# The Metric System

**Eastburn George**

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# THE METRIC SYSTEM

BY

GEORGE EASTBURN, M.A.

# AMERICAN METROLOGICAL SOCIETY.

FOUNDED 1873.

## Objects.

1.—To improve existing systems of weights, measures, and moneys, and to bring them into relations of simple commensurability with each other.

2.—To secure universal adoption of common units of measure for quantities in physical observation or investigation, for which ordinary systems of metrology; do not provide: such as divisions of barometer, thermometer, and densimeter; amount of work done by machines; amount of mechanical energy, active or potential, of bodies, as dependent on their motion or position; quantities of heat present in bodies of given temperatures, or generated by combustion or otherwise; quantity and intensity of electro-dynamic currents; aggregate and efficient power of prime movers; accelerative force of gravity; pressure of steam and atmosphere; and other matters analogous to these.

3.—To secure uniform usage as to standard *points of reference*, or physical conditions to which observations must be reduced for purposes of comparison; especially temperature and pressure to which are referred specific gravities of bodies; and the zero of longitude on the earth.

4.—To secure the use of the decimal system for denominations of weight, measure, and money derived from unit-bases, not necessarily excluding for practical purposes binary or other convenient divisions, but maintained along with such other methods, on account of facilities for calculation, reductions, and comparison of values, afforded by a system conforming to our numerical notation.

## Modes of Operation.

1.—The society will endeavor to carry out its objects, by appeals to congress, state legislatures, boards of education, higher institutions of learning, and to directors and teachers of schools of every grade throughout the country, urging adoption of measures in their several spheres for diffusing information as to the present state of the world's metrology and recent progress in its reform, and specially for instructing the rising generation in these matters, to the end that our people may be early and fully prepared to act intelligently on the important questions connected with weights and measures.

2.—By invoking the aid and cooperation of bodies organized to consider questions of scientific or social interest, boards of trade, chambers of commerce, societies of engineers, industrial associations, professions and trades, in this country and elsewhere.

3.—By specially urging scientific bodies to open communication with similar bodies in other countries, with a view to general agreement on values to be henceforth uniformly given to units of measures and points of reference which particularly concern them; i. e. to the so-called constants of science.

4.—By memorializing congress in favor of laws requiring the use, in certain departments of the public service, of metric weights and measures, wherever such legislation may tend to relieve commerce of some of its burdens, to facilitate international communication, to promote international jurisprudence, and to familiarize our own people with the benefits of that system of metrology, with the least interference with their ordinary habits of thought or daily business.

5.—By direct appeals to the people through the public press, and by circulating so far as means allow, books and documents informing the public of the defects of the common system of weights and measures, the means most proper for its amendment, and the great advantages which the acceptance of a universal system would insure to all mankind.

## Membership.

1.—Any person interested in the objects of this society may be elected a member at any meeting if unanimously nominated by the membership committee, to whom all propositions for membership shall be referred.

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Communications for the AMERICAN METROLOGICAL SOCIETY may be addressed to JOHN K. REES, Secretary and Treasurer, Columbia College, New York City.

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# THE METRIC SYSTEM.

**Paper read at the Annual Meeting of the Schoolmasters' Association, Held in Philadelphia, November 29, 1889.**

By GEORGE EASTBURN, M.A., Ph.D.

CHANGE, progress, improvement, are the watchwords of the nineteenth century.

In almost every phase of activity there has been a rejection of old modes and a substitution of new machinery. The spirit of the times is displayed in the selection of that which is best adapted to accomplish a desired end. Wise men recognize the fact that the true value of any piece of mechanism depends chiefly upon two things: first, its efficiency to do the work intended to be done, in the best possible manner; and, secondly, the consumption of the least possible time in the performance of said work. In other words, quality of work and consumption of time are the two all-important factors that enter into the calculation in determining the success of all industrial operations.

Previous to the application of steam and electricity to the development of civilization, international communication was so slow, and commercial intercourse so limited, that the means by which quantity and cost of articles of traffic were ascertained was a matter of secondary importance; but in this age of steam transportation and electrical communication, when we must do in a day an amount of work at which our grandfathers would have been contentedly engaged a month, when a brisk commerce is carried on with almost every nation of the earth, the mode of making calculations in business, and of representing the most common terms for expressing quantity in language that can be universally understood throughout the civilized world, becomes a

matter of most serious concern. Throughout the whole sphere of commercial and industrial operations, there is not a single piece of work executed that has not, in some way or other, the necessity of the use of some means of measurement connected with it. The grocer must use his weights and measures of capacity in disposing of his sugar, tea, and coffee, his molasses, fruits, and vegetables; the dealer in dry goods must use his measures of length in selling his muslins, cloths, silks, and velvets; the pharmacist and the chemist bring into constant requisition delicate weights and measures in their investigations; manufacturers, builders, and architects have measures and measurements in their minds almost continually; in fact, in all business calculations, quantity, indicated by measures of some kind or other, interposes the greatest obstacle in finding cost.

As there is such a need for weights and measures in order to render intercourse between man and man possible, it is of the highest importance that the system in use should be the best that can be devised. As weights and measures serve only as a piece of mechanism for ascertaining quantity in some particular phase of business or investigation, unquestionably that system of weights and measures is the best, *per se*, which is best adapted for the easy and rapid calculation of quantities in which are involved lines, surfaces, and volumes. The system which supplies these requisites is one in which the basic linear measure unit, or some division or some multiple of the same, is taken as the base of the unit for the computation of area, of capacity, and of weight; and to facilitate calculation, the notation is decimal.

This preface introduces to you my subject, entitled "The Metric System," which I propose to treat under the four following general divisions:

I. The objections to the measures now in use in the United States.

II. The advantages of the Metric System for the uses of measurements.

III. What has been done toward the universal adoption of the system.

IV. What should we, as citizens of the United States, do to secure its exclusive use at an early date in our country?

## Objections to the Weights and Measures now in Use.

Under the first general head, I present the five following named objections :

1. Entire absence of any linear basis upon which quantities of capacities and of weight can be scientifically computed.
2. Multiplicity of names.
3. Differences of values in units of the same name.
4. Irregularity of the notation.
5. Dissimilarity to the weights and measures of any other nation.

To any one acquainted with the Metric System, it is evident that one of the most valuable features of a system of weights and measures is a common linear basis from which areas, volumes, capacities, and weights may be easily calculated. In the weights and measures now in use, having given the linear dimensions of a volume, there is no connecting commensurable unit by means of which the capacity and the weight may be directly found. The consequence of this incommensurability is the necessity and inconvenience of first calculating, from the linear dimensions given, the cubical contents of the capacity or volume, and then, by a long process of division or multiplication, the capacity or weight is found in the denomination desired.

Secondly, the multiplicity of names used to designate the units found in the various measures constitutes a very objectionable feature. In our best arithmetics there are not less than twenty different names given to units of length alone ; ten, to units of surface ; seven, to units of solidity ; fifteen, to units of capacity ; ten, to units of weight—making sixty-two arbitrary names of units to designate measurements of lines, areas, volumes, capacities, and weights alone. Such a diversified, meaningless, heterogeneous nomenclature as is found in naming the units used in our tables of weights and measures is enough to discourage any ordinary student in the hope of ever mastering them, and to cause the most exacting teacher to feel justified in excusing his pupils from a thorough knowledge of the tables and of their relations to one another.

The third objection that I offer to our weights and measures is that several of the units bearing the same name do not represent the same quantity. Let us first turn our attention to the weights. There are in practical use in our country to-day four different sets of weights; namely, the troy, the apothecaries', the avoirdupois, and the diamond.

The unit by which the values of the weights of different denominations are compared is the troy grain. Of the denomination of weights the values of whose units differ, I mention the ounce, the pound, the hundred-weight, and the ton. The troy ounce contains 480 grains, and the avoirdupois ounce 437½ grains. There are twelve ounces in a pound troy, and sixteen ounces in a pound avoirdupois. By multiplying 480 grains by 12 we obtain 5,760 grains in the troy pound, and by multiplying 437½ grains by 16 we obtain 7,000 grains in the avoirdupois pound; thus results the peculiar fact that an ounce of gold weighs 42½ grains more than an ounce of lead, but that a pound of lead weighs 1,240 grains more than a pound of gold. The ordinary hundred-weight contains 100 avoirdupois pounds, yet there is another hundred-weight, used in certain specified cases, which contains 112 pounds, and the two tons (each having in it twenty hundred-weight of its own kind) bear the same ratio to each other as the hundred-weights. The coal-dealer within the city limits of Philadelphia is required to furnish 2,240 pounds to the ton, while the dealer just beyond the city limits supplies his customer with 2,000 pounds to the ton. Let us now consider for a few moments the irregularities in the units of capacities having the same name. The measures of capacity known under the respective names of wine, ale or milk, and dry have each three denominations—the pint, the quart, and the gallon—of the same name; yet no two of these measures of the same name have the same capacity. Taking the cubic inch as the unit of comparison, the wine gallon contains 231 cubic inches, the ale or milk 282 cubic inches, and the dry 268.8 cubic inches; and dividing these numbers respectively by 4 and then by 2, we obtain the proportionate number of cubic inches for the quart and pint of each of the measures. In the absence of any legal provision requiring the testing and the sealing of weights and measures, one needs but little knowledge of the tricks of trade

to see the opportunities for practicing deceit upon the unwary customer. In fact, this diversity of capacity of units of the same name, and the appropriation of special titles to certain measures, open the way to an unconcealed injustice to a large class of producers of one of our most important daily necessities. I refer to the dairymen who reside along the lines of railroad communication with the city of Philadelphia. When the milk-dealer of this city contracts with the dairyman for milk, he demands, as his right, that he shall receive as a quart the milk quart, 70½ cubic inches. Then follows a mode of measurement which marks the transaction as unjust; for, after the milk has been brought to the city, the consumer is not allowed the privilege of buying the article as milk or ale, but it has been so changed, at least so far as measurement is concerned, that it is dealt out as wine, or 57¾ cubic inches to the quart. This state of affairs results from the omission of the United States Government to enforce the use of the only system of weights and measures which Congress has adopted, and in permitting local authorities and associations to establish their own customs in traffic. Just here I desire to impress upon your minds, that, of all the measures now in common use in this country, the only single one that is authorized by law is the troy pound, and that the legislation enacted with reference to that weight was not to legalize its use as an instrument to facilitate traffic, but merely to secure a uniform standard by which the coinage of England and the United States might be compared, and that the Metric System is *the only system of weights and measures* for which national legal authority can be claimed in our country.

The fourth objection which I bring to your notice is the irregularity of notation. This is exhibited in its perfection in the tables of linear and surface measures, in the former of which the factors in reductions are 12, 3, 5½, and 320, and in the latter 144, 9, 30¼, 160, and 640. In fact, this irregularity of notation, combined with the diversified variety of the tables of weights and measures, constitutes, in an educational point of view, the most forcible objection to them.

The difficulty of learning such a mass of arbitrary names, and of remembering so many irregular, uncorrelated numbers, is so