

# AT THE TURN OF THE CENTURY

## CHAPTER I

### MAIN STREET, 1900

On May 3, 1900, the House Committee on Coinage, Weights and Measures met to consider a letter recently submitted by the Secretary of the Treasury. The Secretary requested the establishment of a national standardizing bureau.

Knowing little, perhaps, of the science of measurement, but learning that it was "a matter in which a great many people seem to be interested, one which is thought to be very necessary for this country," the committee heard out the group of eminent men called from science and industry to testify at the hearing. It was a brief hearing, lasting less than 2 hours and reported in 15 pages, yet so persuaded was the committee that its members reported to their colleagues in the House:

It is therefore the unanimous opinion of your committee that no more essential aid could be given to manufacturing, commerce, the makers of scientific apparatus, the scientific work of the Government, of schools, colleges, and universities than by the establishment of the institution proposed in this bill.<sup>1</sup>

There were some in Congress by no means certain such an agency was needed, but 10 months later the bill founding the National Bureau of Standards passed both houses of Congress.

The idea of a national bureau of standards was presented at an auspicious hour. America in the year 1900 thought well of itself. The hard times of 1893-95 were all but forgotten in the aura of prosperity and sense of achievement that energized the Nation. Industry and invention boomed and business flourished as never before. The prophets at the turn of the century unanimously agreed on the good years to come.

The Nation was now an industrial power to be reckoned with. In the 3 years preceding 1900 the value of American manufactured goods sold abroad almost trebled, and total foreign commerce passed the 1 billion mark as exports exceeded imports for the first time. The great commercial invasion of Europe had begun.

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<sup>1</sup>H.R. 1452, "National Standardizing Bureau," 56th Cong., 1st sess., May 14, 1900 (U.S. House Reports, serial 4026, vol. 6, 1899-1900). This is the inscription over the new Bureau laboratories at Gaithersburg, Md.

In a reverse invasion that had been going on for a century, immigration had swollen the population to 76 million, more than two-thirds of the increase occurring since 1850. Although concentrated in the East, fully a quarter of the population had spread across the Midwest, clustered in Texas, and settled along the Pacific coast. Gold miners, oil prospectors, homesteaders, ranchers, and builders of railroads and cities had followed the course of empire westward, urged on by the growing financial power of the bankers and industrialists in the East. And with the splendid prizes of the recent Spanish-American War, the United States had at last become a world power, complete with an oversea empire.

The little war with Spain from May to August 1898 freed Cuba, Puerto Rico, and the Philippines. Cuba, returned by our troops to the revolutionists who had called for help against Spanish oppression, became a protectorate in all but name; Puerto Rico was made an outright protectorate, as was Guam, ceded to us at the peace table. But the Philippines, destined for self-government, but then coveted by Germany and Japan and eyed with concern by England, France, and Russia, we decided to annex. Soon our burgeoning industry would be glad of those 7 million customers, and beyond them the teeming millions of China. Our share in that great market in the Orient was assured through Secretary of State John Hay's announcement of the Open-Door policy, in a note sent in 1899 to the major European powers. That same year the Hawaiian Islands came under our wing, gaining territorial status the next year, and in 1900 Samoa was thrust upon us by her island king, made uneasy by the European warships roaming the Pacific.

The new sense of power was flaunted at the Pan-American Exposition that opened in Buffalo in May 1901 to proclaim the coming of age of the Western Hemisphere. The great fireworks display that closed each day of the fair ended with an emblematic pageant entitled "Our Empire," dramatizing in patriotic pyrotechnics our winning of Cuba, Puerto Rico, and the Philippines.

Looking back as the new year came in, all America acclaimed the century of science and invention to which it was heir. In the past 30 years alone the steam engine had changed the Nation from an agricultural to an industrial economy, turning the wheels of factories, farm machinery, locomotives, and electric dynamos. The original 13½ miles of railroad track built in 1830 between Baltimore and Ellicott's Mills, Md., now sprawled across almost 200,000 miles of the Nation, and a new high-speed train was making the trip between New York and Chicago in an incredible 20 hours.

The character of the Nation's waterfront was also changing under the force of steam. Two-thirds of the ships built in 1900 were still sailing vessels or auxiliaries—barks, schooners, sloops, canal boats, and barges—but that year also saw 19 side-wheelers, 117 stern-wheelers, and 216 propeller-driven ships built for the lake, river, and coastal traffic.

The marvel of the age, however, was not steam, whose power could only be used in place, but electricity—power made portable over wires. And the turn of the century saw the greatest threat to further development of electric power removed. The reciprocating steam engine had about reached the extreme limit of practical size for the production of electricity when it was replaced by the high-speed steam turbine. Originally designed for the propulsion of battleships and ocean liners, the new turbine proved a peerless electric generator.

The commercial application of electricity, beginning with the telegraph, was half a century old, but checked by hit-or-miss methods of development, costly power sources, and the natural conservatism of the public, its promise had been redeemed only in the last decade. In urban transportation electric trolleys were rapidly replacing the old horse cars. Electrification of the elevated railroads in Boston and New York would soon end the noise, smoke, and ash of the overhead steam trains. It had made practicable the 5 miles of subway recently completed in Boston, and New York and Chicago planned similar systems under their streets. New York's rapid transit line, begun in 1900 and completed 3 years later, ran 9 miles under Manhattan, from City Hall to the Harlem River. As ground was broken there was talk of extending the line by a tunnel under the East River, connecting Manhattan and Brooklyn.

Beginning with a single strand on poles set up between Baltimore and Washington in 1845, electric telegraph wires now festooned city streets everywhere and followed the railroads from coast to coast. A new development was a printing telegraph, in which the Postal Telegraph Co. and the Associated Press were interested. More amazing were the reports of Guglielmo Marconi's experiments in transmitting electric signals without wires. His signal had already spanned the English Channel. In December 1901 he would astound the world with his demonstration of transatlantic wireless telegraph.

If the telegraph was everywhere, the telephone, even with more than half a million subscribers, was still found only in the largest cities and towns, in business houses, shops and factories, and the homes of the well to do. Even Edison's electric lamp, invented in 1879 and first sold commercially 3 years later, was still a novelty. His Pearl Street power station opened in September 1882 with six generators of 125 horsepower each, sending current along 13 miles of wire and lighting a few streets and shops with arc and incandescent lamps.<sup>2</sup> But in 1900 most of the streets in New York, as elsewhere, were still lighted by gas lamps, and except in the city homes of the

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<sup>2</sup> Only one generator was used that night in September, to light 400 lamps for 85 customers. By 1904 a single generator supplied enough current to light 100,000 lamps; by 1914 it lighted 1,700,000 lamps.



*Carriages and buggies and horse-drawn wagons continued to predominate on Pennsylvania Avenue in 1908, but the electric trolley had replaced the horse car.*



*By 1904 the elevated railroads in New York had been electrified. None of the new electric trucks is visible here in Herald Square. The elegant car in the foreground is probably a 1904 Locomobile, a gasoline car that was made by the Stanley Steamer Co. for several years. Almost half of the 54,590 cars then registered in the United States were new that year.*

prosperous more than a decade would pass before electric wire and bulbs began to replace the oil lamps and gas mantles in common use.

The promise of things to come dominated the Pan-American Exposition of 1901. As gaudy and significant as its patriotic fireworks display was the symbol of the fair, the 410-foot Electric Tower. Lighted by the three 5,000-horsepower generators built at Niagara Falls 6 years before, 40,000 lamps made a torch of the tower for 50 miles around.<sup>3</sup>

For all the islands of light in city and town, the application of electricity most in evidence at the turn of the century was in transportation, propelling the trolleys that went out to the suburbs and the vans and drays in the commercial center of the big cities. Electric delivery wagons capable of speeds up to 15 miles an hour trundled along with the throngs of wagon teams in downtown New York, while up on Fifth Avenue electric taxis sped past the horse-drawn stages and weaving crowds of bicycles. As late as 1913 the National Bureau of Standards in Washington did not own a single gas-driven car or truck, depending on electric vans for ordinary express and teams of horses to bring heavy equipment up the hill to the laboratories.<sup>4</sup> The electric truck, more reliable and efficient in city traffic than the gasoline-driven car, had but one drawback. Its huge storage battery had to be recharged after every 20 or 30 miles of service.

Yet the gasoline auto had ceased to be a rarity by 1900. Henry Ford had built his first buggy, run by a two-cylinder, 4-horsepower engine, in 1892 while working at the Edison Illuminating Co., in Detroit. By 1900 at least 80 firms, owned by or hiring the services of the Duryea brothers, Ford, Elwood Haynes, F. E. Stanley, A. Winton, Elmer A. Sperry, Ranson E. Olds, and the Studebaker brothers, were making gasoline, electric, and steam automobiles. About 700 of their cars were on the road as the century began, and almost 4,000 more were rolling before the year was out.<sup>5</sup>

<sup>3</sup> Communication from Mr. Gardner H. Dales, Niagara Mohawk Power Corp., Jan. 26, 1962 (in NBS Historical File). The symbol recurs: the Tower of Light planned for the 1964-65 New York World's Fair was to be a 24-million-candlepower beacon, visible by night from Boston to Washington. As actually erected, its brilliance was of the magnitude of 24-billion-candlepower, but it was not visible for any great distance because it was a stationary light and because of the great quantity of ambient lighting on the fairgrounds.

<sup>4</sup> Letter, Stratton to Assistant Secretary of the Treasury, July 13, 1913 (National Archives, Record Group 167, NBS Box 11, file IG). NBS records in the National Archives will hereafter be identified only by NBS box number and file letters.

<sup>5</sup> Gardner D. Hiscox, *Horseless Vehicles, Automobiles and Motor Cycles* (New York: Norman W. Henley, 1901), p. 14, said 700 "was probably an exaggeration." An appendix in Hiscox, listed 272 manufacturers of automobiles and parts across the country. Bulletin 66, U.S. Bureau of Census, April 1907, reported 1,681 steam, 1,575 electric, and 936 gas automobiles manufactured in 1900.



*The Bureau's electric van, with "Bureau of Standards, Department of Commerce and Labor," somewhat blurred, inscribed on its panel, at the express office on Pennsylvania Avenue, picking up a shipment of instruments or equipment. The van has been identified as a Pope-Waverly, probably the 1903 or 1904 model.*

The great wonders of the age, everyone agreed, were electricity and the electric light, the automobile, the telephone, the railroad, and telegraph lines threading the Nation, and the growing number of farm machines operated by steam engines.<sup>6</sup> Tributes to new engineering skills included such stone structures as the Cabin John Bridge above Washington, the great steel Brooklyn Bridge, and the combination of these materials in the new skyscrapers in Chicago and in the 21-story Flatiron Building, New York's first skyscraper, then under construction.

<sup>6</sup> Of the telephone Thomas C. Mendenhall, president of Rose Polytechnic Institute, said: "But the wonder of it all is [that it works]. Nothing like it in simplicity of construction, combined with complexity of operation, is to be found in any other human contrivance." *A Century of Electricity* (Boston and New York: Houghton & Mifflin, 1887), p. 208.

Equally amazing were the phonograph and gramophone with their sound tracks on cylinders and disks, the Pianola, and the kinetoscope parlors exhibiting Mr. Edison's 1-minute amusements on film. Everybody seemed to be inventing something and looking for ways and means to make their notions commercial. A crude washing machine had recently been patented and would soon be on the market, but the zipper, invented back in 1893, was still being tinkered with and as yet had no use.

Business firms by the thousands had spawned across the country to provide raw materials or to make new products, as well as to supply the increasing everyday needs of the soaring population. Small, inefficient, and often brutally competitive, they were destined to be swallowed up by combines and corporations organized to exploit their growing success. The last decade of the 19th century became an age of trusts as industrialists, bankers, and speculators bought out or merged the multitudes of individual enterprises into great monopolies. The first had been Standard Oil, founded in 1882 when it began consolidating the oil industry by taking in 80 companies that year. By 1900, sugar, whisky, tobacco, glass, lead, cordage, copper, rubber, timber, waterpower, coal, steel and iron, wire nails, tinplate, sheet steel, urban railroads, farm machinery, gas, electric, and telephone utilities, stoves, watches, carpets, beef, flour, matches, candles, kerosene, and even coffins, school slates, and castor oil had passed into the hands of trusts.<sup>7</sup> With no other power to appease but its conscience, monopoly in these commodities more often than not resulted in higher rather than lower prices and frequently in an inferior product. On the other hand, it was a manifest stage in industrialization, the consolidation of scores and sometimes hundreds of small businesses engaged in a single commodity leading to a degree of standardization of product and introducing economy and quantity production and centralized management.

Under a traditionally *laissez-faire* government, public and private complaints against the abuses of big business fell on deaf ears, and the Sherman Anti-Trust Act of 1890 remained unexercised lest it endanger continued prosperity. Even Theodore Roosevelt, that maverick wielder of the big stick, was to clinch his place on the McKinley ticket in 1900 by declaring: "We are for expansion and anything else that will benefit the American laborer and manufacturer." All monopolies profited from the assumption that such so-called natural monopolies as the railroads, the telephone and telegraph, gas and electric companies, and the traction systems in the cities were public necessities, and theoretically at least, subject to some degree of regulation in the public interest.

<sup>7</sup> Ernst von Halle, *Trusts or Industrial Combinations and Coalitions* (New York and London: Macmillan, 1895), pp. 328-337, lists over 473 commodities controlled by trade combinations.

In the half-century between 1850 and 1900, as a result of the development and marketing of inventions, the enormous growth of business, industry, commerce, and banking, and the ascendancy of the empire builders, the national wealth increased from \$4½ to \$88 billion.<sup>8</sup> Much of this was concentrated wealth through the consolidation of industry and few of its rewards reached the marketplace. Prices had actually gone up slightly in the past decade. Yet the standard of living of the man on Main Street in 1900 was said to compare favorably with that anywhere else in the world.

For much of the Nation, the comparison of American living standards with those of other nations did not stand up very well in daylight. At least two-thirds of the workers, immigrant and native born, in the mills, mines, factories, farms, and offices of the country, who put in a 12- to 14-hour day, 6 days a week, made less than \$600 a year (roughly equivalent to \$2,400 today), or well below what economists then considered a living wage. The relatively small middle-income group, the professions, technicians, businessmen, and minor executives, however, with incomes between \$1,000 and \$5,000, lived comfortably and by present-day standards sometimes well.<sup>9</sup>

A house in the best residential section (Dolphin Street in Baltimore, for example) cost a middle-income executive less than \$5,000. A two-story house with bay windows and a furnace, in a slightly less desirable section or out in the suburbs, could be had for as little as \$750; a three-story house for \$1,200. Or the young executive could rent a 7- to 10-room house in the city for between \$10 and \$25 per month. Other expenses were commensurate. His good business suit might cost as much as \$10.65, his wife's wool Kersey and covert cloth outfit, \$5.98 ("Buy now and pay later," the 1901 handbill said). A felt hat was \$0.89, children's shoes sold for \$0.19, those for men and women from \$0.98 to \$2. Food prices in the city were not considered excessive when an 8-pound leg of mutton came to \$1.20, prime rib roast was \$0.15 a pound, corned beef \$0.08 a pound, butter \$0.28 a pound, eggs \$0.22 a dozen, and milk \$0.08 a quart.

<sup>8</sup> U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1957* (Washington, D.C., 1960), p. 151. Hereafter cited as *Historical Statistics*.

<sup>9</sup> John A. Ryan, *A Living Wage* (New York: Macmillan, 1906, reprinted 1908, 1910, 1912), pp. 136, 150, 161-162. His "reasonable and irreducible minimum" for a family of seven came to \$601.03 (p. 145). In a city like Baltimore it was \$750, in Chicago \$900, and in New York \$950. See 18th Annual Report of the Commissioner of Labor: *Cost of Living and Retail Prices of Food, 1903* (Washington, D.C., 1904), p. 648, and *Historical Statistics*, pp. 179-180.

Prices in 1900 were not appreciably greater than those itemized in Catherine Owen's *Ten Dollars Enough: Keeping House Well on Ten Dollars a Week* (Boston and New York: Houghton, Mifflin, 1887), in which, on \$100 a month a young couple spent \$20 for rent, \$12 for a full-time servant, \$45 for housekeeping, \$15 for clothes and general expenses and \$8 for commutation into the city.



Among the small pleasures of life was a trolley ride to the suburbs for 3 cents (soon to advance, amid bitter outcries, to 5 cents), and on special occasions one might hire a coach with rubber tires, electric lights, and carbon heater for a day in the country for \$3. And there were no city sales taxes, no State, county, or Federal income taxes.

Freedom from taxes made it possible for Andrew Carnegie to keep every penny of his personal income in the year 1900, well over \$23 million, and for Henry Clay Frick to spend \$17 million for a marble and limestone palace covering a square block on Fifth Avenue. Charles Schwab's house built on Riverside Drive in 1905 had 75 rooms and 40 baths, but was no match for Edward Stotesbury's 130-room hall in Philadelphia, or John D. Rockefeller's \$30 million estate near Tarrytown, N.Y.

Under a benevolent and business-minded Government, more than 20 percent of the total wealth of the Nation was in the hands of fewer than 4,000 men, the bankers, speculators, and industrialists who through headlong exploitation of the world about them created immense fortunes for themselves and controlled the fortunes of the Nation. "Malefactors of great wealth," Teddy Roosevelt in the White House might call them, but as yet only they had the resources and power to turn the discoveries of science, invention, and exploration into the shape of things to come.

## THE SHAPE OF THINGS TO COME

The builders of America's industrial complex had little interest in standards as such, but the scientists, engineers, and experimenters working for industry or independently found themselves increasingly hampered without them. The need for a Federal bureau of standards was talked about for almost 20 years before legislation for its establishment was introduced in 1900. By then the necessity had become imperative as science and industry, ready to take giant steps in the new century, looked for better measurements and more uniformity, precision, and control in the laboratory, factory, and plant.

The climate that produced the National Bureau of Standards is thus to be found in the world of science and technology as it appeared at the turn of the century. Some of this has been described in the previous section. More is furnished by contemporary historians who catalogued in book after book the century's birthright of invention. The promise was great, and prophets abounded with predictions of the future of science, industry, and society.

Without exception, the calendars of invention and histories of progress published in the early years of the new century gave first place to the electrical marvels of the previous decade and the "electrical magicians,"



*Still the largest stone arch in America, the Cabin John Bridge was completed in 1859, a 220-foot span carrying a water conduit and carriage way over Cabin John Creek. For 44 years it was the largest masonry arch in the world, until larger ones were built in Saxony and France. Since then masonry has been replaced by concrete in great bridges, as more economical.*

Thomas Edison and Nikola Tesla. Succeeding chapters in the histories recounted the latest developments in electric, gasoline, and steam vehicles and the new roadways being built for them, the growth of the iron and steel industry, of railroads and steamships, and the development of the machine tool industry, of petroleum products, textiles, clay products, rubber goods, glass making, and leather goods.

Among the new instruments of science described were the spectroscope and improved telescopes, opening new prospects in astronomy; the X-ray machine and fluoroscope; and according to one contemporary historian, Edison's phonograph and kinoscope, which "belong naturally under this chapter," though they also had their "commercial and amusement purposes."<sup>10</sup> (Yet it is doubtful whether he foresaw the use science would

<sup>10</sup> Charles H. Cochrane, *Modern Industrial Progress* (Philadelphia & London: J. B. Lippencott, 1904), pp. 406, 409. See also Edward W. Byron, *The Progress of Invention in the Nineteenth Century* (New York: Munn & Co., 1900); William H. Doolittle, *Inventions in the Century* (The Nineteenth Century Series, London & Philadelphia: Linscott, 1902); Trumbull White, *Our Wonderful Progress* (Chicago, 1902); *Calendar of Invention and Discovery*, compiled by John C. Wait (New York: McGraw, 1903); and anticipating these, Robert Routledge's *Discoveries and Inven-*

make of recording devices and of slow-motion photography.) Engineering feats included new triumphs in bridge-building, the first great dikes and dams along the Mississippi, and canals and tunnels, while among "odd and curious developments" were listed the comptometer, the trackless trolley, the new towering smoke stacks of industry, the extension fire ladder, and the escalator and elevator, the latter developed to serve those "modern tall steel skeleton fire-proof buildings, commonly called skyscrapers."

The marvels achieved presumed greater ones to come, and more than one prophet looking into the new century envisioned a utopian age of science and industry within a matter of years, made possible, as John Bates Clark said in the *Atlantic*, by "omnipresent and nearly gratuitous electrical energy!" In addition to coal and water power, Clark optimistically predicted that it would not be long before the waves and tides and even the electric currents generated within the earth itself would be harnessed for the production of cheap and virtually unlimited electric power. Industry, commerce, and the home would be filled with automatic machines ("... we touch a button and they do the rest," said Clark), putting in the hands of every man a hundred silent servants, raising wages, dispelling poverty, and stilling the unrest of the laboring classes.<sup>11</sup>

H. G. Wells, with frequent glances at the American promise, agreed in his "Experiment in Prophecy" in 1901 on the equalizing force of the electrical century to come, saw homes and factories heated, ventilated, and operated by electricity. But with this revolution, he predicted, would come a world so closely linked and controlled by electrical conveniences and communications as to reduce all to a gray mass, to a virtually classless world of respectable mechanics.

Even greater social and political changes than those resulting from electricity, Wells thought, would come from the inevitable mass production of commodities and the future development of the internal combustion engine. Certain to come was a smooth-riding, powerful, and stenchless gasoline automobile and great networks of paved roads for it, making journeys of 300 miles in a day possible. Then motor trucks would replace the railroads, and motor coaches supplant the horse cars and electric trolleys that ran out to suburbia, where, as Wells said, the conforming gray mass of the future lived.<sup>12</sup>

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tions of the Nineteenth Century (London: Geo. Routledge, 1876) and the survey of the century's wonders in *Sci. Am.* 75, 50-96 (1896).

<sup>11</sup> John Bates Clark, "Recollections of the Twentieth Century," *Atlantic*, 89, 4 (1902). Clark was professor of political economy at Columbia University from 1895 to 1923, specializing in trusts and monopolies. See also George Sutherland, *Twentieth Century Inventions: A Forecast* (New York & London: Longman's Green, 1901).

<sup>12</sup> H. G. Wells, "Anticipation: an experiment in prophecy," *North American Review*, vols. 172-173 (June-November 1901).

The visible achievements of technology and invention, though many were still crude and far from generally available, made prophecy a game any number could play, and with some knowledge of human nature, foreseeing the social changes they would bring only meant projecting the changes already begun. Predicting the future of pure science, however, was something else, and the few who ventured any guesses did so cautiously and in the vaguest of terms.

One who ventured was John Trowbridge, director of the Jefferson Physical Laboratory at Harvard. The work of Maxwell, Hertz, Roentgen, and Thomson between 1873 and 1897, in demonstrating the electromagnetic nature of light and formulating the concept of the electron, in mass much less than one-thousandth part of the chemist's lightest known atom, had almost certainly, said Trowbridge, made the study of the infinitely small the new direction physical science would take.

The word "electronics" had not been invented, and Professor Trowbridge saw no "use" in the study of the electron yet, except as it might possibly lead to an answer to an unexpected problem recently encountered. This was in the electrolytic effects observed in Boston, where the iron mains carrying water under Boylston Street had been found badly corroded by the electric current of the trolley system. The investigation of this phenomenon, declared Trowbridge, "has laid the foundation of a new branch of science, that of physical chemistry, which promises to be one of the most important sciences in the world." Electrochemistry, the branch of physical chemistry concerned with electrolysis, seemed to Trowbridge certain to provide the key to exploration of the nature of the smallest particles of matter yet found.<sup>13</sup>

But the world of electronics and the physicist's exploration of the atom was still far off. For the most part, the world of science in 1900 had little conception of the truly revolutionary ideas to come. Robert A. Millikan was to say that of the basic principles of universal order taught at the end of the 19th century, not one but its universal validity was to be questioned by serious and competent physicists, while most were definitely proved to be subject to exceptions. In 1895, the very year some physicists were declaring that "the great discoveries in physics have all been made," that the field of physics was "dead," Roentgen announced his discovery of X rays. A year later came Becquerel's discovery of the radioactivity of uranium, marking the birth of nuclear physics, and in 1897, J. J. Thomson in England established beyond question the existence of electrons as fundamental con-

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<sup>13</sup> John Trowbridge, "The study of the infinitely small," *Atlantic*, 89, 612 (1902). Professor Trowbridge, a physicist and specialist in electricity, was director of the Jefferson Physical Laboratory from 1888 to 1910.

stituents of all atoms in the universe.<sup>14</sup> Seventeen years would pass before the latter discovery, stirring Professor Trowbridge to prophecy, would be applied to the electronic amplifier tube, making possible the first wireless telephone and the long distance telephone.

The breakthrough in the world of physics continued in the first quarter of the 20th century with Planck's quantum theory (1901), Einstein's concept of the relativistic transformation of mass into radiant energy, expressed in his equation  $E=mc^2$  (1905), and his elaboration of the principle of relativity (1905-25). That same period witnessed the isolation and measurement of the electron (1910-17), the discovery of the wave nature of X rays (1912), and the quantitative working out of their properties (1910-25). These revelations were followed by Bohr's model of the atom (1912-22), the investigation of crystal structures with the aid of X-ray spectroscopy (from 1913 on), the discovery of isotopes through the chemistry of radioactive elements (1913), and the discovery of cosmic rays (1926).<sup>15</sup>

Thus, active as pure science was at the turn of the century, in this country its efforts were largely unknown. For one thing, most of the work was done abroad. We were not to develop any significant number of pure scientists, let alone theoretical physicists, until the 1930's. The early career of the Bureau of Standards, so much of it given to basic research in standards and to technological research, is witness. (When Louis W. Austin came to the Bureau in 1905 by way of Cambridge, after 2 years' study at the Reichsanstalt, the national physical laboratory of Germany, he brought with him Rutherford's book on radioactivity, just published by the Cambridge University Press. Reviewed at a weekly staff meeting at the Bureau, it caused some stir among the assembled physicists, but more perplexity. The subject was as yet beyond the province of the Bureau.)<sup>16</sup>

Besides being developed abroad, the theories and hypotheses of the new physicists remained incapable of proof or practical application as they awaited better instruments and precision measurements. Hence the general public, when it chanced on notice of them, hadn't the slightest understanding of the new discoveries, and even among men of science their implications for the future of science were not widely understood or appreciated. To the average man, science appeared to be in the hands of the experimentalists, inventors, and mechanics and in the application of their work to new in-

<sup>14</sup> Robert A. Millikan, "The last fifteen years in physics," *Proc. Am. Phil. Soc.* 65, 68 (1926); Millikan, "The evolution of twentieth-century physics," *Annual Report, Smithsonian Institution*, 1927, pp. 191-199; *The Autobiography of Robert A. Millikan* (New York: Prentice Hall, 1950), pp. 106, 271.

For repeated statements of the stasis reached in physics, especially in electricity, see T. C. Mendenhall, *The Age of Electricity*, *passim*.

<sup>15</sup> Millikan, "The last fifteen years in physics," pp. 70-78.

<sup>16</sup> Interview with Dr. Llewelyn G. Hoxton, Nov. 27-28, 1961 (NBS Historical File).

dustry and enterprise. What the average man did not realize was the extent to which science, pure and applied, was becoming involved in experiment and invention. The genius of Thomas A. Edison is a case in point.

Despite the fact that much of his best work was done before 1900, Edison was in many respects the symbol of the age as he was its hero, widely accepted as the typical self-trained, empirical genius of American science. Though his knowledge of physics and chemistry was ill-grounded and his disdain for mathematics profound, the world owed to Edison through his hundreds of patents the electric light bulb and phonograph, the kinoscope, the first effective storage battery, and the first practical electric power system. These were the products of his invention factory. Set up in New York with 50 men in 1870 and moved across the river to Menlo Park in 1876, it was unquestionably the greatest of his inventions and the prototype of today's industrial research laboratories. Without detracting in the least from his undeniable genius, the wizard had help. Few were aware of the mathematicians, chemists, and physicists, many of them trained abroad, who worked at Menlo Park to make the necessary calculations for Edison's inventions.

Behind the histories of progress and invention at the turn of the century, wherein Edison was accorded first place, was a new phenomenon, the accelerated pace at which science was contributing to the inventions and processes that apply it to daily life. Commerce and industry could no longer wait while scientists projected theories without demonstrations, while isolated inventors tinkered unassisted with crude working models. By bringing scientists and inventors together, along with talented engineers to translate their theories and models into commercial products, industry sought to telescope time and effort.

By the turn of the century small research laboratories had been set up in the Pennsylvania Railroad yards at Altoona, Pa., at B. F. Goodrich, and Bethlehem Steel & Iron, staffed with inventors, engineers, and chemists. The first systematic effort to incorporate science and technology in industry was, as might be expected, in the electrical field, when the General Electric Research Laboratory, a direct offshoot of Edison's Menlo Park, was organized at Schenectady in 1900. The decade before the First World War saw similar laboratories organized at DuPont, Bell Telephone, Westinghouse, Eastman Kodak, Standard Oil (Indiana), at U.S. Rubber, and Corning Glass. In the 1920's, under the dynamics of mass production, new research factories for the mass production of technological ideas proliferated at the rate of over a hundred a year.

Even before the founding of Edison's laboratory, scientists, whether directly engaged by industry or working independently in university laboratories or in their own workshops, were becoming increasingly active in the

commercial life of the Nation. And under pressure to produce or to satisfy their own demands for quantitative results, it was the scientists who sought better standards of measurement, better tools, precision instruments, and materials. It was they who realized that the arbitrary standards they worked with or of necessity had to create for themselves were all but meaningless and represented a needless loss of time, effort, and money. Science, better than industry, was aware that only Federal legislation could establish the necessary criteria, criteria that would possess national as well as international validity.

Other nations, more advanced in commerce and industry, had long since recognized the need for such legislation and had established national standards laboratories. America, growing in commerce and industry, in national power and prestige, had nothing comparable to them. The meeting of these forces at the end of the 19th century—the growing needs of science and technology, coinciding with a new sense of national pride—was the impulse that created the National Bureau of Standards.

When the Bureau was founded, the first power-motored flight by Orville Wright was just 2 years away. That first decade would see the development of audion tubes by Fleming and DeForest, long-distance telephony, the diesel engine, high-speed tool steel, the mercury vapor arc, and the first real plastic (bakelite). In the ever-widening fields of electricity, automotive engineering, aviation, plastics, textiles, and construction materials, the Bureau was to do basic and in some cases pioneer research. And in doing so it was to lay the groundwork for its later investigations in fields as yet undreamed of, in the application of the new physics to metrology, in free radical research, cryogenic engineering, atomic and radiation physics, space physics, plasma physics, and radio propagation engineering.

Beginning with the formulation of improved standards of electrical measurement, the Bureau was to develop better standards of length and mass, develop new standards of temperature, light, and time. It would establish standards of safety in commerce and industry, of performance in public utilities, and prepare and maintain hundreds of standard samples of materials for industry. The advance of science would demand increasingly precise instrumentation, greater and greater ranges of measurement, and wholly new standards such as those of sound, frequency, and radiation. The Bureau would eventually become the custodian of and final arbiter over more than 700 different standards.

Such an agency, providing vital services to the Nation outside the province of any possible private, institutional, or industrial organization, might have had its birth simultaneously with that of the confederation of the colonies. Why it was over a hundred years coming into being is an integral part of its history.

## GOVERNMENT, SCIENCE, AND THE GENERAL WELFARE

The Nation had been born in an age of scientific exploration and experiment, its very founding a consequence in part of the industrial revolution in England. Among the framers of the Constitution, men of science like Franklin, Madison, Pinckney, and Jefferson looked to the early establishment in the new Nation of a national university and Federal societies of the arts and sciences, for the promotion of agriculture, commerce, trades, and manufactures. But because the new States feared centralization of power of any kind in the Federal Government, these institutions were not spelled out.

The powers granted Congress by the Constitution "to promote the progress of science and useful arts" by issuing patents to authors and inventors, by conducting a periodic census, and supervising coinage, weights, and measures, were exercised in spirit if not to the letter. In any case, their scientific implications were ignored. Small autonomous laboratories appeared before long in a number of the executive departments of the Government, providing certain functional services involving research, but encouragement and support of fundamental science were left to such privately organized agencies as the American Philosophical Society (Philadelphia, 1743), the American Academy of Arts and Sciences (Boston, 1780), and in Washington, the Smithsonian Institution (1846), and the American Association for the Advancement of Science (1848). In no way an adjunct of the Government but merely an advisory body in scientific matters was the National Academy of Sciences, incorporated by an act of Congress on March 3, 1863. Without authority or independent funds, it was only required, "whenever called upon by any department of the Government \* \* \* to investigate, examine, experiment, and report upon any subject of science or art" submitted to it, the investigations to be paid from regular congressional appropriations made for that purpose.

Congress repeatedly demonstrated great reluctance to provide even small sums of money for the support of any private scientific or inventive enterprise, however beneficial to the Nation. Robert Fulton's pleas for Federal aid in the 1830's went unanswered. Governments abroad were more helpful with his submarine, and on his return private funds made his steamboat "folly" possible. Only after 6 years of petitions was Congress persuaded to grant Samuel F. B. Morse the sum of \$30,000 to set up his experimental telegraph line between Baltimore and Washington in 1843.

The scant concern of the Federal Government with science is evident in the delayed organization of some of its most essential scientific agencies. Military and civil exploration were provinces of the Army Corps of Engineers until the Geological Survey was established in the Department of the Interior in 1879. The Treasury's Coast and Geodetic Survey, founded in 1807 to



chart the coasts for American shipping, provided the only scientific mensuration supported by Federal funds until the miniscule Office of Weights and Measures was set up within the Survey itself in 1836. That same year the Patent Office was established in the State Department, over strong opposition from many in Congress who declared its inclusion in an executive branch an unconstitutional usurpation of authority.

Government concern with medicine and public health was left to the Army Medical Department (1818), and except in the short-lived National Board of Health (1879-83), medical research remained a function of the Army until the establishment in 1902 of the Public Health Service. In the Navy Department was the National Observatory and its Hydrographic Office, organized in 1842, which, with the telegraph facilities operated by the Army Signal Service, provided meteorological and weather services to the Nation until 1890 when these functions were transferred to the Department of Agriculture. That Department itself was not established until 1862, under wartime pressure for greater food production.

In a nation predominantly agricultural until the last decade of the 19th century, these Government services seemed sufficient.<sup>17</sup> Such research as they conducted was restricted by law and lack of funds to that immediately necessary to carry out their functions. Yet inevitably these agencies acquired specialized personnel for their problems, were aided and encouraged by the independent scientific organizations of the Nation, and in some instances achieved on meager appropriations remarkable results. The work of the Naval Observatory in astronomy and of the Army Medical Corps in bacteriology produced contributions to fundamental science well beyond the pragmatic strictures of Congress.<sup>18</sup>

Federal reluctance to enter scientific fields and congressional agreement to keep in bounds those it perforce established grew out of the nature of the Constitution, which reserved to the individual and to the States the greatest possible freedom and the maximum opportunity for private enterprise consistent with the public good. The industrialization of America in the late 19th century coincided with a kind of glorification of this political theory of *laissez-faire* and its concomitant gospel of work and wealth. It was little wonder that a proposal made in 1884 for the establishment of a Department of Science in the Federal Government foundered even as it was launched.

<sup>17</sup> In 1890 agricultural, mining, forest, and fishery products accounted for 82 percent of our exports; domestic manufactures 18 percent. By 1900 agricultural products were 68 percent of exports and manufactures had risen to 32 percent. *Statistical Abstracts of the United States, 1900* (Bureau of Statistics, Treasury Department, Washington, D.C., 1901), p. 187.

<sup>18</sup> A. Hunter Dupree, *Science in the Federal Government* (Harvard University Press, 1957), pp. 184-186, 263 ff.

Yet the time was ripe. By the 1880's science and invention had become as fervid subjects of public concern as welfare would be in the 1930's, With the dramatic rise of the electrical industry there was no longer any question about the necessity of Government support, only about the degree and immediacy of it. Indeed, in 1884 Congress went so far as to appropriate \$7,500 for a national conference of electricians at Philadelphia. But it took no action on the recommendation of the conference for a Federal agency "charged with the duty of examining and verifying instruments for electrical and other physical measurements."

Some felt that more than measurement was wanted in the young and directionless industry. Writing in 1887 about the development of the storage battery, Thomas C. Mendenhall, physicist and president of Rose Polytechnic Institute in Indiana, said: "A good deal of valuable information concerning [its] behavior \* \* \* has been accumulated; at an expense far greater, however, than would have been necessary, had the whole subject received in the beginning an exhaustive examination at the hands of a competent commission under Government authority and at Government expense. The vast importance of the questions involved would seem to justify such a course."<sup>19</sup> Such an authority had recently been proposed and, with little debate, dismissed.

The proposal for a Department of Science arose out of an investigation of intramural bickering over functions in the survey agencies of the Government. A joint congressional commission, headed by Senator William B. Allison of Iowa, was directed to consider the possible reorganization for greater efficiency of the agencies involved, that is, the Army Signal Service, the Department of Interior's Geological Survey, the Treasury's Coast and Geodetic Survey, and the Navy's Hydrographic Office. The Allison Commission turned to the National Academy of Sciences and asked it to appoint a committee to make a study of similar European institutions and recommend methods of coordinating the work of these scientific agencies in the Government.

In September 1884 the committee made its report. "The time is near," said the National Academy, "when the country will demand the institution of a branch of the executive Government devoted especially to the direction and control of all the purely scientific work of the Government." It therefore recommended the establishment of such a branch, to be called the Department of Science, with the purely scientific functions of the survey agencies in contention reorganized in this Department. It was to comprise four bureaus: the Coast Survey, the Geological Survey, a meteorological bureau combining the weather services of the Army and Navy offices, and a new physical laboratory. The latter was to take over the little weights and

<sup>19</sup> T. C. Mendenhall, *A Century of Electricity*, pp. 213-14.

measures office in the Coast Survey and extend the present investigations of that office to include electrical standards. It would also undertake "to observe the laws of solar and terrestrial radiation and their application to meteorology, with such other investigations in exact science as the Government might assign to it."<sup>20</sup>

The proponents of the new department agreed that it should undertake no work that "can be equally well done by the enterprise of individual investigators"; that its bureaus would cooperate, not compete, with university research laboratories; that they would investigate only in those fields, still unoccupied, "where private enterprise cannot work"; and confine themselves "to the increase and systematization of knowledge tending 'to promote the general welfare'"—in particular, to research vitally affecting the establishment or expansion of new industry in the Nation.

The committee pointed to photography, which since the daguerreotype in 1839 had grown into a \$30 million a year industry, and to the new, promising electric telegraph, telephone, light, and electric railway industries, as proof that "the pursuit of science is now directly connected with the promotion of the general welfare" and therefore a Federal responsibility.

But the old arguments prevailed. The Government could not fail to compete with the university laboratories or the enterprise of individual scientists. With its "capacity \* \* \* for indefinite expansion," a Federal agency of science would encroach more and more upon individual effort and on industry, and by proliferation and publication soon come to create, control, and diffuse the scientific knowledge of the Nation.<sup>21</sup> The Allison Commission shelved the proposal for a department of science. The prospect of anything like a centralized research agency in the Government was bad enough, but that it might ultimately lead to some kind of intervention in industry or regulation of business was too much for the times.

In those last decades of the century, as Frederick Lewis Allen has said, "business was supposed to be no affair of the government's." The farm States in 1887 had forced creation of an Interstate Commerce Commission to regulate the railroads, but its powers were small, uncertain, and unexercised. There was no Department of Commerce, no Department of Labor, no Federal Trade Commission, no Federal Reserve System, and when in need of credit, Washington without the aid of John Pierpont Morgan was helpless.<sup>22</sup> The Federal Government was without the power or inclination either to inter-

<sup>20</sup> Report of M. C. Meigs, Chairman of NAS Committee, to O. C. Marsh, President, NAS, Sept. 21, 1884 (Allison Commission, Testimony, Mar. 16, 1886, 49th Cong., 1st sess., S. Misc. Doc. 82, serial 2345), p. 8.\* Hereafter cited as Allison Commission, Testimony.

<sup>21</sup> *Ibid.*, pp. 7\*-8\*, 66-69, 177-179, 999-1001; Dupree, *Science in the Federal Government*, pp. 215-226, 231.

<sup>22</sup> Frederick Lewis Allen, *The Big Change: America Transforms Itself, 1900-1950* (New York: Harper, 1952; Bantam Books, 1961), p. 72.

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.<sup>23</sup>

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

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<sup>23</sup> 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."<sup>24</sup>

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.<sup>25</sup> Its history reflects the century-long hesitation 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 impost. 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.<sup>26</sup> 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

<sup>24</sup> Allison Commission, Testimony, p. 370.

<sup>25</sup> 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.

<sup>26</sup> 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. 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 on this city, prevents my receiving it till the 1<sup>st</sup> of April, and an illness which followed soon after, retarded unavoidably some weeks to the delay: so that it was not till about the 20<sup>th</sup> of May that I was able to finish the report. A desire to lessen the number of the imperfections, which are still to be found in it, as well on the 15<sup>th</sup> of June, as to withhold it a while longer, till on the 15<sup>th</sup> of June, arrived my hands from Paris a printed copy of a proposition made by the Bishop of Meulan 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 a disposition on their part to know 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,

The Speaker of the  
House of Representatives }  
and most humble servant  
Thos. 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.<sup>27</sup>

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."<sup>28</sup> 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.<sup>29</sup>

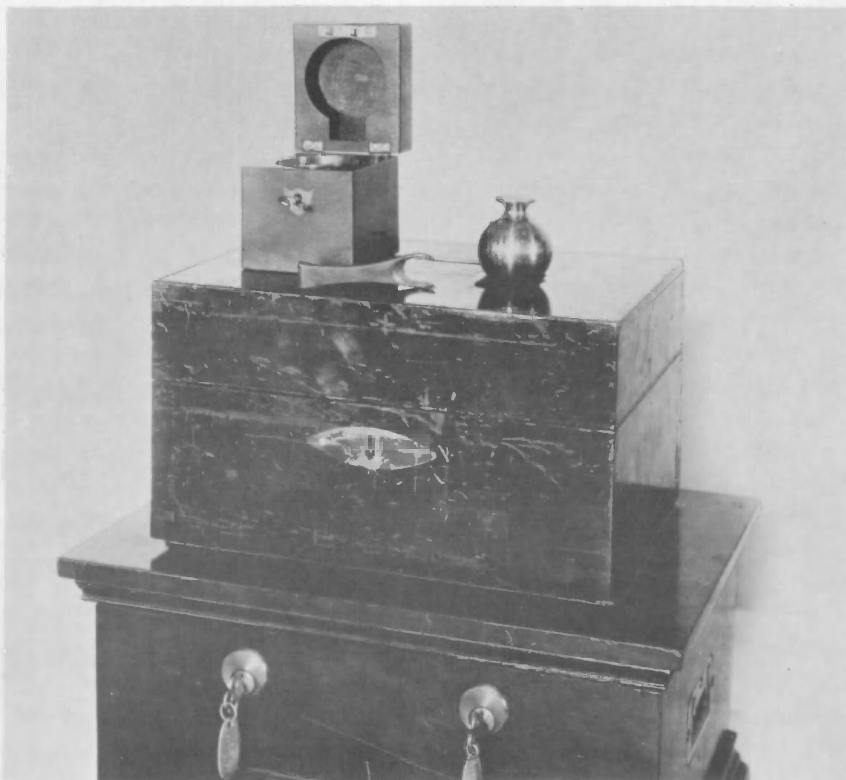
But coinage was not alone in dealing with unknown quantities. The history of weights and measures in this country had more than its share.

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<sup>27</sup> 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.

<sup>28</sup> Allison Commission, *Testimony*, pp. 372-374.

<sup>29</sup> 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.*

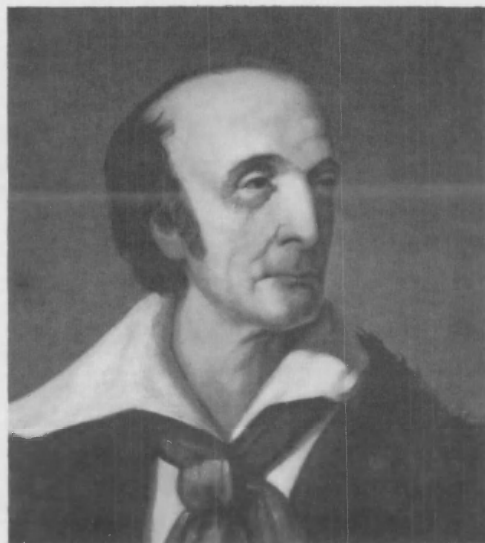
The first real effort to provide accurate, if nonlegal, standards of weights and measures was made by Ferdinand Rudolph Hassler (1770–1843), a Swiss engineer and metrologist who emigrated to this country at the age of 35. Upon the establishment of the Coast Survey in the Treasury Department, Hassler 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.<sup>30</sup>

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

<sup>30</sup> 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."<sup>31</sup>

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.<sup>32</sup>

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.<sup>33</sup>

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

<sup>31</sup> [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.

<sup>32</sup> *Ibid.*, pp. 1-2.

<sup>33</sup> *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.<sup>34</sup>

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.<sup>35</sup>

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.

<sup>34</sup> [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.

<sup>35</sup> 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.<sup>36</sup> 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.<sup>37</sup> 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.

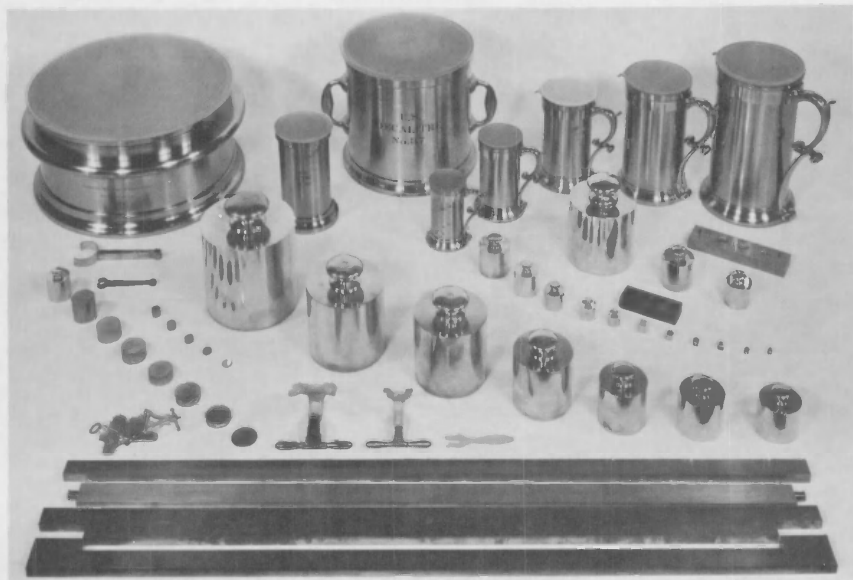
Implementing the new law, a joint resolution of Congress that same year authorized the Secretary of the Treasury to furnish each State with a set of metric weights and measures. Until replaced at the end of the century by new international metric standards, a brass meter brought by Hassler to this country 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.<sup>38</sup> 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.

<sup>36</sup> [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).

<sup>37</sup> See app. B for a brief history of the metric system.

<sup>38</sup> 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.<sup>39</sup>

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.<sup>40</sup> 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.<sup>41</sup> 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.

<sup>39</sup> 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.

<sup>40</sup> 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).

<sup>41</sup> "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.<sup>42</sup>

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

<sup>42</sup> 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."<sup>43</sup> 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

<sup>43</sup> 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.<sup>44</sup>

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.<sup>45</sup>

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."<sup>46</sup> 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-

<sup>44</sup> Weber, *The Bureau of Standards*, pp. 35-36.

<sup>45</sup> Allison Commission, *Testimony*, pp. 370, 371-372, 375.

<sup>46</sup> *Ibid.*, pp. 372, 378.

technic Institute faculty, complained in the pages of *Science* magazine that he had to contend with eight different "authoritative" values for the U.S. gallon, including two accepted by the U.S. Pharmacopoeia, three found in current standard chemical textbooks, one in Oldberg's *Weights and Measures* (1885), and two in Treasury Department reports—that given by Bache in his 1857 report describing Hassler's 8.3389-pound gallon and a currently adjusted standard, an 8.3312-pound gallon. In this confusion, Professor Mason declared he had elected to work with a ninth value, one he had determined for himself.

Although dignified by the term "standard," said Professor Mason, the truth was, "the U.S. gallon has no statutory existence whatever," nor had any of our common weights and measures with the single exception of the troy pound. "It seems \* \* \* highly desirable that this whole question of standards and relation of weight to measure, be finally settled by law, and preliminary to this, by a new scientific investigation."<sup>47</sup>

Thomas C. Mendenhall, author of *A Century of Electricity* (1887) and in charge of weights and measures as superintendent of the Coast Survey from 1889 to 1894, fully agreed: "The system of weights and measures in customary use is so confusing, so unscientific, and, in some instances, apparently so contradictory that it is difficult to write of it, even briefly, without falling into error."<sup>48</sup> Permissive use of standards, poor construction of commercial weights and measures, and the progress of science had long since combined to vitiate the merits of Hassler's good work.

Some degree of the confusion in precision measurement at least may be traced to Hassler's standard of length—and the basis for all the other standards. As Mendenhall said: "The Troughton 82-inch scale was formerly accepted as a standard of length, but for many years it has not been actually so regarded. By reason of its faulty construction it is entirely unsuitable for a standard, and for a long time it has been of historic interest only."<sup>49</sup>

The hazard in Hassler's yard measure, based on the Troughton scale, seems to have been first pointed out by John Henry Alexander, Maryland metrologist and later professor of natural philosophy at the University of Maryland. For lack of the necessary equipment, Alexander carried out many of the metrological tests for the construction of his yard measures for

<sup>47</sup> William P. Mason, "Confusion in weights and measures," *Science*, 20, 358 (1892).

<sup>48</sup> Mendenhall, *Science*, 21, 79-80 (1893).

<sup>49</sup> Upon completion of construction of its new imperial standards in 1855, Great Britain presented copies of the yard and avoirdupois pound to the United States. The new bronze yard No. 11, when compared with the Troughton yard, revealed that the accepted 36 inches of the Troughton scale was 0.00087 inch longer than the British imperial yard. Since the new yard was far superior as a standard of length, the Office of Standard Weights and Measure adopted it as the U.S. standard. NBS M64 (1925), pp. 12-14.

the State of Maryland in Hassler's Washington laboratory and continued to work there after Bache took over.<sup>50</sup> The brass in Hassler's yard scale, made with "ingenious and novel methods" and containing a zinc of more than usual purity, said Alexander, presented—

in several physical characters a marked difference from the ordinary brass of commerce; it is softer, freer, more uniform in texture, of a more agreeable color, and oxidates even with a pleasanter aspect. This last particular was a point upon which the late Superintendent, whose remarkable versatility of genius found nothing too great or too small for attention, in a manner piqued himself; and the bright eye of the aged philosopher gleamed brighter as it watched the deepening of what he called his "oerugo nobilis." \* \* \* All these peculiarities would have made the employment of such metal, had it been possible, of great interest and advantage: but it was only to be procured by a repetition of the original process—a step manifestly disproportionate to the end now in view. Under these circumstances, resort was had to the article as more usually obtained.<sup>51</sup>

Alexander's use of ordinary brass made comparison with the original standard all but impossible because there was no "means of knowing positively the expansion of Mr. Hassler's brass." The 30 different yard-measures that Alexander constructed for the State of Maryland between 1842 and 1845, each with a "correction for excess of U.S. Standard," agreed with one another within two parts in a ten-thousandth of an inch. Even though this was "a quantity fully observable," Alexander nevertheless considered his bars entirely satisfactory for "measuring the yards in common use that may be applied to them."<sup>52</sup>

Alexander appears to have been a careful craftsman, and he had access to the best equipment available in this country, that in Hassler's laboratory. It is doubtful whether many other State metrologists enjoyed either advantage. Yet a comment he made on Hassler's mission at the beginning of his report provides, unwittingly, a clue to the attitude of the age toward weights and measures and to the outcome of Hassler's efforts:

The Establishment of a system of Weights and Measures belongs not merely to the domain of mechanical science, but enters also into the regions of metaphysics and the higher generalizations of history.

<sup>50</sup> J. H. Alexander, Report on the Standards of Weights and Measures for the State of Maryland and on the Construction of the Yard-Measures (Baltimore: John D. Toy, 1845), pp. 167, 183.

<sup>51</sup> *Ibid.*, pp. 178-179.

<sup>52</sup> *Ibid.*, pp. 208-210.

When in addition reproducibility of the basic standard was doubtful and comparison with the original impossible, metrology indeed became metaphysical. And so it proved.

Fifty years later Mendenhall was to report that, supplied with replicas of Hassler's standards, "nearly all of the States made these copies their standards, and thus practical uniformity was secured. Theoretically or rigorously, however, there are about as many systems of weights and measures in use to-day as there are States in the Union."<sup>53</sup>

In its effort to maintain the highest accuracy of the yard and pound, Mendenhall's Office had itself contributed to the confusion. While interested States continued to construct their standards as best they could on Hassler's models, the Office of Weights and Measures, rejecting Troughton's scale, defined the U.S. yard as identical with the imperial yard of Great Britain, the standard of mass with the imperial or avoirdupois pound. In 1893, 27 years after legalization of the metric system by Congress, the Office turned to that "infinitely more perfect order" and redefined its yard and pound in terms of the meter and kilogram.<sup>54</sup>

Without an authoritative national standard or an adequate testing and comparison agency, regulation of Hassler's standards had been left to the States, and they had few funds for proper construction, maintenance, or control. With almost no precision instrument makers in this country, industry and science turned to Europe, while the construction of commercial weights and measures was left to business supply houses. Some measure of the general ensuing chaos may be seen in the report in John Perry's *The Story of Standards*, that in Brooklyn, N.Y., in 1902, "city surveyors recognized as legal four different 'feet': the United States foot, the Bushwick foot, the Williamsburg foot, and the foot of the 26th Ward. All legal, all different. Some strips of Brooklyn real estate were untaxable, because, after two surveys, made with different units, these strips, legally, didn't exist!"<sup>55</sup>

The widening gap between so-called Federal and State standards, and the inability of the Office of Weights and Measures to supply the growing variety of standards needed in the Nation, inevitably led to the creation of a whole galaxy of entirely arbitrary standards affecting almost every measurable quantity required by farm, factory, or laboratory. Standards were further debased as the classic *laissez-faire* control supposedly exercised by a free market broke down completely at the end of the century, a market that ceased to exist when not only the necessities of life but virtually every article of commerce came under the control of trusts and monopolies.

<sup>53</sup> Mendenhall, *Science*, 1893.

<sup>54</sup> *Ibid.* See above, p. 30.

<sup>55</sup> *The Story of Standards* (New York: Funk & Wagnalls, 1955), pp. 5, 13. Perry's book, with the National Bureau of Standards as its frame of reference, is a brief, highly readable history of the idea of standards from ancient times to the present.

Some of the consequences were revealed in an article in *Scientific American* in 1896 describing the increasing unreliability of household products, industrial goods, and construction materials. In the construction of buildings, between 15 and 20 percent more material than needed had to be ordered to allow for the uneven quality found in every lot. The tensile strength of cement varied with the shipment, a certain quantity of steel tubing and forgings could be counted on to prove defective, and in one recent test sampling only two of six makes of white lead submitted deserved the name. Among household items, a conspicuous example of outright fraud was lard oil containing a high percentage of paraffin oil.

A number of independent testing agencies had sprung up to assist industry, the article continued, but their subjective standards were in no way comparable to those established in the bureaus under government supervision in Europe. As a result, "at present it is very difficult to get a paint which is worth anything, or a good lubricating oil at a reasonable price, and many of the soaps sold throughout the country are so injurious to clothes as to be worse than useless. Is this not, after all, a matter for governmental control?"<sup>56</sup>

Henry Ives Cobb, designer of the Chicago Opera House and Newberry Library and consulting architect to the Federal Government, concurred on the state of construction materials, and in testimony before a congressional committee some 4 years later, he and other highly qualified witnesses left no doubt of the consequences in this country of laissez-faire standards. Although the Office of Weights and Measures had adopted the English standard of light, said Carl Hering, president of the American Institute of Electrical Engineers, it was so indefinite and inadequate that scientific laboratories referred instead to the German standard as more precise and reproducible. The electric light industry, finding neither the British nor German standards useful, had adopted standards of its own in the manufacture and sale of lighting equipment. By agreement among the electric light companies, Prof. Henry A. Rowland of the Johns Hopkins University testified, a lamp requiring 10 amperes of current at a pressure of 45 volts was called 2,000 candlepower, when in reality—that is, by British or German standards—it amounted only to 400 to 500 candlepower.<sup>57</sup>

Dr. Henry S. Pritchett, then superintendent of the Coast and Geodetic Survey, acknowledged that the Nation was without a definite, accurate photometric standard or even the means to arrive at one. But then neither had we accurate means to test thermometers, barometers, pressure gages, electrical standards and measuring apparatus, polariscopes, instruments of

<sup>56</sup> L. S. Randolph, "Systematic inspection of material," *Sci. Am.* 75, 347 (1896).

<sup>57</sup> Hearings before the Subcommittee of the Committee on Commerce, Dec. 28, 1900 (56th Cong., 2d sess., S. Doc. 70, serial 4033), pp. 12, 15.

navigation, steam engine indicators, or almost any other instrument of precision. Even though many of these were being made in this country, "nearly all such instruments have to be sent to Europe \* \* \* for standardization." As for those used in high-precision work in university laboratories, in scientific institutions, and Government laboratories, they could only be procured from abroad. The same was true of all our chemical apparatus. It came from abroad.<sup>58</sup>

The electrical industry by 1900 represented a \$200 million investment in this country, Prof. Arthur E. Kennelly of Harvard testified, yet for lack of recognized standards the industry was involved in frequent and costly litigation, putting a brake on its continued growth.<sup>59</sup> As the crowning insult resulting from our failure to establish national standards, the Physikalisch-Technische Reichsanstalt, Germany's national standards laboratory, used the Weston voltmeter-ammeter, an American-invented and American-made instrument, for its precision measurement of electrical currents and electrical pressures, but refused to accept the calibration of its manufacturer. The Reichsanstalt had also adopted the Weston cell in preference to its own standard, for the determination of electromotive force. These and other electrical instruments made in this country for domestic sale and export were regularly sent first to Germany for recalibration, because the manufacturers' standards were either not known or not accepted.<sup>60</sup>

National laboratories abroad were already at work answering the demands of science and industry for instruments of greater reliability, accuracy, and range. In this country we were still incapable of supplying either a certified instrument to a scientific laboratory or an authoritative common measure to the marketplace. Besides impeding the scientific and commercial development of the Nation, witness after witness told Congress, the necessity of sending abroad for certification was consuming of time, expensive, and damaging to our national prestige. Establishment of a national standardizing laboratory could be deferred no longer.

#### **"A NATIONAL NEED . . . A NATIONAL HUMILIATION"**

A Federal standards laboratory had been under discussion for almost 20 years before the burst of nationalism at the turn of the century and the surging growth of American industry together conspired to assure its serious consideration. The coincidence made for compelling arguments. As a result of the Spanish-American War we had in a few short months become a

<sup>58</sup> Hearings before the Committee on Coinage, Weights and Measures, May 3, 1900 (56th Cong., 1 sess., H. Rept., no document or serial number), p. 2.

<sup>59</sup> *Ibid.*, p. 13.

<sup>60</sup> Hearings \* \* \* Dec. 28, 1900, p. 17.

world power, intensely proud of the new respect with which the nations of the world now dealt with us. Our foreign and domestic commerce flourished as never before; in the decade before 1900 the export of American manufactures almost doubled. Only Germany's oversea trade had exceeded this rate of increase in the same period, largely because, as our manufacturing and trade associations pointed out, she was able to guarantee the uniformity and quality of her exported goods.

Since the 1870's, Austria, Russia, Germany, and England had established national standardizing laboratories or reorganized existing agencies, all with the avowed purpose of applying science and scientific methods to their nation's commerce and industry.<sup>61</sup> Most successful had been Germany, working with industry through the great *Physikalisch-Technische Reichsanstalt*, organized in 1887. In a single decade she had achieved world monopoly in the manufacture of aniline dyes and dye products, and her porcelain industry, artificial indigo industry, Jena optical glass, and scientific and precision instrument industries had no peers. Employing 13,600 people in 760 firms, the instrument and optical glass industries alone had trebled the export of their products in the past decade, making no secret of their debt to the *Reichsanstalt* for their growth.<sup>62</sup>

Great Britain, in an admittedly desperate effort "to retain her supremacy in trade and in manufacture," established her National Physical Laboratory in 1899.<sup>63</sup> The United States remained the only great commercial nation without a comparable standards laboratory. Our further development of the remarkable discoveries made in pure and applied science of the past century might well be forfeited, Scientific American warned, without sound and accepted commercial and industrial standards. A national laboratory had become "a national need."<sup>64</sup>

The initiative came from Lyman J. Gage, Secretary of the Treasury since 1897 and executive head of the Office of Weights and Measures. Gage, a solid, conservative Chicago banker, who had been brought to Washington by McKinley and possessed a talent for charming Congressmen with his diplo-

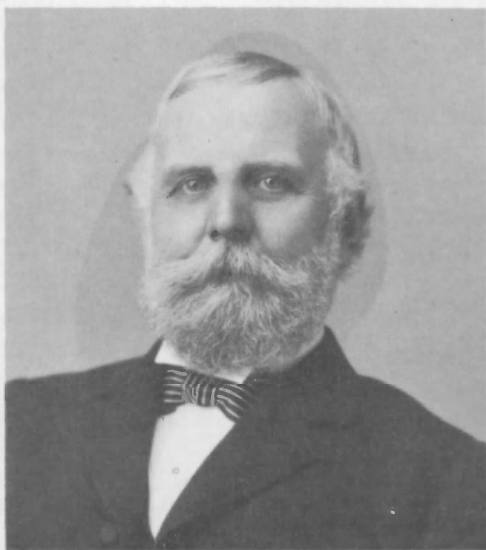
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<sup>61</sup>Among the great powers, only France (and the United States) had lagged. The great service of France in fostering international standards of length and mass was widely recognized, "but her national bureau for this purpose [was] considered to be too limited in scope to solve \* \* \* new problems \* \* \*." H. S. Carhart, "The Imperial Physico-Technical Institution in Charlottenburg," *Science*, 12, 702-703 (1900).

<sup>62</sup>Henry S. Carhart, "The Imperial Physico-Technical Institute in Charlottenburg," *Annual Report, Smithsonian Institution, 1900*, pp. 403-415. In an earlier (1892) account of the PTR, Prof. A. G. Webster had urged it as a model for an American standards laboratory. See *Science*, 56, 170 (1922).

<sup>63</sup>Richard Glazebrook, "The aims of the National Physical Laboratory of Great Britain," *Annual Report, Smithsonian Institution, 1901*, pp. 341-357.

<sup>64</sup>Editorial, *Sci. Am.*, 82, 307 (1900); *Science*, 10, 342 (1899).



*Lyman J. Gage, Secretary of the Treasury under President McKinley, who initiated and led the campaign for a national standardizing laboratory in the Federal Government.*

macy and wit, was to prove a wise and able mentor in the establishment of the Bureau.

In the late summer of 1899 he asked his Assistant Secretary, Frank A. Vanderlip, subsequently president of the National City Bank of New York, who had come to Washington as Gage's private secretary, to suggest someone to prepare a report proposing legislation for a national standards laboratory. Vanderlip wrote to Samuel W. Stratton, a classmate when they were undergraduates at the University of Illinois and at that time a 38-year-old professor of physics at the University of Chicago.

Stratton was invited to Washington. On October 28, 1899, the incumbent officer in immediate charge of weights and measures, "an expert leveler but without a glimmer of knowledge of physical principles,"<sup>65</sup> was transferred and Gage appointed Stratton to the nominal position of Inspector of Standards. Before long Stratton was at work drafting the bill to be included in the Secretary's letter report to Congress and organizing the arguments for the congressional hearings to come.

Securing endorsements for the proposed standards laboratory proved no difficulty. It had the overwhelming support of the National Academy of

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<sup>65</sup> Speech, Dr. Frank A. Wolf, 25th anniversary of the NBS, Dec. 4, 1926 (NBS Blue Folder Box 3, APW-301c).



Sciences, the American Philosophical Society, the American Association for the Advancement of Science, the American Physical Society, the American Chemical Society, the American Institute of Electrical Engineers, and other scientific institutions and associations. In personal testimony, letters, resolutions, and editorials, the leading scientists of the country, virtually every scientific agency in the Federal Government and in the States, leading manufacturers and commercial concerns, the railroad and iron and steel industries, manufacturers of electrical apparatus and appliances, and all scientific and technical journals and periodicals endorsed the proposed bill without reservation.<sup>66</sup> As James H. Southard, Representative from Ohio and champion of the bill in the House, said: "Never has a bill come with such a number of endorsements."

The arguments in the avalanche of endorsements were summed up in "the conditions which necessitate the establishment of a national standardizing bureau," set down in Secretary Gage's letter to Congress on April 18, 1900, and here slightly abbreviated:

The establishment of uniform standards, their maintenance, and the solution of problems connected with them, has until recent years been confined to standards of length, mass, capacity, and temperature; "but the increased order of accuracy demanded in scientific and commercial measurements and the exceedingly rapid progress of pure and applied science have increased the scope of such work until it includes many important branches of physical and chemical research, requiring \* \* \* a complete laboratory, fitted for undertaking the most refined measurements known to modern science."

An examination of the functions and sums of money devoted to the maintenance of the German, English, Austrian, Russian, and French institutions "is the most convincing evidence of the importance of problems pertaining to standards and standard-measuring apparatus."

Institutions of learning, laboratories, observatories, technical institutions, and scientific societies in this country are proliferating and growing "at a rate never equaled in the history of any nation," their work "requiring accurate reliable standards, which in nearly every case must be procured from abroad, or cannot be procured at all."

"The extension of scientific research into the realm of the extremes of length, mass, time, temperature, pressure, and other physical

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<sup>66</sup> These endorsements will be found in the congressional documents dated Apr. 18, May 3, and Dec. 28, 1900, cited in footnotes below.

quantities necessitates standards of far greater range than can be obtained at present."

"The introduction of accurate scientific methods into manufacturing and commercial processes involves the use of a great variety of standards of greater accuracy than formerly required."

More and more, "commercial transactions are \* \* \* based upon the reading of electrical measuring apparatus, inaccuracies of which involve great injustice and financial losses." It should be possible "to calibrate or test electrical standards of all kinds for commercial, as well as the most refined scientific work."

"The scientific work carried on by the different departments of the Government involves the use of many standards and instruments of precision, which are too frequently procured from abroad" and regularly returned there for testing.

The manufacture of scientific apparatus and instruments of precision recently begun in this country is growing, and "to secure the requisite degree of uniformity and accuracy" in their products, "American manufacturers of such apparatus must have access to a standardizing bureau equivalent to that provided for the manufacturers of other countries, notably Germany and England."

Not least,

"The recent acquisition of territory by the United States increases the scope and importance of the proposed institution, since the establishment of a government in these possessions involves the system of weights and measures to be employed," and in the near future "large public improvements \* \* \* [such as] schools, factories, and other institutions will be established, all of which require the use of standards and standard-measuring apparatus."<sup>67</sup>

These were, for the most part, immediate and pressing considerations. They indicated clearly the degree of dependence of American science, industry, and commerce upon European agencies, and made glaring the contrast between the work possible in the little Office of Weights and Measures and in the German Reichsanstalt.

Interestingly enough, except for the general reference to the scientific work of Government agencies, no mention was made in the "conditions" of better standards required in the collection of customs and internal revenue, in the purchase of supplies for the Government, or in establishing specifica-

<sup>67</sup> Letter, Secretary of the Treasury, Apr. 18, 1900, sub: National Standardizing Bureau (56th Cong., 1st sess., H. Doc. 625, serial 3997), p. 3. See also Annual Report, Secretary of the Treasury, 1900, p. lxxvii.

tions for Government purchases, which were to occupy so much of the time of the Bureau in its early years. Nor did the conditions include better standards for the general public, whose every purchase and transaction is based on standards. Yet from the beginning the Bureau was to become involved in Government specifications, crusade for the consumer, and act to put better weights and measures in the hands of State and municipal authorities.

The proposed bill contained in Gage's letter of April 18 recommended that the Office of Standard Weights and Measures be reorganized as a separate agency to be designated the National Standardizing Bureau, and that it remain under the Secretary of the Treasury. As stated in the letter,

*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 determining 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.<sup>68</sup>*

These six functions, subsequently enacted into law without change, made the Bureau the source of national standards and their custodian. The Bureau was to have no regulating or policing powers; enforcement of standards was left to the discretion of the States. On the other hand, the responsibility of the Bureau for the establishment of standards, standard instruments, tests, and analytic procedures, and for the determination of physical constants and the properties of materials, made its scope of research in the physical sciences virtually unlimited. And the delegation of responsibility to it for the investigation of any problem in connection with standards was to enable the Bureau to span the gap between standards of measurement and standards of performance in the coming age of mass production, and to leap thence to the age of atomic research and space physics.

<sup>68</sup> Letter, Apr. 18, 1900, p. 1. The bill as enacted into law appears in app. C.

The proposed bill made the services of the Bureau freely available to the Federal Government and to State and municipal governments, and, for a fee, to 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 Bureau personnel, scientific, technical, clerical, and custodial, were to be under Civil Service appointment, and to insure that the Bureau served the best interests of science and commerce, a visiting committee of five members appointed by the Secretary of the Treasury from among the leading scientists and industrialists in the Nation was to visit the Bureau at least once a year and report to the Secretary upon the efficiency of its work and the condition of its facilities and equipment.

The staff of the new agency recommended in Gage's proposed bill consisted of a director at \$6,000 per year, a physicist at \$3,500, a chemist at \$3,500, two assistant physicists or chemists at \$2,200 each, two laboratory assistants at \$1,400 each, two others at \$1,200, a secretary at \$2,000, two clerks at \$1,200 and \$1,000 respectively, a messenger at \$720, an engineer at \$1,500, a fireman at \$720, three mechanics at \$1,400, \$1,000, and \$840 respectively, a watchman at \$720, and two laborers at \$600 each, making a total of 21.

The bill asked for appropriations of \$34,900 for staff salaries, \$10,000 for general expenses, \$25,000 for the purchase of a laboratory site, \$250,000 for a suitable laboratory, and \$25,000 to equip the laboratory. These sums, Gage pointed out, were in no way excessive by comparison with those allowed the national laboratories abroad. The Normal Eichungskommission, established in 1868 in Berlin to regulate and inspect weights and measures, had been granted an appropriation equivalent to \$250,000 in 1899 for new buildings and equipment, and its annual appropriation was \$36,000. The Reichsanstalt at Charlottenburg had cost \$1 million and had an annual appropriation of \$80,000. Together the German bureaus were spending \$116,000 a year.

In England the testing bureau at the Kew Observatory (1871), the Standards Department (1879), the Electrical Standardizing Laboratory (1890), and the new National Physical Laboratory (1899) had total appropriations equivalent to \$62,100. Austria's Normal Eichungskommission, established in 1871 in Vienna, currently spent \$46,000 a year, and the Russian Central Chamber of Weights and Measures, established in 1878 at St. Petersburg, with laboratories costing \$175,000 and added structures built in 1895, spent \$17,500 annually. By contrast, the appropriation for the U.S. Office of Weights and Measures for 1897-98 had been \$10,000.<sup>69</sup>

<sup>69</sup> *Ibid.*, pp. 9-11.

Secretary Gage's letter was referred to the House Committee on Coinage, Weights, and Measures on April 23, 1900. At the first hearing, on May 3, several members of the committee wondered aloud at the willingness of the superintendent of the Coast Survey to lose an office of his agency, demurred at creating another bureau in the Federal Government, and, coming to the heart of the matter, expressed the opinion that both the salaries and construction costs for the new bureau seemed much too high.

Dr. Henry S. Pritchett, superintendent of the Coast Survey but soon to become president of MIT, had been consulted by Stratton on the matter of salaries. Pritchett told the committee that he himself received \$5,000, although by law the position called for \$6,000, the same salary proposed for the director of the new bureau. There was apt to be considerable difference between a \$5,000 and a \$6,000 a year man, he said, and if the right man was found he should have the higher figure. As for the salaries of the other scientists, they were "about what they would get in college life"; a good, even a first class, chemist or physicist such as the bureau must have could probably be found for \$3,500.<sup>70</sup>

When someone questioned whether the head of the proposed bureau should receive a salary within \$2,000 of that of the Secretary of the Treasury himself, Lyman Gage briskly replied: "Almost anybody will do for the Secretary of the Treasury \* \* \* [but] it takes a very high-grade man to be chief of a bureau like this. There are plenty of patriotic citizens who are willing to be Secretary \* \* \* at almost any salary they might get, but this \* \* \* [man] must have and hold the esteem and confidence of all \* \* \* scientific men everywhere, and unless he is as good or a better man than is found in private institutions and concerns he will not have the respect and confidence of the community."<sup>71</sup>

To objections that the amount asked for the laboratory seemed too large, the committee was told that the structure would have to be erected outside the city proper, in an isolated place free from vibration, traffic disturbances, and interference from electric streetcar lines. It would have to be solidly built with at least twice as much material as in an ordinary building of the same size, with twice as complex heating, piping, and plumbing arrangements, and with four or five times more wiring. In addition, it must have a heating plant, engines, dynamos, motors, pumps, and other heavy machinery, as well as instrument shops, in a separate structure apart from the main laboratory.<sup>72</sup> It was an impressive structure Stratton described, and he won his point.

<sup>70</sup> Hearing before the Committee on Coinage, Weights, and Measures, May 3, 1900 (56th Cong., 1st sess., H. Rept, no document or serial number), p. 14.

<sup>71</sup> *Ibid.*

<sup>72</sup> Congressional Record, 56th Cong., 2d sess., Mar. 2, 1901, p. 3475.

On May 5, 1900, after defeat of a motion to reduce the director's salary to \$5,000, James H. Southard, Chairman of the Committee on Coinage, Weights, and Measures, introduced the bill (H.R. 11350), essentially identical with that proposed in Gage's letter, in the House. His final argument, insuring the unanimous endorsement of his committee, was that under proper administration the expenses of the new agency would be "largely repaid by fees resulting from its work."<sup>73</sup> On May 14, Jonathan Rose of Vermont introduced the bill in the Senate (S. 4680). Further hearings were delayed until after the summer recess of Congress.

The hearing before the Senate Subcommittee of the Committee on Commerce opened on December 28, 1900. Once again the proposed salaries of the scientists came under fire. Secretary Gage admitted that they were "relatively high as compared with \* \* \* the salaries the Government pays in a good many other directions," but in the new bureau the United States had to have "the best in the world." Stratton added that they were no higher than those for corresponding positions in the leading universities, and further, that an academic career was apt to be preferred as less likely subject to political weather changes. Moreover, bureau personnel would not have the 3 or 4 months of annual vacation available to academic faculty for study or travel. As for the salary proposed for the director, said Stratton, scientific directors in some of the large industrial corporations were able to command as much as \$10,000 a year.<sup>74</sup>

The Senate subcommittee nevertheless cut back the salary schedule from \$34,900 to \$27,140 by reducing the director's salary to \$5,000 and eliminating 8 of the 21 positions, including 2 laboratory assistants, the secretary, a clerk, the fireman, 2 mechanics, and a laborer. Other modifications in the Senate bill saw the sum for equipping the main laboratory reduced from \$25,000 to \$10,000 and "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" reduced from \$10,000 to \$5,000.

Returned to the House for full debate on March 2, 1901, the bill met with predictable mixed reactions. Upon its reading, Mr. John W.

<sup>73</sup> Although by the 1960's fees from calibrations, testing, and other services exceeded \$6 million annually, the Bureau was never to be, as Congress seemed to think it should be, self-supporting. See Hearings before the Subcommittee of the House Committee on Appropriations \* \* \* for 1906 (Dec. 2, 1904), p. 230 (L/C:HJ10.B33 and HF105.C55). House appropriations hearings will hereafter be cited as Hearings \* \* \*.

<sup>74</sup> Hearings before the Subcommittee of the Committee on Commerce, Dec. 28, 1900 (56th Cong., 2d sess., S. Doc. 70, serial No. 4033), pp. 4-7. \$10,000 was the salary of Albert Ladd Colby, chief metallurgical engineer of the Bethlehem Iron & Steel Co. and member of the first Visiting Committee, whose physical and chemical laboratory employed 36 people. See also Congressional Record, March 2, 1901, p. 3476.

Maddox of Georgia rose to say: "I do not know anything about the bill. If I understood it, or if it was possible for me to understand it \* \* \* I might be in favor of it. I want to know what it will cost." Southard explained. Mr. Joseph G. Cannon of Illinois, who as "Uncle Joe Cannon" was to be the long-time autocratic Speaker of the House (1903-11) but was then Chairman of the House Appropriations Committee, proved characteristically forthright: "I don't think there ought to be any [such] bureau organized."<sup>75</sup> But Mr. John F. Shafroth of Colorado, who had objected earlier to the idea of another bureau in the Government, spoke up again, saying he had changed his mind. Perhaps moved by the reading in the House of a telegram from Carl Hering of the American Institute of Electrical Engineers ("National humiliation not to have own standards"), he declared: "There is a new creation \* \* \* of measure and of standards in the world \* \* \*. [The bill] is a measure which this Government should have passed long ago."<sup>76</sup> He was for it, and he was in the majority.

"To meet all possible objections in the amended bill," the House accepted the Senate salary and expense changes and on March 3, 1901, the bill was enacted into law (31 Stat. 1449), to take effect on July 1. The functions and responsibilities of the bureau as originally described in Secretary Gage's letter remained unchanged, but instead of "National Standardizing Bureau," the name by law became the "National Bureau of Standards."<sup>77</sup>

In 1903 when the Bureau was transferred from the Treasury to the new Department of Commerce and Labor, the word "National" was eliminated from the name at the direction of the new department chief. No reason was given but it was said the change was made because the word "National" was inconsistent with the titles of such similar bureaus as the Coast and Geodetic Survey and the Geological Survey. Thirty years later, in 1934, as the proliferation of "bureaus of standards" in State governments, chambers of commerce, and even department stores threatened total loss of identity of the Federal agency, the original name was restored.<sup>78</sup>

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<sup>75</sup> As Dr. Frank A. Wolff remembered it, "Speaker Cannon, the then watchdog of the Treasury, though [later] a friend of the Bureau, HAD to oppose it. In his speech he ridiculed the idea of a \$250,000 building to house 14 men." Speech, 25th anniversary of the NBS, Dec. 4, 1926.

<sup>76</sup> Congressional Record, Mar. 2, 1901, pp. 3476-3477.

<sup>77</sup> *Ibid.*, pp. 3472-3473.

<sup>78</sup> Memo, Secretary of Commerce for Director, NBS, Apr. 27, 1934 (NBS Box 370, AG); Science, 78, 453 (1934); interview with Dr. Lyman J. Briggs, Nov. 1, 1961.



*A 16th century measuring rod, for measuring pastures, fields, vineyards, meadows, and fruit gardens. "To find the length of a measuring rod the right way and as it is common in the craft . . . Take sixteen men, short men and tall ones as they leave church and let each of them put one shoe after the other and the length thus obtained shall be a just and common measuring rod to survey the land with." Jacob Köbel, Geometrei, von Künstlichen Messen und absehen . . . (1536), Dii-Diii.*