

Here Come The Metrics:

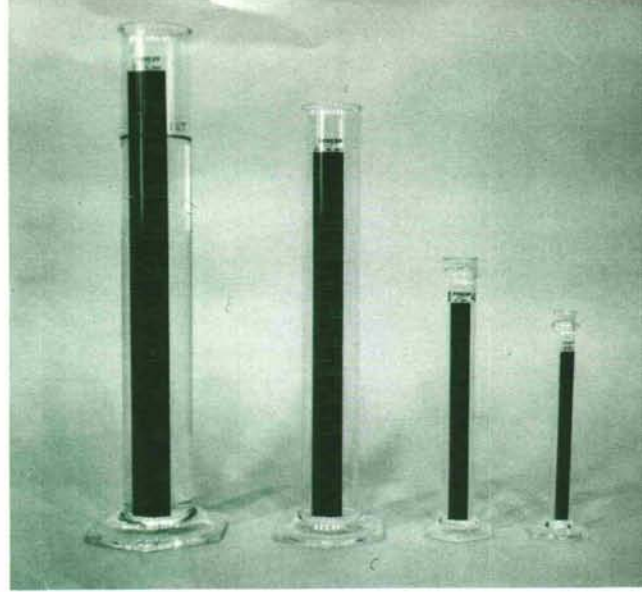
The Liter and the Meter

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For all of their obvious shortcomings, the inch and foot, the ounce and pound have been around an incredibly long time! They have confounded and confused us since grammar and high school mathematics. Even now, most of us would be hard pressed to recall how many firkins make a hogshead (seven) or how many gills in a pint (four). But once we have even partially mastered this old friend, we are reluctant to let him go. We feel comfortable with our customary, or English-language measurements. Nevertheless, times are changing now and the rest of the world is passing us by. The metric system must finally come to the United States.

On August 18, 1972, the United States Senate passed the Metric Conversion Bill by unanimous voice vote. It now rests with the House Committee on Science and Astronautics. The Bill is the result of a 3-year study on metrication by the National Bureau of Standards. Essentially it recommends a gradual conversion to the metric system over a 10-year span. The best guess is that by the early 1970s, the United States will be predominately, although not exclusively metric. The conversion to metrics will not have been blazingly fast. John Quincy Adams seriously considered it in 1821 in his "Report Upon Weights and Measures."

Compared with the ease, simplicity and logic of the metric system, our "customary" or English scale is complex and inexact. For example, your height is still measured by the length of the foot of an ancient king, and the acre, our most common measurement of land, is based on how large an area an ox could plow in a single day. The inch is about the length of the end joint of a human adult thumb. Later it was determined to be the space covered by



three dried barley corns taken from the middle of the ear and laid end to end. The yard is the distance from one's nose to the extended tip of one's fingers. A rod was originally the combined length of left feet of 16 men lined up to go to church. The mile (from the Latin *Milia Passuum*) is about the distance traveled by a Roman soldier in a thousand 2-pace stride. But our measurement difficulties just begin here. What happens when we combine 12 thumb-end joints to a foot and find 3-foot lengths to a yard and 1,760 fingertip-to-nose lengths to a mile? We have built an advanced technical civilization from such measurements but only with great difficulty in making conversions through long-numbered multiplication and division tables and our own memorization.

We have invented ways to confuse ourselves even more. There is a long ton (2,240 pounds) and a short ton (2,000 pounds). There are register tons, measurement tons, wheat tons, timber tons and the English water ton. We have decided on 16 ounces to a pound avoirdupois but only 12 ounces to a pound troy; 32 ounces in a quart. In all, we have more than 80 units of measurements in our present confusing system.

Against this tangle and maze, the metric system is unbelievably simple and consistent. In place of fractions to make units larger or smaller (1-inch equals $1/12$ foot, etc.), the metric is a decimal system and the units are related to each other by powers of 10. For example, the meter, the basic unit of length in the metric system, is equal to 10 decimeters, or 100 centimeters, to 1,000 millimeters. Therefore, to convert 53.74 meters to decimeters, merely move the decimal point one place to the right. Further, the terminology is easy to understand Latin-derived prefixes are assigned to the submultiples or divisions; "deci" equals

APPROXIMATE COMMON EQUIVALENTS

U.S. to Metric

Length									
1 inch	=	25.0	millimeters (mm)	=	1 millimeter (mm)	=	0.04	inch	
1 foot	=	0.3	meter (m)	=	1 meter (m)	=	3.3	feet	
1 yard	=	0.9	meter	=	1 meter	=	1.1	yards	
1 mile	=	1.6	kilometers (km)	=	1 kilometer (km)	=	0.6	mile	
Area									
1 sq. inch	=	6.5	sq. centimeters (cm ²)	=	1 sq. centimeter (cm ²)	=	0.16	sq. inch	
1 sq. foot	=	0.09	sq. meter (m ²)	=	1 sq. meter (m ²)	=	11.0	sq. feet	
1 sq. yard	=	0.8	sq. meter	=	1 sq. meter	=	1.2	sq. yards	
1 acre	=	0.4	hectare*	=	1 hectare*	=	2.5	acres	
1 sq. mile	=	2.6	sq. kilometers	=	1 sq. kilometer	=	0.39	sq. mile	
Mass									
1 grain	=	64.8	milligrams (mg)	=	1 milligram (mg)	=	0.015	grain	
1 ounce (dry)	=	28.0	grams (g)	=	1 gram (g)	=	0.035	ounce	
1 pound	=	0.45	kilogram (kg)	=	1 kilogram (kg)	=	2.2	pounds	
1 short ton	=	9.071	kilograms	=	1 metric ton	=	1.102	tons (short)	

Volume									
1 cubic inch	=	16.0	cubic centimeters (cm ³)	=	1 cubic centimeter (cm ³)	=	0.06	cubic inch	
1 cubic foot	=	0.03	cubic meter (m ³)	=	1 cubic meter (m ³)	=	35.0	cubic feet	
1 cubic yard	=	0.76	cubic meter	=	1 cubic meter	=	1.3	cubic yards	
1 teaspoon	=	5.0	milliliters (ml)	=	1 milliliter (ml)	=	0.2	teaspoon	
1 tablespoon	=	15.0	milliliters	=	1 milliliter	=	0.07	tablespoon	
1 fl. ounce	=	30.0	milliliters	=	1 milliliter	=	0.03	ounce	
1 cup	=	0.24	liter (l)**	=	1 liter (l)**	=	4.2	cups	
1 pint	=	0.47	liter	=	1 liter	=	2.1	pints	
1 quart (liq)	=	0.95	liter	=	1 liter	=	1.1	quarts	
1 gallon (liq)	=	0.004	cubic meter	=	1 cubic meter	=	264.0	gallons	
1 peck	=	0.009	cubic meter	=	1 cubic meter	=	113.0	pecks	
1 bushel	=	0.04	cubic meter	=	1 cubic meter	=	28.0	bushels	
Power									
1 horsepower	=	0.75	kilowatt (kw)	=	1 kilowatt (kw)	=	1.3	horsepower	
Energy									
1 calorie	=	4.18	joules (j)	=	1 joule (j)	=	0.24	calorie	

*1 hectare equals 10,000 sq. meters

**1 liter equals 1 cubic decimeter (dm³)



A conversion scale, showing pounds on the bottom and grams on the top. One gram equals the weight of 1 cubic centimeter of pure water at 4° centigrade.

division by 10, "centi" equals division by 100, "milli" equals division by 1,000, and then to "mega," "giga," and to "terra." Easy to remember, not much to forget.

It was the Vicar of St. Paul's Church in Lyons, France—Gabriel Mouton—in 1670 who first proposed what we know today as the metric system. He called for a comprehensive decimal system having as a basis a fraction of the length of the great circle measured along the meridian passing through Dunkirk, France, to Barcelona, Spain.

The meter, the unit of length, was to be one ten-millionth of the distance from the north pole to the equator. Eventually the gram, the unit of mass, was to be equalled to the mass of a cubic centimeter of pure water at 4 degrees centigrade. The liter was defined as the volume equivalent to the volume of a cube each side of which has a length of one decimeter. The "are" was defined as the measure of area for land equal to 10 square meters. The "stere" was to be a measure of volume equal to a cubed meter. It may take the place of one cubic yard at some future date.

It took over 100 years for Mouton's proposal to be officially accepted. In 1795 France adopted the "metric system." In 1798, the French Foreign Minister invited representatives of all European countries and other friendly nations to learn of the new system. Slowly it gained acceptance. By the mid 1800s, Greece, the Netherlands, Italy and Spain adopted it. By 1880 nearly all of Europe and South America went metric.

The only major holdouts by the turn of the century were Great Britain and the United States, even though Congress did make metric system units legal standards of measures in this

country in 1866. But there were no pressing needs for change, and so the maze of gallons, inches and pounds endured. Indeed, they have endured from the days of our founding fathers. George Washington, in his first message to Congress announced that, "Uniformity in the currency, weights and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to." Thomas Jefferson, then Secretary of State, proposed the establishment of a decimal system of weights and measures similar to the one already adopted for coinage. But politics and inertia, even then a way of life, prevented Congress from moving on this proposal.

Numerous other proposals were developed and likewise expired. Between World War I and the Depression years alone, some 40 Congressional bills on metrication were introduced and failed. We generally liked our "customary units." But not everyone. Certain sectors of industry started to convert to metrics on their own. The optical and photography industries (35 mm film) were leaders. The pharmaceutical industry changed over in 1955. It took four years for the drug companies to complete their conversion. In athletics, our Olympic Teams have always competed under the metric standards.

The Russian Sputnik in 1957 again stirred general public interest and the Army converted to the metric system for weaponry about the same time. A 22 caliber rifle became a 5.56 mm rifle. But it was not until 1965, when the British Board of Trade announced that the United Kingdom would "go metric," that the United States decided to act. It was then that the studies leading to the Metric Conversion Bill were undertaken.

With the conversion of Great Britain to metrics, the United States was almost alone in the boat of "customary" measurements. Barbados, Gambia, Liberia, and Tonga made up about half of the remaining passengers. Economics, however, is of far more importance. Failure to convert to metrics has started to take its toll, and it is already costing us money.

According to Frank Kendig of the *Saturday Review of Science*, the United States exported \$14 billion worth of measurement products and devices such as computers, vacuum pumps, typewriters, etc. in 1969. This figure would have increased an estimated \$600 million in 1975 if we had converted to metrics during the early 1970s. In addition, other major industrial nations throughout the world are now at work establishing trade agreements among themselves based on the metric system. Electronic standards have already been agreed upon by Great Britain, France and West Germany. The markets of China, Russia, and the developing

nations will be lost to us if we continue to ignore the metric system. The Yankee Trader will be out of business.

This will not happen. Already some United States automobiles are being built to metric standards, and ever so gradually but ever so surely, we are moving toward conversion. To the golf course superintendent, this means learning a new but simpler language.

The coming change will be gradual, probably over a period of 10 years. There will be retraining of personnel and a slow phasing out of old equipment and introduction of new. Metrics will become more prevalent in public education, and television will probably lead the way. We may even hear of "third down and two

meters to go." Even then, the cost for total transition is estimated at \$10 to \$200 billion.

In 1906, Alexander Graham Bell, testifying before the Committee on Coinage, Weights and Measures of the House of Representatives said,

"Our forefathers legislated pretty well for the future in the adoption of the Constitution; and later, Congress did well in abolishing the old system of pounds, shillings and pence and adopting a decimal system for our money. We will do well for the future of our country if we provide the metric system for the whole of the United States."

Bell again had the right number—and we will soon be a part of the metric system.

CONVERSION FACTORS FOR ENGLISH AND METRIC UNITS

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
0.621	Length: kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.540
0.386	Area: Kilometer ² , km ²	mile ² , mi ²	2.590
247.1	kilometer ² , km ²	acre, acre	0.00405
2.471	hectare, ha	acre, acre	0.405
0.00973	Volume: meter ³ , m ³	acre-inch	102.8
3.532	hectoliter, hl	cubic foot, ft ³	0.2832
2.838	hectoliter, hl	bushel, bu	0.352
0.0284	liter	bushel, bu	35.24
1.057	liter	quart (liquid), qt	0.946
1.102	Mass: ton (metric)	ton (English)	0.9072
220.5	quintal, q	pound, lb	0.00454
2.205	kilogram, kg	pound, lb	0.454
0.0353	gram, g	ounce (avdp), oz	28.35
0.446	Yield or Rate: ton (metric)/hectare	ton (English)/acre	2.242
0.892	kg/ha	lb/acre	1.12
0.892	quintal/hectare	hundredweight/acre	1.12
14.22	Pressure: kg/cm ²	lb/inch ² , psi	0.0703
0.968	kg/cm ²	atmospheres, atm	1.033
0.9807	kg/cm ²	bar	(1.0197)
9/5 C + 32	Temperature: Celsius, C	Fahrenheit, F	5/9 (F-32)
	-17.8°	0°	
	0°	32°	
	20°	68°	
	100°	212°	