Metrology.*

PARTIAL USE OF DECIMAL SYSTEM THIRTY-FIVE YEARS AFTER LEGALIZATION.

[CONTRIBUTED.]

The process of transition to the use of Federal money, inaugurated by resolutions of the Congress of the Confederation, July 6, 1785, and Aug. 8, 1786, was protracted through the time of our grandfathers, the generation following that which established the money. Kelly's *Universal Cambist,* whose preface is dated in 1821, thirty-five years after the original legislation, is a standard authority, having had official support. It said of the United States:

"Accounts are kept here in different ways, but chiefly in Dollars, which are divided into 10 Dimes, 100 Cents, or 1,000 Mills. This is called Federal Money, to distinguish it from the various currencies which were formerly the monies of the United States, and which are still partially retained in domestic traffic," etc.

The constitution of Massachusetts said then, and says now, in Chapter VI:

"III. In all cases where sums of money are mentioned in this constitution, the value thereof shall be computed in silver, at six shillings and eight pence per ounce," etc.

The United States Mint, though it began to coin money in 1793, did not strike many coins except cents, half-cents and half-dollars down to 1820; and coins of the several nations of western Europe continued in circulation. The Spanish original of our dollar was well known as the "piece of eight," meaning eight "bits" in the vernacular tongue of the United States, where the Spanish name is less familiar; one bit thus becomes 12½ cents obviously to us, but our grandfathers knew it as of the value expressed according to their long established custom in their different monetary reckonings. John Quincy Adams, Secretary of State, in his celebrated report on weights and measures, also dated in 1821, wrote as follows:

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* * * "now, when the recent coinage of dimes is alluded to in our public journals, if their name is mentioned, it is always with an explanatory definition to inform the reader that they are ten-cent pieces; and some of them which have found their way over the mountains, by the generous hospitality of the country, have been received for more than they were worth, and have passed for an eighth, instead of a tenth, part of a dollar. Even now, at the end of thirty years, ask a tradesman or shopkeeper, in any of our cities what is a dime or a mille, and the chances are four in five that he will not understand your question. But go to New York and offer in payment the Spanish coin, the unit of the Spanish piece of eight, and the shop or marketman will take it for a shilling. Carry it to Boston or Richmond, and you shall be told it is not a shilling but nine pence. Bring it to Philadelphia, Baltimore, or the city of Washington, and you shall find it recognized for an eleven-penny bit; and if you ask how that can be, you shall learn that, the dollar being of ninety pence, the eighth part of it is nearer to eleven than to any other number," etc.

This was characterized by Mr. Adams as absurd, and justly. Oh, yes—but—by the way, what is it that we are doing, A. D. 1901, thirty-five years after the inauguration by our fathers by the Act of Congress of July 28, 1866, of the change to metric weights and measures? Our rates of postage on foreign mail matter are by weights in grams, and we try to look them up in pocket diaries or other common places of reference and find them inaccurately stated by weights in ounces. We turn to the Revised Statutes of the United States, Section 3515, referring to our minor coins, and read:

"The weight of the piece of five cents shall be seventy-seven and sixteen-hundredths grain troy":

a circumlocution for five grams. We have had profile paper printed with metric subdivisions for its whole length and have measured it off in portions for sale by the yard. Imported paper in rolls of ten meters we have advertised as eleven-yard rolls. These few examples suffice out of many instances of misapplication of units of quantity in business and in publications.

We see the unreasonableness both of the Massachusetts constitution and of the adherence by our grandfathers, so long after they had established decimal reckoning, to their antiquated book-keeping, which occasioned great inconvenience from the incongruity of the two methods in use at the same time. When our grandchildren look back to 1901, what will they say of our now

hanging on to weights and measures that are out of date by consequence of the substitution of the metric units legalized thirty-five years ago?

Consider electricity, whose standards of measurément are fixed upon a metric basis by the law of July 12, 1894. The following is an extract from it:

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

Several of the electrical units have become familiar to us through the enormously rapid development of the applications of electricity. This is the case especially with the kilowatt, a commercial unit which we meet with in almost every technical publication we take up; but it has not yet entirely displaced that anomalous old unit, the horse-power (as to which reference may be made to *Engineering,* vol. 63, pp. 245 and 325, for Feb. 19 and March 5, 1897).

Consider the matter of assaying and coinage, in which the metric system is established. It has been used in the Mint for years, and is used in published tables or schedules of coins. The United States subsidiary silver money weighs one gram per four cents, and thus metric weight is in everybody's pocket. The troy pound has dropped out of practical use. Nevertheless, the troy ounce, incongruous as it is with other weights and measures, still comes in our way sometimes (in other places besides the Massachusetts constitution).

Consider pharmacy and some other matters connected with chemistry. The *United States Pharmacopoeia,* the reference manual of the apothecary, is exclusively metric. The *Dispensatory,* the corresponding manual of the physician, has metric values throughout. The use of the metric system was introduced in the United States Marine Hospital service about a quarter of a century ago quite thoroughly, and in the army and navy more recently. In practice in civil life prescriptions are to a large and increasing extent written in metric terms; but the mysterious old "apothecaries'" weights and measures (which for sales of candy and popular wares are not used by apothecaries) continue to be

used in the prescriptions of some of the older physicians, who in the natural course of events are gradually passing off the stage. Meanwhile pharmacists have double sets of weights and measures, and employ clerks who understand both, with extra trouble, cost and risk of mistake. In the sale of high grade chemicals the metric system has been introduced. E. R. Squibb & Sons, of Brooklyn, have used it exclusively for nine years, and the Bausch & Lomb Optical Co., of Rochester, issues a sixty-page priced catalogue "G" of "Chemicals and Reagents" in metric terms, with a conspicuous notice at the top of each page, "Prices of Chemicals are by Metric, NOT Avoirdupois Weight." Much glassware and rubber stoppers are made to metric scale. As to chemical manufacturing, all the tanks in a factory built by the Merrimac Chemical Company, of Massachusetts, for their extensive sulphuric acid works, were made on metric dimensions, and the Pennsylvania Salt Manufacturing Company have built a large plant entirely upon metric dimensions. The great Solvay Process Company, of Syracuse, makes use of the metric system in every way possible in its works. Drawings to go outside of the works for construction, etc., are not made in the metric system. The company says it finds no disadvantages, and would be very glad if its entire work could be upon the metric system. That means that as long as people outside cling to ancient weights and measures, so that conformity with them is required of the Solvay Process Company, the company gets only part of the advantages naturally belonging to its system. Chemical analyses are expressed in parts per million, per hundred thousand or per thousand, corresponding to grams per cubic meter, per hektoliter or per liter. Grains per gallon are out of date. Nevertheless, in dealing with quantities and consumption of water there still lingers some use of the United States liquid gallon, a unit long ago abandoned in Great Britain and Canada, distinguished for its lack of connection with other measures or weights, and not ordinarily used in the reading of water meters.

Consider geodesy and precise leveling. The metric measure has been very extensively used in precise leveling or other work of the United States Coast and Geodetic Survey, the United States Geological Survey, the United States Lake Survey, and the sur-

veys under the Mississippi River Commission. Among other literature from which evidence may be obtained about this, and about working in old measures incongruous with metric, there is an article and discussion on "Precise Spirit Leveling," occupying pp. 1-206 of Vol. 45 of the Transactions of the American Society of Civil Engineers, June, 1901.

Bulletin No. 26 of the United States Coast and Geodetic Survey, dated April 5, 1893, contained an announcement signed by T. C. Mendenhall, Superintendent of Standard Weights and Measures, and approved by John G. Carlisle, Secretary of the Treasury, from which the following is an extract:

* * * "the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the international prototype meter and kilogram as fundamental standards, and the customary units, the yard and the pound, will be derived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this Office for several years," etc.

The Treasury Department is the department to which are attached the Mint, the Marine Hospital Service and the Coast and Geodetic Survey, in all three of which, as above stated, the metric system has been in practical use for years. Incongruity is found, however, in the fact that the Treasury Department continues the use of old weights and measures in other branches of its work; for example, in its Bureau of Statistics, largely occupied with foreign trade (whereas metric units have been introduced to some extent in the Bureau of Foreign Commerce of the State Department and in the section of Foreign Markets of the Agricultural Department); and, for another example, in the Customs Service, where there will be special gain in the substitution of the international system, and where its substitution has been repeatedly urged, officially and unofficially.

Consider manufactures. The April, 1900, report of the American Railway Association's Committee on the Metric System enumerated among manufactures in which the metric system has been introduced watches, injectors, refrigerating apparatus, screw-cutting lathes, scales, drills, gauges, astronomical and physical instruments, measuring implements and draughtsman's supplies. A very large number of manufacturers have had some call for the application of metric measurement for goods for

export, if only on a small order; and goods of widely diverse character are among the metric manufactures. We have exported to metric countries a great deal of ordnance and machinery for manufacturing ordnance, and rapid-firing guns have been designated by their caliber in millimeters. The Baldwin Locomotive Works' illustrated catalogue of narrow-gauge locomotives has printed on its title page, "Adapted Especially to Gauges of 3 Feet 6 Inches or One Metre," and on each of the sixteen pages (108-38), on which are tabulated various types of locomotives, has printed conspicuously, "Gauge, 3 Feet 6 Inches, or One Metre." The Library Bureau, of Boston, has cards and cases made of exact metric dimensions. In the *Electrical Review* (New York) for June 22, 1901, Geo. H. Draper says:

"There is no first-class shop in America that will not undertake to build machinery according to metric measurements, and many of them are at the present time compelled to build stock forms of machinery in measurements of this system in order to be able to compete for trade in foreign countries where the specifications are given in round metric terms."

NOTES.

A Decimal Association. At the August meeting of the American Association for the Advancement of Science, held in Denver, Colo., Jesse Pawling, Jr., of the Central High School, Philadelphia, read an instructive paper on the metric system, advocating the formation of a Decimal Association, similar to the one in England, for the purpose of promoting metric reform and urging the passage of a metric bill by Congress.

The Metric System and International Commerce. Under this title Cassier's for September contains an interesting paper by J. H. Gore, secretary of the American Metrological Society. The one great question now paramount in the minds of the commercial world, he says, is how to extend trade—how to remove the barriers that stand in the way of natural tendencies and artificial stimuli. He quotes Mr. Furbish, formerly director of the Bureau of American Republics, who says: "The failure of the United States Government to adopt the metric system is one of the most inexplicable instances of false conservatism in the history of the country. We send consular representatives to every quarter of our globe for the express purpose of making possible an extension of our foreign commerce, and then busy ourselves in an attempt to make such foreign commerce impossible, and retain a system of weights and measures which adds to our own difficulties and makes us mere barbarians to the more

progressive nations." He mentions that letters from eighteen important consulates to the British House of Commons, in every case state that the adoption of the metric system by Great Britain would greatly promote her commerce. "There can be no possible doubt of these facts, and the United States, in its commerce, is today suffering from the same cause. We are out of touch commercially with all the nations of the world except Russia, with which our commerce is small, and England, with which our trade is not growing."

Evolution of Standards of Measurement. In the September *Cassier,* John A. Brashear writes of the development of linear standards and machines for making exact divisions. The early standard in Biblical writings and in Egypt, Babylonia, Persia, Greece and all eastern countries was the cubit. Medieval metrology is omitted for "a period of more than a thousand years over which the connection of units of measure is very uncertain." The Belgic foot was probably carried over to Great Britain in the tenth century, and was 13.22 of our present inches. The legal foot of 12 inches was enforced by law in 950, at which time Henry I. made it one-third of a yard, the later standard being half the distance from the finger tips of that king's outstretched arms.

In 1324 Edward II. created a new standard—the barley corn, 3 grains of which placed end to end were decreed to make an inch. From this time onward for 500 years the yard and ell had various values, until 1824, when George IV. gave a legal definition to the yard as marked on a certain bar made by Bird in 1760. This was known as the Imperial Standard Yard, and has ever since remained the standard of length in England.

The rise of the metric system is briefly described. Down to the beginning of the seventeenth century there were no instrument makers, but about the middle of that century astronomy demanded a higher grade of instruments. Whereas the earlier *circles* were all divided by hand, dividing engines are now employed with much greater precision, as in setting off *linear* measurements. Space is given to the names and work of inventors and users of these engines. Reference is made to the work of Michelson with the refractometer in measuring the length of light waves, which furnished a delicate subdivision of the meter.

The paper ends with a brief account of the invention since about 1860 of machines for making interchangeable parts and standard screw threads, in which latter, the author says, there has been a saving to the railways of the United States of hundreds of thousands if not millions of dollars. The fineness of such measurements is shown by the possibility of making all standard gauges accurate to within one-forty- or fifty-thousandth of an inch; while gratings by Rowland's engine can be made 120,000 to the inch so accurate that an error of one two-millionths of an inch is not found between adjacent lines. Such lines open great possibilities in spectrum analysis.

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