upon the business of inspecting commercial standards, because that is done already by the States in a satisfactory way." [46] One must remember that the year was 1884.

LAISSEZ-FAIRE STANDARDS

The States were no better equipped to control commercial standards than the Office of Standard Weights and Measures was to provide national standards. In 1892, William Mason, a member of the Rensselaer Poly-

[44] Weber, The Bureau of Standards, pp. 35–36.
[45] Allison Commission, Testimony, pp. 370, 371–372, 375.
[46] Ibid., pp. 372, 378.