# Chapter 3

## Legalizing The Metric System in The US

In May of 1863, an international meeting of postmasters convened in Paris. The participants of this International Postal Conference agreed to adopt the gram as the unit for international standard postal rates. This agreement immediately precipitated a problem for the US Postal Service—the metric system was not legal for trade in the US.

That same year in Berlin, a statistical conference was held. In the eighteenth and nineteenth century, statistics was assumed to be demographic and economic data, which had been collected about countries or states. This data was generally used for determining tariffs and trade. The conference participants believed that a single set of weights and measures should be agreed upon for use by all the participating nations. They resolved that the metric system would be the most advantageous for international commerce. This decision put pressure on the US to take legislative action to rectify the inability of current US law to engage with the metric system.

Congress also created the National Academy of Sciences (NAS) in 1863. By 1866 the NAS had indicated their preference for adopting the metric system.

The American Civil War would worm its way into the monograph documenting the 1863 conference. The report noted that at an earlier congress in 1860, held in London, that:

> The undersigned, on taking his seat in the body, was invited, in behalf of the United States, to confer and unite with that Commission in its proposed and forthcoming report. A draft of that report had been printed, presenting, in review, the different nations which had adopted, or were disposed

> to adopt, the metric system of weights and measures, but in which it was stated that "the *Confederate States* of America have expressed a desire to introduce the metric system of weights and measures." The undersigned, on perceiving the statement, protested at once against its propriety, or its admission into the report, on the ground that the "Confederate States," so called, had no separate, national, lawful existence, but still formed integral portions of the United States of America. The objection was acquiesced in, and the words in question were modified to read, "Some of the States of America have expressed a desire," &c., &c.[1]

The Confederacy wanted metric, but the North argued they had no legal status as a separate country to invoke the metric system. The metric system had become a political football in the American Civil War.

John Adam Kasson (1822-1910), was a Republican member of the House of Representatives from Iowa. He had been a First Assistant Postmaster General in the Lincoln administration. Kasson had also represented the US at the Paris postal conference. The international resolution was of interest to him, and in 1864 he became chairman of the Committee on a Uniform System of Coinage, Weights and Measures. He soon also became a leading advocate for the implementation of the metric system in the US. In 1866, Kasson penned The Metric Act of 1866, which passed without controversy, and made the use of the metric system legal in the US. Kasson became a leading proponent of the metric system, He supported metric adoption throughout the rest of his life. Historian Charles F. Treat states: "To him belongs most of the credit for the enactment of the 1866 Act legalizing the use of the metric system."[7] The metric system was made legal, but not promoted. The everyday life of U.S. citizens had not changed. Those who might know about the legislation were free to ignore it. There was, however, a great optimism among the legislators about the future of the metric system in the US:

> The interests of trade among a people so quick as ours to receive and adopt a useful novelty, will soon acquaint practical men with its convenience. When this is attained–a period, it is hoped not distant–a further Act of Congress can fix the date for its exclusive adoption as a legal system. At

 

> an earlier period it may be safely introduced into all public offices, and for government service.

Senator Charles Sumner (1811-1874), who was on the Senate side of the legislation in 1866, was very optimistic about mandatory adoption of the metric system in the US. A blue ribbon committee was appointed the same year, and it was believed that metric adoption would be a forgone conclusion. Charles Davies (1798-1876), who was the committee chairman, and member Frederick Augustus Porter Barnard (1809-1889), were both from Columbia University.

The President of the University was Frederick A.P. Barnard. The obvious merits of the system were plain to him. He and other committee members expected the group would quickly endorse legislation adopting the exclusive use of the metric system in the United States. It would come as a surprise that Professor Charles Davies of Columbia, a member of the same committee, would voraciously object.

The report offered by Chairman Davies, in its 1871 final form, was his personal view, and not those of a collaboration. Davies saw the introduction of metric terminology as an assault on the English language. He also claimed it would separate us from our historical documents. Property in the US would now be expressed in a new *foreign* language. The work of John Quincy Adams was cited by Davies in his arguments against metric adoption. The anti-metric views of British astronomer John Hershel (1792-1871) were also introduced into the report.

Davies complained the meter was an inconvenient length, and that further measurements indicated it did not really represent a fraction of the distance along the surface of the Earth. The foot, based on the division of a yard, based on a seconds pendulum, was a much more acceptable length for Davies. He argued that decimals might be superior for calculation purposes, but fell short for practical applications encountered in everyday life. Davies did not offer examples of the everyday applications which might be complicated by the metric system. The Chairman felt that the metric prefixes would be too complicated and abstract for school children to learn. They were Greek and Latin based, which would be foreign, and not comport well with English. The difference between deca-meter and deci-meter would not be immediately obvious to an English speaking student. He asserted that only sharp, short, Anglo-Saxon words like inch, foot, peck and ton would be easily learned and embraced. Davis argued the public would not put up with any mandatory change, and would reject lengths which were not based on body parts.

Davies colleague, President Frederick A.P. Barnard was a man of many talents, he was president of The American Association for the Advancement of Science, Director of Printing and Lithography in the United States Coast Survey, and a charter member of the National Academy of Sciences. He was fervent that access to higher education should be provided to women. This lead to the posthumous establishment of Barnard College for women at Columbia not long after his death. Barnard pointed to the considerable number of new countries adopting the metric system, and offered a point by point refutation to the assertions Davis had made. The arguments made by these men would set the tone for metric conflict in the US over the next forty years.

The debate had moved outside of the confines of Congress, lingered for a short time in the academic sphere, then became a debate among people with no working knowledge of metrology, and finally was embraced by those with well honed skills of inflammatory polemic. It was a portent.

This disagreement became known to history as the Davies-Barnard schism. In response, mandatory metric legislation in 1866 stalled—and then died.

The report generated by Davies became a template for future anti-metric polemicists. Charles Treat observed:

> Their report was the first one of any consequence to clothe social, political and economic arguments on the subject in a scientific garb in order to give credence to otherwise unsupported assertions. It also raised several new objections, including the foreign origins of the system . . .[2]

The US now had two legally sanctioned sets of weights and measures. It was similar to what John Quincy Adams had cautioned would happen if the metric system were adopted, that measurement units would only be added and never subtracted from use by the public. The weights and measures of the US became more muddled as a result of this legislative augmentation, which has not been resolved to this day.

Metric advocates in the US began to organize after this unexpected defeat. Three organizations were created, two for metric adoption, and one opposed. The two in favor were, the American Metrological Society

 

(1873), created by Frederick A.P. Barnard, and the American Metric Bureau (1876) which asserted it was "a missionary society for educational purposes." In 1877, American Metric Bureau (AMB) member and American architect J. Pickering Putnam (1847-1917), penned a monograph called *The Metric System of Weights and Measures.* A summary figure of the metric system is presented at the end of the monograph. It is reproduced as Figure 3.1

The chart illustrates how the metric system in the 19th century has pre-metric usage and culture imposed upon it. Modern usage of the metric system has simplified metric use to an extent that would probably surprise members of the AMB. In modern common usage, only milliliters (mL) and liters (L) are used for volume measurement. The chart has 1/2, 1/5, 1/10, 1/20, 1/50 and 1/100 fractions of a liter as suggested volumes. These are 500 mL, 200 mL, 100 mL, 50 mL and 10 mL volumes. When written in a modern manner, they are all nice whole numbers which can be immediately compared; but that's not what was suggested by the pro-metric American Metric Bureau chart. It expressed liters in the common vernacular of the day—fractions, which do not provide an instant recognition of magnitude. The nineteenth century was still a place with an almost uncountable number of measurement units—so what appears to a contemporary mind to be a very large number of measures on the AMB chart, would probably seem like a simplification.

The chart also has names for quantities below one-half liter. They are the Double Deciliter (200 mL), Deciliter (100 mL), Demi Deciliter (50 mL), Double Centiliter (20 mL) and Centiliter (10 mL). The original metric decree of 1795 contains this paragraph:

> 8. In weights and measures of volume, each of the decimal measures of these two types shall have its double and its half, in order to give every desirable facility to the sale of divers items; therefore, there shall be double liter and demiliter, double hectogram and demihectogram, and so on with the others.

This explains the name proliferation found in the American Metric Association graphic. The metric system originally had prefixes for doubling and halving quantities: double and demi. Double is straighforward in English. The prefix demi (in the linguistic sense) is from

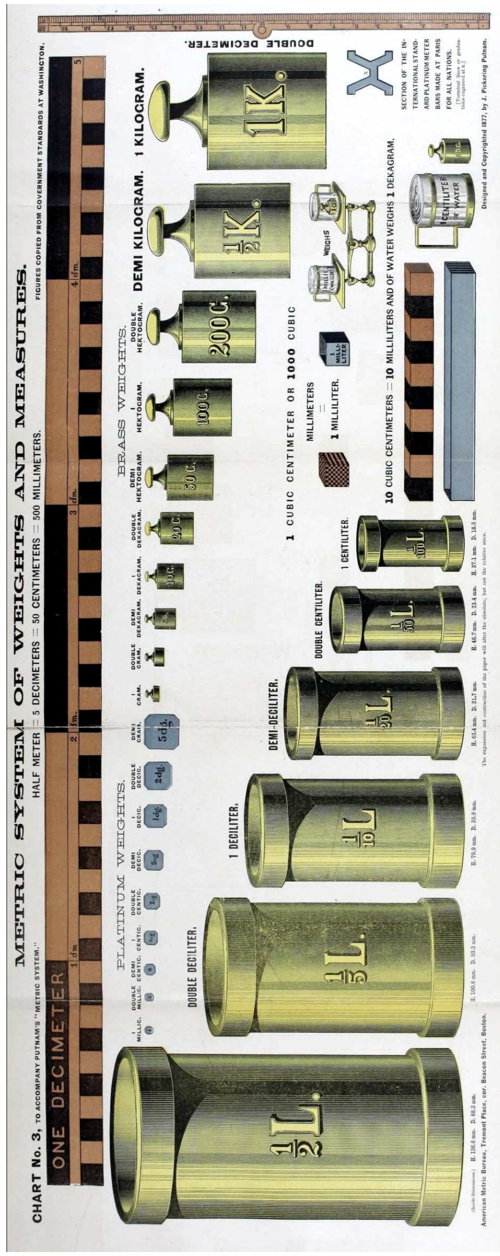


Figure 3.1: Metric Chart from *The Metric System of Weights and Measures* by J. Pickering Putnam, American Metric Bureau, 1877.

Latin dimidium or "divided in half," and via Old French and Middle English, it became demi. It was accepted practice to concatenate metric prefixes to produce a proliferation of unnecessary units such as a demi hectogram, or double deciliter.

The unit proliferation common in the day has slowly been distilled, but contemporary usage is still littered with the unnecessary atavistic prefixes centi, deci, deca and hecto. Thankfully double and demi have not been embraced in *modern* metric countries which use the liter and milliliter exclusively in everyday measure.

When looking at the Figure 3.1, the example values for mass in grams appear to use a capital G, with a typeface that looks like a C. In this case Putnam actually uses integer values of 1, 2, 5, 10, 20, 50, 100 and 200 grams; but at the last moment resorts to 1/2 for 500 grams, and 1K for 1000 grams. Each quantity again gets its own name: 1 gram, double gram, demi dekagram, 1 dekagram, double dekagram, demi hektogram, double hektogram, and demi kilogram.

In French doublé means double and demi is a word prefix for half. Before modern measurement, scales were developed that have a readout with a continuum of numerical values, it was easiest to halve or quarter items with a beam balance or volume container. The introduction of continuous volume and mass measurement allowed for a large variety of values. The introduction of double and demi appears to be an attempt to bring order to pre-metric mass and volume measures which had somewhat binary relationships, but quickly possess discontinuous exceptions. In terms of volume, pre-metric measures had these inconsistent numerical relationships:

1 tun = 2 pipes
1 pipe = 2 hogsheads
1 hogshead = 2 barrels
1 barrel = 3 $\frac{1}{2}$ firkins
1 firkin = 9 gallons
1 gallon = 4 liquid quarts
1 liquid quart = 2 liquid pints
1 liquid pint = 4 gills

Most of the unit names have no traceable origin. The word *quart* is from a Latin word that means "four" as it takes four of them to make a gallon. The word firkn appears related to an Old English word that also means "four." Halving and quartering are vestigial leftovers from premodern times and fortunately this unnecessary proliferation of word designations were eventually dropped from the metric system.

The AMB book offers a four decimeter rule for length, which appears to be a sort of "metric foot" size of rule. It is marked in decimeters and has black and light brown patches which show centimeters, but no millimeters. It does identify that a Half-meter = 5 decimeters = 50 centimeters = 500 millimeters. They also offer a "Double Decimeter" length rule which is divided into centimeters and millimeters. The best modern usage is millimeters only, with common ruler lengths of 150 mm, 300 mm, 600 mm.

These examples are all artifacts from an era when the metric system was still in its infancy; it was not understood how it might best be used. Clearly the chart did not need fractions for the volume, milliliters would have been fine, with a reminder that 1000 mL is a liter. None of the names for each division are needed, and are not currently used. The gram values could all have been shown as integers, and again there is no need to name each multiplication of a gram shown. When illustrating volume, they started with the liter, and subdivided it with fractions. In the case of the gram, they started with it, and used integer multiples. In modern use, milliliters and grams make the most sense. We know that 500 mL of water is 500 grams, and the integer values match. The American Metric Bureau's suggested use of the metric system in the 19th century offered familiarity, but not simplicity.

Engineering and science continued to progress, and the original prototype meter was becoming obsolete, and worn from usage. The artifact also tended to flex when used for calibration, which decreased its accuracy. The original artifacts were over 70 years old. This precipitated concern that other, alternative measurement artifacts might be developed, and a measurement "fork" might occur.[1]

In 1870, Scientists from nations around the world were invited by Napoleon III to attend a conference in Paris to address the problem. The Franco-Prussian War delayed the conference, and lead to the ouster of Napoleon III. The delay had the positive outcome that Germany and Italy, along with a handful of other nations, adopted the metric

[1] The term *fork* refers to what happens with open source software when a group of programmers have irreconcilable differences. They often split into two new programming groups with two competing sets of software which are intended to implement a similar vision. This software split is referred to as a fork.

 

system afterward. In 1875, scientists from 30 countries attended. The delegates were tasked with the development of new meter, and Kilogram artifacts. The metric system was now under international control, which would make it more attractive as an international standard, and would clearly further its adoption. The original French standards would now be replaced with standards which would be produced and agreed upon by international consensus.

The issue of using the Earth as a "metrology standard" was eschewed, and the reproduction of the existing artifacts as exactly as could be achieved was decided upon. The flexing problem which plagued the original rectangular bar meter artifact, was addressed by redesigning the meter bar with an "X" cross-section instead. This design change reduced the flexing considerably. Rather than using the ends for measurement planes, the new meter bars had inscribed lines, which were exactly 1 meter apart.

On the 20th of May, 1875, Mr. E. B. Washburne (1816-1887), Minister to France, signed the Treaty of the Meter on the behalf of the US. This made the US an active participant in the decisions, and insured they would receive calibration standards for the meter and Kilogram when they were fabricated. These standards were delivered to the US in 1889.

There were attempts to reform British measures in the late 18th century. These were precipitated by the considerable number of scientific discoveries which took place at this time. The eighteenth century metrologists were interested to incorporate the results of new scientific discoveries and theories into any weights and measurements reform which might take place. Communication between the French and the British concerning cooperation with weights and measurements reform broke down, and the British decided to strike out on their own.

Riggs Miller (1760-1800) was an avid proponent of the seconds pendulum for a length standard. As the second of time was determined by the motion of the Earth, it was argued that the length of a seconds pendulum, at a given latitude, would produce an objective and repeatable standard of measure. In the end, the seconds pendulum was seen as too radical a change from contemporary metrology of the day and dropped.[3] The British also considered using a measurement of the Earth as a "standard," but this idea also faded away with time. Author Robert Zupko summarizes the situation during this period:

> A number of conclusions can be drawn from this examination. Besides the many faults mentioned in the preceding discussions, all of the plans advanced before 1824 suffered from the fact that they were undertaken as independent actions by private citizens and were not sponsored or sanctioned directly by the central government. Since they responded vociferously to centuries of government recalcitrance in effecting significant and wide-spread reform, London viewed them as vicious attacks and generally spurned them. All the of the major changes in British metrology between the Tudor and Hanoverian periods were brought about through the work of government-sponsored commissions, and the dominant characteristic of these panels was conservatism.

In response to the creation of the metric system, the British, in 1824, established measurement standards for the yard, the troy pound, and the gallon. All other weights and measures were to be derived from these standards. This was a radical departure from earlier practice. The use of the new units was to be short-lived. Ten years later, in 1834, a fire swept through the British Parliament building, destroying the Troy pound and the Yard-Bar. There is an irony in this situation, in that wooden tally sticks which were used as an early form of money were being burned, and in turn caused the fire which destroyed the Troy pound which was the basis of coinage in Britain and the US.

A panel was convened to determine how to create replacements for the lost artifacts. A new imperial standard for the yard was constructed of gunmetal, which was 1 inch square in its cross-section and 38 inches in length. Two 3/8 inch diameter holes were drilled half-way into the bar at each end. These are known as well-holes. The distance between the centers of these well-holes defined the length of 36 inches. At the bottom of each hole was placed a small gold stud with finely engraved lines that could be used to determine the standard length. This was the most accurate and reliable standard the British had ever created.

The common weight standard for ordinary commodities was to be the avoirdupois pound. In the case of gold, silver, platinum, diamonds, or other precious stones, only the troy ounce, or decimal divisions of it were allowed.

New imperial standards were sent to the US in 1855. Two standards for the yard, and one for the avoirdupois pound arrived at the US Office of Weights and Measures. Engineering and technology continued to improve, and it was later discovered that the yard standard was unstable and measurably shortening. The pound standard was also found to be unsuitable as a measurement touchstone.

Fortunately, the US had a standards option. Because they had signed The Treaty of the Meter, metric standards were available. The metric standards had been better designed for comparison, and as they were the only viable option, became the defacto measurement standards for the US. This situation continued for several years.

Then on April 5, 1893, T.C. Mendenhall (1841-1924), Superintendent of Standard Weights and Measures, concluded that 1) there are no existing standards for the current customary weights and measures which are of sufficient quality for use in defining these weights and measures. 2) his office from this day forward will regard the meter and Kilogram standards which are on hand as the fundamental standards 3) the customary units, the yard and the pound, will be derived from these standards mathematically. 4) As there has been no alternative this has been the only option available and has been the procedure used for a number of years. In Mendenhall's words: "Indeed, this course has been practically forced upon this Office for several years, . . ." [4]

This became known as The Mendenhall Order. Congress yet again remained silent on the weights and measures of the US, but scientific progress had rendered the current situation untenable. The trade and industry of the US would be hampered without contemporary measurement accuracy, and Mendenhall had to unilaterally act to maintain accurate metrology in the US.

The fundamental "customary" standards of length in the United States were no longer based on those in England, but were now defined in terms of the metric standard (i.e. the meter). It was agreed that 1 yard = 3600/3937 meter (0.914402 meter). The inch, foot, yard and mile were now all defined in terms of the international meter, and had no physical definition without this system of measurement. Prototype Kilogram number 20 became the basis for US mass measurement.

This order was not the break from tradition that some metric advocates assert. It is essentially part of the "Adams Doctrine" which indicates that the only purpose of metric standards would be as calibration standards for the current set of Ye Olde English measures as inherited from the past.

  

It is clear, however, that Mendenhall was very taken with the metric system. In the 1902 metric hearings before Congress, John Brashear (1840-1920), who was the President of The Engineer's Society of Pittsburgh and an instrument manufacturer, testified that after hearing a lecture by Mendenhall, he became a metric enthusiast. If Mendehall had the influence to convert the US to metric, he almost certainly would have exercised it.

In 1893, the World's Colombian Exposition in Chicago placed on display for all to see, the wonders of Westinghouse electric lighting, but another nearby gathering of great importance occurred, which is generally forgotten. It is described by Hallock and Wade:[5]

> In 1893 in connection with the Worlds Colombian Exposition at Chicago, an International Congress of Electricians was held, and a Chamber of Delegates, composed of officials appointed by various governments, proceeded to define and name the various electrical units.

The US Congress passed an Act on July 12, 1894 which defined and established the units of electrical measure for the United States. These consisted of those agreed upon at the Chicago congress of Electrical Engineers in 1893, which displaced the ohm in use by Great Britain. According to Hallock and Wade:[5]

> At a meeting held in 1884 an international commission decided the length of the column of mercury for the standard ohm, and the legal ohm was defined as the resistance of a column of mercury of one square millimeter section of 106 centimeters in length at a temperature of melting ice.

This did not win out however when:

> ...Professor Henry A. Rowland in America and Lord Rayleigh in England, carried on further investigations to evaluate the true ohm, with the result that the length of the mercury column was found to be nearly 106.3 centimeters, which accordingly was adopted by the British Association Committee in 1892, together with the definition of the column in length and mass, rather than length and cross-section.

 

This is a clear example where millimeters demonstrate their superiority as the primary small unit for the metric system. The length would have originally been 1060 mm and changed to 1063 mm which are integer values eliminating the decimal point.

The ohm, ampere, volt, coulomb, farad, joule, watt and the unit of inductance, named the henry, after American Scientist Joseph Henry (1797-1878), were all defined in Chicago. There were no US representatives trying to define alternative “US Customary” equivalents of the electrical units. No argument for the inclusion of barleycorns, inches or yards in the electrical definitions were contemplated, they were all metric. Electricity, the most important discovery, perhaps since fire, is not described in any way by US English Units.

In 1895, the 54th Congress convened, with Republicans in control of both houses. Representative Denis M. Hurley (1883-1899) introduced a mandatory metrication bill. It mandated that all Government Departments exclusively adopt metric on July 1st of 1897, and by July 1, 1899 the metric system would be the only legal system of weights and measures in the US. For ten years Hurley had worked as a weigher’s foreman in the New York custom house. He stated:

> It was while I was thus employed, . . . using the weights and measures everyday, that I saw the want of a better of a better system than the irrational and poorly constructed ones in use. Then, too, I found the French metric system so full of beauty and utility that I have been its warm adherent ever since.[6]

In 1896, the US House of Representatives passed a bill which would have finally implemented the metric system on a mandatory legal basis, but then immediately voted to reconsider. The legislators began to have concerns about a possible reaction to mandatory legislation. A second vote was taken, and the bill was then “unpassed.” According to NIST Historian Charles Treat in 1971: “This was as close to achieving legislative endorsement as the metric system was to come in this country. Congress came within an eyelash of approving a measure to adopt the metric system.”[7]

  

## References


[1] Ruggles, Samuel B. *Report to the International Statistical Congress, at Berlin on The Resources of the United States* September 14, 1863 pg 10.

[2] Treat, Charles F. *U.S. Metric Study Interim Report - A History of The Metric System Controversy in the United States*, National Bureau of Standards Special Publication 345-10, August 1971 Page 53

[3] Zupko, Robert E. *Revolution in Measurement*, The American Philosophical Society 1990 Page 88

[4] Barbrow, Louis and Judson, Lewis *Weights and Measures Standards of the United States, NIST Special Publication 447* 1976 Appendix 3

[5] *The Evolution of Weights and Measures* 1906 pg 207

[6] *U.S. House of Representatives Hearings on H.R. 2758*, January 30, 1896 pg 1

[7] Treat, Charles F. *U.S. Metric Study Interim Report - A History of The Metric System Controversy in the United States*, National Bureau of Standards Special Publication 345-10, August 1971 Page 41