THE METRIC FALLACY

January 13, 1908

Dear Sir:

We send you under separate cover by this mail a copy of the "Metric Fallacy" by Messrs. Halsey and Dale. The book has been endowed with funds voluntarily subscribed by American manufacturers, and this copy is sent to you with the compliments of the Committee in charge in the hope that you will find a place for it on the shelves of your library.

Very respectfully,

NATIONAL ASSOCIATION OF MANUFACTURERS

"It is a tormenting of the people for mere trifles."

NAPOLEON.

"Compare the uniformity that you must lose with the uniformity that you may gain."

"The substitution of an entire new system of weights and measures instead of one long established and in general use, is one of the most arduous exercises of legislative authority. There is, indeed, no difficulty in enacting and promulgating the law, but the difficulties of carrying it into execution are always great and have often proved insuperable."

"The legislator * * * finishes by increasing the diversities which it was his intention to abolish, and by loading his statute books only with the impotence of authority and the uniformity of confusion."

JOHN QUINCY ADAMS.

THE METRIC FALLACY

BY

FREDERICK A. HALSEY

AND

THE METRIC FAILURE

IN THE TEXTILE INDUSTRY

BY

SAMUEL S. DALE

NEW YORK

D. VAN NOSTRAND COMPANY

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PREFACE.

This book is an outgrowth of a paper presented to the American Society of Mechanical Engineers at its December, 1902, meeting and the discussion which followed, and by permission of the Council of that Society much of the paper is here included. The points raised in the discussion have been rewritten and placed in their appropriate places. The list of countries in which it was shown in the paper that old units continue in use has been about quadrupled, while new chapters have been added on The Reasons for the Failure of Compulsory Laws, Scientific and Industrial Measurements, Scientific and Industrial Difficulties, "The Government Will Pay the Cost," The "Confusion" of our Weights and Measures, The Complications Due to a Mixture of Units, The Inaccuracy of the Meter, The Abandoned Portions of the Metric System and The Object of the Bill.

Part II. on The Metric Failure in the Textile Industry has also been entirely rewritten and is believed to be the first critical anti-metric analysis of the system from the standpoint of the textile industry that has been made.

The table of Continental systems of numbering spun yarn has been compiled from the latest French, German and Spanish authorities and submitted to several practical French and German textile manufacturers and merchants for examination and criticism. One of them, a large dealer in yarns and the proprietor of a German conditioning house, returned the list with a suggestion which has been adopted, as to the method of expressing the equivalents of each system, and added this remark: "The work is very useful and instructive."

This table is believed to be the most complete of its kind ever published. Care has been taken to eliminate all systems not in actual use. The list will therefore be useful not only in showing the Continental chaos of textile weights and measures, but also in aiding the unfortunate Continental manufacturers in finding the reciprocal equivalents of the multifarious systems of yarn counts with which they are now tormented.

Should the reader be surprised at the facts regarding the limited use of the metric system herein given, he should remember that *no proof of anything to the contrary has ever been offered.* Whenever the metric advocates have learned that a government has passed a law favorable to the system, they have straightway conveniently *assumed* that it has become the common system in trade and commerce. They have not inquired into the working of these laws nor into their scope or nature. Their logic has been, "Such a country has passed a metric system law, *therefore* the people of the country have dropped their old units and taken up the new." Their stories of the imposing number of hundreds of millions of people who use the system have no other basis than this. They have simply added the figures for the population of those countries which have passed some kind of a metric law, including those in which the laws are simply permissive, and those in which the system has been adopted for government purposes alone. If the facts which are given in these pages turn their case to ridicule, they have nothing to thank but their own credulous willingness to believe anything favorable to their system and to their free use of their own imagination without regard to facts.

The assertions of the wide use of the system have been repeated so many times that they have come to be generally believed, but the mere repetition of an untruth does not make it a truth. The reader should, therefore, reverse his attitude of mind at the start and regard the extensive use of the system not as a fact but as an unproven assumption. Remembering that assertions have no weight as against facts, he will then be in a position to form a just estimate of this the only considerable collection of *facts* relating to the use of the system that has ever been published.

The reader will not fail to note the numerous countries in which the system has been adopted for government purposes for many years, but in which government use has failed to bring about the general adoption of the system in trade and commerce. As this is precisely the programme which is relied upon to bring about the general adoption of the system by the American people, the experience of these countries is of immediate and obvious application.

The chapter on Reasons for the Failure of Compulsory Laws has equal application to the conditions of the British Empire, where the metric programme is based upon avowed compulsion. It is shown in this chapter that general compulsory laws have no jurisdiction over factory measurements, and that the only effect of such laws will be to plaster a set of commercial metric units over a set of factory English units, leading to nothing but what John Quincy Adams so aptly calls "the uniformity of confusion."

The authors will be glad to receive additional information from any part of the world for incorporation in future editions. They may be addressed in care of the publisher.

ERRATA.

Page 146, 8th line, decigramme to decimetre.
" 146, 8th line, centigramme to centimetre.
" 195, 6th line, kilogramme to 453.59 grammes.
" 195, 8th line, " " " "
" 195, 10th line, " " " "
" 203, 5th line from bottom, grammes to grains.
" 203, 5th line from bottom, centimetres to inches.
" 210, 17th line, 8.95 to 8.92½.

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INTRODUCTION.

The English system of weights and measures is the exclusive standard of all English-speaking countries, while the metric system is the exclusive standard of no nation on earth. Anglo-Saxon nations are blessed with substantial uniformity of weights and measures, while others are cursed with a confusion that is a reproach to their civilization.

The Anglo-Saxon nations are the only ones that have ever dealt with the subject of weights and measures in a rational manner. For centuries, while these matters were elsewhere drifting into worse and worse confusion, England, by fostering that process of development which has always characterized the Anglo-Saxon race, was giving heed to the injunction, "Prove all things, hold fast that which is good." The United States in turn—not by legislative interference, but by the spontaneous action of the community—has followed the same process and eliminated some of the superfluous units which are still current in England.

In no matter does the contrast between the Anglo-Saxon and the Latin races show to better advantage or more characteristically than in this. In France the policy of drift had, at the time of the Revolution, brought about a state of things which can only be described as chaos, and in true French style the remedy was sought not in evolution but in revolution, and the result was the metric system.

The history of the system elsewhere is the same. Throughout the German Empire and throughout Spanish-speaking countries the same intolerable confusion reigned, and the same remedy was sought. At its birth the offspring of revolution, it has remained the foster child of force. While proclaiming it as the perfect thing, its friends have relied not on its merits but have everywhere resorted to compulsion. In the United States they disclaim compulsion, it is true, but they have nevertheless introduced in Congress a bill which is compulsory to the limit permitted by the Constitution; while in England, Canada and

Australia, where such limitations do not exist, they urge compulsion without disguise.

Nowhere has the system made material progress in industry except when backed by the policeman's club. For more than a century it has been the pet of the legislator, and with the result that in France to-day its most ardent advocates are calling for more laws to compel its use by whole industries that do not, and by the testimony of these same advocates will not, use it unless compelled to do so.

With their system of weights and measures as a foundation, the English-speaking peoples have built up the greatest commercial and industrial structure the world has known. This system they are asked to abandon for the benefit of others at a cost that is beyond estimate, and for compensating advantages that to themselves are wholly trivial and imaginary. They are asked to enter the slough of despond in which metric Europe wallows in order to help metric Europe out. They are asked to destroy the very warp and woof of their own vast industrial fabric in order that they may assist in weaving another of alien origin and with no resulting gain except to aliens.

We hear much of the unity of the Anglo-Saxon race—unity in language, in customs, in laws, in popular government, in progress, in ideals, in civilization. In nothing is this unity more marked than in weights and measures—the foundation of that commercial and industrial structure which others may imitate but cannot copy. Representative of their historic methods of development, foundation of their industrial life and bond of union between all sections—shall all these be destroyed for this French fad?

THE PRO-METRIC ARGUMENT.

The argument for the adoption of the metric system by the American people is based upon the tacit assumption that they can do it, and do it easily. The statements made at the hearings of the House Committee on Coinage, Weights and Measures of the 57th Congress are sprinkled with opinions that the change is an easy one, and that the period of transition will be short. Thus Professor Elihu Thompson (page 2*) said:

"I think the government could begin right off and should give the manufacturers about two years for preparation in getting their new gauges and in making plans for new work in the metric system."

Mr. F. O. Blackwell (page 2) thought time should be allowed, "say five or six years." Mr. E. M. Hewlett thought (page 3) that "two or three years would be required for the change provided manufacturers from whom raw materials are obtained coöperate." Mr. H. G. Reist (page 3) thought that "two to five years time should be allowed for the change." Mr. Christie (page 8) thought that "perhaps a few years might occur before the transformation was entirely effected." Mr. William Whitman (page 17) said:

"I think at least two years' notice ought to be given * * * During those two years there would be ample time for all the necessary preparation and discussion. * * * I do not apprehend any difficulty in bringing about the change."

Dr. H. W. Wiley (page 52) said:

"If you can put it in here two or three years or four or five years ahead, everybody can accommodate himself to that."

Mr. Jas. K. Taylor (page 58) said:

"I would strongly favor it except that I should say that there were difficulties ahead for about two years."

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* Unless otherwise specified or obvious from the context, all page references in this book are to the pamphlet containing the statements made before the House Committee on Coinage, Weights and Measures.

Mr. Bates, in questioning Mr. Bond (page 92), asked:

"During the period of transition can you not use interchangeable terms for a year or two in both systems?"

Mr. G. L. Cabot, after stating that "in the case of Germany and Austria only between two and three years were required to make the complete change (page 135), added:

"It seems to me reasonable to suppose that in this country the change could be made quite as speedily."

Professor Stratton, when addressing the Western Society of Engineers in May, 1902, said:

"The experience of other countries has shown that the inconvenience and expense has been greatly over-estimated."

Professor Simon Newcomb (page 72) said:

"My conclusion is that the system can be introduced with great advantage to all concerned, and if once introduced we will in five or ten years be ready to wonder that we were ever willing to use any other system."

At the discussion of the Mechanical Engineers * Mr. F. J. Miller quoted Lord Kelvin thus:

"I believe that in a fortnight people would become so accustomed to the perfect simplicity and easy working of the metrical system that they will feel that instead of its being a labor to pass from one system to the other it will be less than no labor."

The metric case is again based upon the convenient assumption that the old units will disappear with the adoption of the system, whatever that word may mean, whereas, as a matter of fact, in no country of the world is the change complete nor is the end in sight.

The pro-metric argument is, substantially, an *a priori* argument. The metric advocates adopt the methods of the old philosophers who laboriously sought to prove what ought to be. My method is that of modern science, which interrogates nature in order to learn what is. For instance, they tell us how easily

* This discussion of the American Society of Mechanical Engineers took place at its meeting of December, 1902. It will be referred to repeatedly in these pages.

and how quickly this nation ought to make this change; I shall show how slowly and laboriously France and Germany have made the change. They will say that we ought to adopt this system to please our foreign customers; I shall show that our foreign customers do not care one picayune whether we adopt it or not, and I shall prove it by a flood of evidence.

THE ANTI-METRIC ARGUMENT.

This book is an attempt to establish the following leading propositions:

1. That as shown by the experience of other countries, the changing of a people's system of weights and measures is a task of enormous difficulty, and is attended with wide-spread confusion. A few general denials of the facts regarding the persistence of old units in metric countries were made in the discussion before the American Society of Mechanical Engineers, to which Society a portion of this volume was originally contributed as a paper; but the facts are overwhelming, and are of such a nature that they scarcely admit of being answered. It may, then, be considered as proven that with us, and especially without general compulsory laws, which the metric advocates disclaim, the change is impossible.

2. That the adoption of the metric system, meaning by that term the retirement of the inch and the substitution therefor of the millimetre, involves the destruction of all mechanical standards. Mr. F. J. Miller, in the above mentioned discussion, said that he did not believe this, and, no doubt, Mr. G. C. Henning considers his table of approximate equivalents* to apply here; but there has been no effective rebuttal of the position taken in the paper, which, therefore, I regard as established.

3. That the prosperity of foreign trade in nowise requires the adoption of the system as a basis of manufacture.† With the exception of a single reëcho of the old assertions to the contrary by one of Mr. Miller's correspondents, there was not in this whole discussion a syllable of disproof of this contention, while the confirmation of it by the experience of machinery manufacturers is overwhelming. This proposition may, therefore, be regarded as not only proven, but as accepted by the metric advocates.

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* Reproduced and discussed on a later page.

† This is not to be understood as referring to its use in commercial literature and correspondence. It is the commonest of common sense to say that commercial information for metric countries should be given in metric units.

4. That the bill now before Congress is a compulsory measure, so far as it relates to those who do business with any of the departments of the government. No reply was made to this, in the above-mentioned discussion, and, indeed, its truth was virtually admitted by Mr. Southard.* It therefore may be regarded as established.

5. That the metric system has for industrial purposes no such superiority as is claimed, and that the claims for the saving of time in calculations and in the school life of children are completely negatived by the certainty that, here as elsewhere, the old units will persist in use and must be learned. This again was substantially ignored in the discussion of the Mechanical Engineers and may be regarded as proven.

6. That the confusion which is said to prevail in our weights and measures is a fiction.

7. That, measured by the number of units in common use, and by their uniform value in all sections and all industries, we have the simplest and the most uniform system of weights and measures of any country in the world.

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* Chairman of the House Committee on Coinage, Weights and Measures of the 57th Congress.

ERRORS OF AND MISREPRESENTATIONS BY THE METRIC ADVOCATES.

In their efforts to show how easily the metric system may be adopted by this country, the metric advocates endeavor to create the impression that it has already made considerable progress. Thus Mr. Stratton, Director of the National Bureau of Standards, stated at the hearings of the House Committee, that the Carnegie Steel Company were about to issue a metric edition of their hand-book. I quote here because this is too important to be treated in any other way. In questioning Mr. Linnard Mr. Stratton said (page 182): "And that the Carnegie people are about to issue a hand-book in which all the formulæ are printed in the metric system? Has that been called to your attention?"

Following is an extract from a letter by the Carnegie Steel Company:

> "In reply to your inquiry, we beg to advise that we have not issued a hand-book containing formulæ according to the metric system, and have no present expectation of doing so."

Mr. Stratton repeated this statement before the Western Society of Engineers,* and with it made another, his words being as follows: "The National Tube Works has one of its largest mills fitted up for the system. The Carnegie people are getting out their hand-book in the metric system."

Following is a letter from Mr. P. C. Patterson, Mechanical Engineer of the National Tube Company:

> "I find the following conditions prevailing in regard to the use of the metric system in this company's business:
>
> "Lap-welded pipe for foreign countries using the metric system is made to either the American or English standard. Special lap-welded goods ordered to metric measurements are made to the nearest fraction of an inch, no attempt being made to get closer that within $\frac{1}{16}$-inch of the dimension called for.

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* See *Journal* of the Western Society of Engineers, August, 1902, page 344.

"Seamless tubes are made to exact metric measurements when ordered by metric measurements."

In a more recent letter Mr. Patterson says:

"This company is not in favor of any movement looking toward a radical change in the standard of measurements."

On page 11 will be found the following dialogue:

Mr. Shaffroth.—Do the jewellers use the metric system in France?

Mr. Troemner.—In France? Oh, yes.

Mr. Shaffroth.—And wherever the metric system is adopted?

Mr. Troemner.—Yes, sir.

Mr. Shaffroth.—Wherever the metric system is adopted and is in practical operation is there any other system at all used?

Mr. Troemner.—None that I know of.

While more will follow later, the following extract from a letter by Tiffany & Company will supply Mr. Troemner with the information which he now lacks:

"In reply to your letter, which we referred to our Mr. Kunz, we beg to state that the carat is the standard of weight for gems all over the world."

The above letter was written in reply to the categorical question: Do French and German jewellers use the gram or the carat in weighing diamonds?

At the hearings of the House Committee Mr. William Whitman said (page 17):

"On behalf of the New England Cotton Manufacturers Association, of which Mr. Charles H. Fitch is president and Mr. C. J. H. Woodbury is the secretary, I recommend the adoption of the system."

The assertion that the New England Cotton Manufacturers' Association has endorsed the system appears a second time on page 203 of the pamphlet containing the proceedings of the House Committee, and it has, in fact, been repeated far and wide. Thus at the discussion of the Mechanical Engineers, Professor W. W. Crosby said:

"The New England Cotton Manufacturers' Association is on record as favoring the international standard (the base is the metric system), for numbering yarns."

Following is a letter from Mr. C. J. H. Woodbury, secretary of this association, to Mr. S. S. Dale:

"In reply to your inquiry of the 6th inst., I would say that the Association never committed itself to the metric system of measuring yarn."

At the hearings of the House Committee Dr. A. E. Kennelly (page 13) stated that,

"The system we use has about 64 units. The metric employs 5 or 6." *

By the report of the bi-partisan committee of the American Society of Mechanical Engineers it will be seen that according to the count of the anti-metric members the units in common use in this country number but 19, while those in common use in metric countries number 30. Many of our supposed units are obsolete and exist in school books only.† Others are obsolescent, and still others (like the apothecary's weights) are of such special use as to be of no importance to the public at large.

A favorite diversion of the metric advocates is to represent the famous report of John Quincy Adams as strongly pro-metric. Thus Mr. Tittman (page 32) said: "Mr. John Quincy Adams, who gave four years to the preparation of his report, speaking in the most glowing terms of the metric system, said that if it could only be adopted it would be an ideal one." Again *in the report of the House Committee* ‡ appears the following:

"He [J. Q. A.], however, advised delay until the metric or international system, which was then in its infancy, had been more fully tried, and to which he referred in a most glowing tribute as possessing all the requisites of a simple, uniform, and workable system of weights and measures."

Following are a few extracts from Mr. Adams' report: §

"The metrology of France is a new and complicated machine, formed upon principles of mathematical precision, the adaptation of which to the uses for which

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* While this statement came from Dr. Kennelly he should not be held responsible for it. This number 64 has become a classic in pro-metric literature.

† For example the league, the furlong, the barleycorn, the rood, the chaldron, the quarter, the sack, the dry gallon.

‡ This report may be found in full in the *Journal of the Western Society of Engineers* for August, 1902. The present quotation is from page 351.

§ This famous paper is not out of date nor will it ever be. It may be found in *The Metric System*, by Charles Davies, to which the page numbers refer, a book which is out of print and scarce. The quotations in the text were obtained from a copy in the Boston Public Library:

The book by Professor Davies (he of the mathematical text books of a generation ago) is the report of himself and Robt. S. Hale as a committee of the University Convocation of the State of New York. It gives the conclusions of an investigation made at the request of Hon. J. A. Kasson, Chairman of the House Committee on Coinage, Weights and Measures in 1866. In the cases of Messrs. Davies and Hale, it is to be noted also that they began the investigation as metric it was devised is yet problematical and abiding, with questionable success, the test of experiment." (Page 178.)

"The decimal numbers applied to the French weights and measures form one of its highest theoretic excellences. It has, however, been proved by the most decisive experience in France that they are not adequate to the wants of man in society." (Page 197.)

"This illustration * * * will disclose to our view the causes which limit the exclusive application of decimal arithmetic to numbers, and admit only a partial and qualified application of them to weight and measure." (Page 198.)

"Thus, then, it has been proved by the test of experience that the principle of decimal divisions can be applied only with many qualifications to any general system of metrology; that its natural application is only to numbers; and that time, space, gravity, and extension inflexibly reject its sway." (Page 202.)

"Nature has no partialities for the number ten, and the attempt to shackle her freedom with them (*sic*) will forever prove abortive." (Page 204.)

" * * * As this system is yet new, imperfect, susceptible of great improvement, and struggling for existence even in the country which gave it birth* * * * " (Page 217.)

"But were the authority of Congress unquestionable * * * it is believed that the French system has not yet attained that perfection which would justify so extraordinary an effort of legislative power at this time." (Page 268).

"For all the professions concerned in ship or house building and for all who have occasion to use mathematical instruments it [the metre] is quite unsuitable * * * This inconvenience, great in itself, is made irreparable when combined with the exclusive principle of decimal divisions. * * * This decimal despotism was found too arbitrary for endurance. * * * The choice of the kilogram or cubical decimetre of distilled water as the single standard unit of weight with the application to it of the decimal divisions was followed by similar inconveniences * * * But on the other hand, decimal divisions are still more inapplicable to measures of capacity for liquids than to linear measures or weights." (Pages 199, 200, 201.)

Mr. Adams had great admiration for the conception and for the efforts of the French Government in its endeavor to establish a universal system of weights and measures. There are also in the report expressions of approbation for the system which certainly do not seem to be consistent with the above citations, but that the report as a whole can be considered as an endorsement of the system in "glowing" or any other terms is simply not so.

What is now the chief argument against the adoption of the system—the anchoring of existing units in manufacturing in-

advocates and finished it as metric opponents. Could these reports be circulated as they deserve to be, the metric agitation would die a natural death.

* Note the words "struggling for existence" *after twenty-seven years* of "the most stupendous and systematic effort ever made by a nation to introduce uniformity in their weights and measures." (Mr. Adams, page 174.) And yet the metric advocates represent Mr. Adams as endorsing the system in "the most glowing terms" and profess to believe that we can make this great change in from three to five years.

dustry—is chiefly a growth since Mr. Adams' time; but, nevertheless, he saw clearly the difficulty of the change, and much of his report is devoted to this as distinguished from his strictly judicial analysis of the merits and demerits of the system. To illustrate this difficulty he (page 150) draws a striking picture of the then far from complete adoption of our system of currency (already thirty years old), and on page 149 he refers to a change of this kind as "a revolution by all experience known to be infinitely more easy to accomplish than that of weights and measures."

In the English brochure, *The Coming of the Kilogram,* by Mr. H. O. Arnold-Foster, the following may be found:

"There are now no longer a great number of sets of weights and measures in use among the civilized peoples of Europe; there are really for all useful purposes two only. These are the weights and measures used by the people of the United Kingdom on the one hand and the weights and measures used by all the other civilized people of Europe on the other.

"We may travel from end to end of the great German Empire and in every part of it we shall find * * * the same weights and measures used in all the factories."

In the pamphlet containing the statements of those who appeared before the House Committee on Coinage, Weights and Measures, the following statement and table appear in an appendix on page 204:

The metric system has been adopted by the following countries:

Argentina.
Austria-Hungary and territories.
Belgium.
—Bolivia.
—Brazil (Republic of).
Bulgaria.
(Central America.)
—China (28 ports).
—Chile.
—Colombia.
—Costa Rica.
—Cuba.
Ecuador.
—Egypt.
Finland (Grand Duchy of).
—France.
French Colonies including Madagascar.
—Germany.
—Greece.
—Gautemala (Republic of).
Haiti.
Holland and dependencies.
—Honduras.
Italy and dependencies.
—Japan.
—Java.
Mauritius and dependencies.
—Mexico.
—Nicaraugua.
—Norway and Sweden.
—Ottoman Empire.
—Peru.
—Philippines.
Porto Rico.
—Portugal, Azores, and Madeira.

—Roumania.
Russia.
—Salvador.
—San Domingo (Republic of).
Servia.
—Spain and colonies.
—Switzerland.
—Uruguay.
Forty-three countries.

The series of questions sent to manufacturers by the Franklin Institute in a circular letter dated October, 1902, contains the following (italics mine):

> In view of the fact that the following countries *officially and customarily* employ the metric system of weights and measures, namely, France, Germany, Austria-Hungary, Norway and Sweden, Grand Duchy of Finland, Holland, Belgium, Switzerland, Spain, Portugal, Italy, Servia, Roumania, Bulgaria, Greece, the Ottoman Empire, Japan, China (28 ports), Egypt, Mexico, the Central American and South American Countries, the dependencies of the above-mentioned countries and the Latin acquisitions of the United States, do you not consider that it would be desirable to adopt the metric system in the United States with a view to bringing about international uniformity in weights and measures?

The preamble of the resolutions passed by the Engineers' Society of Western Pennsylvania contains the following:

> "Whereas the metric system has been adopted by all except two of the civilized nations of the world."

The report of the House Committee on Coinage, Weights and Measures by which the pending bill was recommended to passage contains the words:

> "It is now used by about two-thirds of the people of the world."

No man living or dead has even seen the first scintilla of evidence that these statements are true. They have no foundation in fact, and no foundation of any kind except simple assumption combined with credulous willingness to believe anything whatever favorable to the system. Having made the initial assumption that this change is an easy one, the metric advocates follow it by another—that it has been accomplished in all countries which have passed any kind of a law favorable to the system. How far from true this assumption is will appear from the succeeding sections.

THE PERSISTENCE OF OLD UNITS IN GERMAN TEXTILE INDUSTRIES.

The testimony before the House committee is sprinkled with opinions that this great change can be made in from three to five years (Mr. Bates, page 92, seems to think "a year or two" will be sufficient). In this matter we do not, however, need to regard opinions at all, but may apply the scientific method at once and consult the facts.

At the discussion of the Mechanical Engineers there was exhibited a collection of French and German books from the library of the *Textile World.* These books present a condition of things which is absolutely startling. As instructive as any is a little German book of 105 pages, "Kalkulator für Artikel der Textilbranche" (Calculator for Articles in the Textile Industries), by Friedrich Frowein, third edition, 1901. The object of this book is to give a *simplified* system of calculating for textile fabrics, and it discloses a condition of things in German-speaking Europe compared with which our own is simple indeed. This condition is due to the fact that there are still in use nine different ells in addition to the metre and the English yard. These ells are divided into inches, an inch ranging all the way between $\frac{1}{20}$ and $\frac{1}{36}$ of an ell, and such extraordinary ratios as these being still in use:

Prussian ell..................	$25\frac{1}{2}$ inches.
Würtemberg ell..............	$34\frac{1}{4}$ inches.
Vienna ell....................	$29\frac{1}{2}$ inches.

In brief the book shows that there is still in use in German textile mills an absolute medley of ells, inches, yards, metres, kilograms, and pounds, combined with a vast number of systems of yarn numbering based upon these different units of length and weight, while towering above all these systems of yarn numbering are found the English yard and pound in all branches except the silk industry, in which the metric system cuts a very small figure.

In the *Textile World* for October, 1902, is an article into which has been lifted bodily the following specimen of Frowein's *simplified* calculations of the cost of a piece of worsted cloth:

Kalkulation.

Ein Stück einen Meter breit und hundert Meter lang.

Kette per cm 24 Faden 48r Weft (Double).
Einschuss per cm 28 Schuss 40r Single Weft (einfach).
Rieth (Blatt) per cm 12 Rohr 2fädig.

Englische Weife.

Kette· 48r Weft à 100 Meter $3^3/_4$ Gr.
2400 Faden = 240000 Meter = = 9000 Gr.
Verschmälerung 4 %, 96 Faden = 9600 Meter = 360 „ = 9360 Gr.
Einkreuzen 8% = 19968 Meter 749 „
10109 Gr.

Stoff per engl. Pfd. Mk. 3.—
Färben „ „ „ „ —.20
1 engl. Pfd. Mk. 3.20, daher obige 10109 Gr. Mk. 71,89

Einschuss: 40r Single Weft à 100 Meter $2^1/_4$ Gr.
28 Schuss per cm = 280000 Meter = 6300 Gr.
Einkreuzen 2% = 5600 Meter = 126 „ = 6426 Gr.

Stoff per engl. Pfd. Mk. 2.—
Färben „ „ „ „ —.20
1 engl. Pfd. Mk. 2.20, daher obige 6426 Gr. „ 31.42

	Mk. 103.31
Verlust 6 %	„ 6.20
	Mk. 109.51
Fingirter Satz siehe erste Kalkulation 50 %	„ 54.76
	Mk. 164.27
Spesen und Zinsen 10 %	„ 16.43
Herstellungskosten	Mk. 180.70

Zu obigem Stück sind erforderlich:

Kette 269568 Meter = 294933 Yards à 560 Yards 1 Zahl = $526^2/_3$ Zahlen
Einschuss 285600 „ = 312473 „ à 560 „ 1 „ = 558 „

A German Estimate of Cost of a Worsted Fabric at the Present Time. The English Standards are Marked with Dotted Lines.

Mr. Dale describes the operations performed in this illustration thus:

"The raw material is purchased by the *English pound.* The finished goods are sold by the *French metre.* The yarn counts are *English,* while the length and width of the finished goods are *metric.* The length of the yarn is expressed in *metres,* while the counts are *English,* based upon the *yard* and the *pound.* From this hodgepodge the weight of the yarn is calculated in *grams,* which is extended by another arithmetical somersault at a price given in marks per *English pound,* and to cap the climax the total length of the yarn in *metres* is reduced to *English yards* and then to *English skeins* of 560 yards each.

"There is no theory here. This estimate is an example of German practice at this moment, and yet men can be found who say that the metric system was adopted in Germany in two years without inconvenience, some asserting they were present when the trick was done; and stranger still, other men can be found who believe it."

Note that this example is relatively a simple one, because it contains none of the ells nor inches, but relates to yards, metres, pounds, and grams only. It hence represents exactly the condition which the adoption of the metric system would bring about in our own mills.

A second German book is "Garn-Nummerirungen, Haspelungen und Vergleichende oder Umrechnungstabellen" (Yarn Numbering, Reeling, and Comparative Reckoning Tables), by Heinrich Kutzer, 1901. This book contains a great number of tables for comparing and reducing the numerous units of length and weight, and is of wider scope, geographically, than the first one cited. It shows that 21 ells are in use in European countries in which the metric system is nominally established.

A third German book is "Methodik der Bindungslehre und Decomposition für Schaftweberei" (A System of Weaves and Analysis for Harness Weaving), by Franz Donant, 1901. This contains an explanation of the various systems of yarn numbering used in German-speaking countries. It is chiefly significant because of the order in which these systems occur, as the English system heads every list except the last, in which there is no English system. Following are the lists:

Cotton—English, French, metric (note the *French*).

Linen—English, Austrian (no metric).

Jute—English only.

Worsted—English, metric.

Woollen—English, Austrian, Prussian, Saxon, metric.

Silk—Milan, Turin, Lyons, metric.

11. A fourth German book is "Mechanische Technologie der Weberei" (Mechanical Technology of Weaving), by G. Herman Oelsner, eighth edition, 1902.

This is an elaborate and beautifully printed treatise of 942 pages. In it page after page is devoted to conversion tables giving metric equivalents of Rhenish, Leipsic, and English inches, as well as of Leipsic and Berlin ells and of English yards.

On page 130 may be found the metric equivalents of the following ells: Prussian, Saxon, Brabant, Bavarian, Wurtemberg, Baden, Vienna, English, Danish, Swedish, Russian. On page 74 he refers to the Cockerill system of yarn numbering used in Belgium, and which is based on the length of 2,240 Berlin ells.

On page 75 he refers to six systems of numbering for carded woollen yarn as follows: Prussian, Saxon, Austrian, English, Elbœuf, Sedan.

On page 121 are some striking illustrations of the annihilation of vulgar fractions by the metric system. In a table giving the number of threads per French inch and per centimetre the following mixed numbers occur in the first line: $11\frac{59}{131}$, $31\frac{1}{29}$, $24\frac{106}{131}$, $67\frac{7}{29}$ A footnote to this page states that the French inch is used for gauging the set of fabrics in Switzerland.

In this connection I clip (italics mine) the following from the *Textile World* for September, 1902:

"A writer in the *Leipziger Monatschrift fuer Textil-Industrie* expresses his conviction that German cotton manufacturers must abandon the hope of driving from that country the English system of yarn numbering. This view has been strengthened, undoubtedly, by the action of the tariff committee of the Reichstag, which, owing to the strong opposition of German mill owners, has rejected the proposal to compel the exclusive use of the metric system for yarn, and has arranged the yarn schedules in the new tariff bill in accordance with the English counts, *thus continuing the official German sanction of the English system.*"

The English system of yarn counts carries with it the yard and the pound, and this recognition of them is an official confession that twenty-eight years of effort to introduce the metre and the kilogram as a basis of yarn counts has resulted in failure.

I also give without comment, except italics, the following from *Wochenberichte Handelsblatt der Leipziger Monatschrift fuer Textil-Industrie*, July 16, 1902:

"At the session of the [German] Tariff Commission on the 24th of June, the question came up regarding the employment of the metric system for cotton yarn. According to one delegate, Muench-Ferber, who is also a partner in a woollen and cotton weaving mill, 'the use of the metric system for yarn would lead to ungodly disorder (heillose Verwirrung) in the domestic weaving industry, *since our machines are constructed for the use of the English numbers.*'"

THE PERSISTENCE OF OLD UNITS IN FRENCH TEXTILE INDUSTRIES.

In France the condition is, if possible, still worse. Illustrating this may be cited "Traité Théoretique et Pratique de Tissage" (Theoretical and Practical Treatise on Weaving), by Paul Lamoitier, 1900. This is a standard French work on textiles of 573 pages. On page 27 may be seen a comparative yarn table giving equivalents of the following systems of yarn counting, which are thus compared because they are still in use:

Worsted—Metric, Roubaix, Reims, Fourmies, English, German.

On page 52 is a similar table for

Silk—Lyons, Italian, metric.

On page 60 is a table for

Cotton—English, French, metric (note the French again).

On page 63 is an illuminating sentence. Opening a section on yarn numbering for linen, hemp, and jute is this sentence: "On emploie le titrage anglais" (We use the English system of numbering yarn). Following this comes the following beautiful example of how the decimal system has swept all before it in France:

"The lea is 300 yards, or 274.2 metres; 12 leas make a skein of 3,600 yards; 100 skeins a bundle of 360,000 yards."

On page 88 the author gives a table showing the weight of weft or filling for one metre of worsted cloth by the Fourmies (an old French) system, and on page 87 states that "this table is given because the Fourmies is used to a greater extent than any other system of yarn numbering for worsted."

In the early part of the book, on page 24, the following may be seen:

"We shall further on study the counts of silk, cotton, linen, etc. We regret extremely these anomalies which obstruct business, lead to serious errors, and wantonly complicate all calculations."

Perhaps the most curious example of all in the French textile industries is the count of the weft threads in the fabric—the number of "picks" of the loom. Here, if anywhere, it would seem to be easy to introduce the centimetre, but nevertheless the French weaver counts his picks by the inch (*pouce*), and (save the mark!) 37 French inches equal 1 metre. On page 90 of the book under notice is the following:

"The filling is ordinarily reckoned arbitrarily by the quarter inch, and it is necessary, before the calculation of a fabric, to convert the picks per quarter inch into picks per centimetre. There are 148 quarters of an inch in a metre; 1 centimetre is equal to 1.48 quarters of an inch; 5 picks per quarter inch are equal to $7\frac{4}{10}$ picks per centimetre."

In *L'Industrie Textile*, the leading French textile journal, for August 15, 1902, is a four-page description of a new worsted-spinning frame, and an account of a test of it. At the conclusion of the mechanical description the capacity of the machine is given for different sizes of yarn. These sizes are given in the Roubaix system, under which the test was made, which figures are then translated into the metric system.

It is wholly impossible in a few paragraphs to even indicate the confusion and complexity which are shown by these books to prevail in the weights and measures of metric Europe. The complications introduced by them into textile calculations are beyond belief.

In these books are pages after pages of conversion tables between the various ells and between the ells and the yard and metre, added to which are conversion formulas making a total which is fairly maddening. These comparative calculations and reductions are an essential part of all French and German textile literature. A French or German work on textiles dealing with metric weights and measures alone would be worthless to 99 per cent. of the French and German textile industry. *Note that all books cited are modern.*

They are but a small portion of those in the possession of the *Textile World*, the whole collection offering, in fact, an embarrassment of illustrative material.

A concise statement of present-day French practice from a recognized French authority will, no doubt, be considered by some to possess greater weight than the most obvious deductions from books, and, very opportunely, M. Paul Lamoitier, the author of the book last above cited, publishes a leading article on "The Unification of Yarn Numbering" in *L'Industrie Textile* for October 15, 1902, of which journal he is, I believe, the associate editor.

From advance sheets of the *Textile World* for December I make the following extracts from a translation of this article:

"It is absolutely unworthy of us French who were the first to find and apply the metric system to retain the *aune* and the *denier* for measuring silk. Ah! these Americans are not considerate of our feelings and they are right. We are as much in the anarchy of weights and measures for the textile industry as at the time of the Revolution, for we have the *denier* of Montpelier and of Milan, for silk, with the *aune* as a unit of length. We still have the diverse standards of Roubaix, Fourmies and Reims for worsted, the *moque* of Sedan, the *livre*, the *quart* and the *sous* of Elboeuf, the yard for linen, etc. Ah! the famous *aune*, do you know its equivalent? Exactly 3 feet 7 inches 10 lines and 10 points, or in other words, 1.188447 metres, the foot being equal to .324839 metres and divided into 12 inches, the inch into 12 lines and the line into 12 points. [The foot and inch referred to here are obviously the French foot and inch.]

"The yarn count in the north of France is a length and in the centre, a weight. I will take my oath that the manufacturer of Rouen, if he has not studied each section separately, has no idea what is the standard of Reims or the *denier* of Lyons or Milan. And on the other hand, the manufacturers of Reims and Lyons are likewise puzzled in making comparisons of the diverse numberings of the diverse materials.

"And this is the reason why they are right in mocking us when they say we do not use the metric system for numbering yarn and for weaving calculations. Nothing is more arbitrary than to reckon the yarn by the thousand metres and the width of the cloth and the picks of the filling by the inch. It is nonsense and a derision. Note also that, while I speak here only of France, I could say as much of all Europe."

Later in the article the author calls for a compulsory law to compel the use of the metric system in French textile industries, and adds:

"The advantages? It would put a stop to the chaos which the Americans ridicule. * * * In short, they would not ridicule us any more. It is not pleasant to be thus continually ridiculed by foreigners, especially when they have good reason for doing so. * * * In the face of foreign sarcasm it [the metric system of yarn numbering] should be established at the earliest possible moment."

In the November issue of *L'Industrie Textile*, M. Lamoitier has another article in which he points out an "annoying anomaly," namely, the fact that French loom widths are expressed in quarter yards. Referring to the results of a change in these widths to metric dimensions he adds (italics mine):

"*We have now a confusion which will spread throughout the world and increase with the general adoption of the metric system.*"

The references to American criticism of French practice in the above relate to articles in recent issues of the *Textile World*. The anti-metric fight which Mr. Dale has conducted in the columns of that journal, as well as his assistance in the preparation of this paper, deserves all the recognition which I can give.

At this point it is interesting to quote the testimony of Dr. Wiley (page 51): "There is only one great objection to the metric system, and that is, it is going to weaken our mathematical abilities, because we will not have this immense practice in computation which we have to have now." The system seems not to have had that effect in France and Germany.

In the simplicity and uniformity of its weights and measures this country is fortunate beyond comparison with Continental Europe.

The meaning of all this, and the lesson to be learned from it, is not, however, that the textile industries of France and Germany are infinitely worse off than our own as regards their systems of weights and measures, nor that their textile calculations are infinitely more laborious than ours (both of which, however, are facts), but that twenty-eight years after the compulsory adoption of the metric system in Germany the old units still persist to an extent calling for such books, and that, in France, a hundred years of time, national pride, and a despotic government combined have not succeeded in killing the old units. The only effect of the adoption of the metric system in both of these countries has been to add a new set of units to the old ones. Shall history repeat itself here?

If the reader wishes further confirmation of these facts, he may find it in the "Report of the International Congress for the Unification of the Numbering of Yarn," held at the Paris Exposition of 1900. From Mr. C. J. H. Woodbury's translation I make the following extracts:

M. De Pacher "believed that the numbering of yarns could not be introduced in every country except by the authority of a law positively ordering its use to take place on a certain date for all textile industry and for all commerce in every kind of yarn. The change would be made by a law, or it would not be made at all. He was convinced that the spinners who commenced to wind and to number their products according to the resolutions of the Congress before a law should be enacted to forbid the sale of yarns wound and numbered according to the old way, would probably keep their yarns and would be obliged to sell at a loss."

Note the agreement of this speaker with M. Lamoitier, that after 110 years of the metric system in France *more compulsory law is needed.*

Said the Corresponding Secretary of the Congress, M. Ferdinand Roy (italics mine):

At present, one of the arguments of the English Government is this: the international commerce is carried on under the English numbering and this proves how much this numbering has entered into the customs so that *even in certain countries where the metric system is obligatory, the custom tariffs are established for yarns according to the English numbering.* * * * For raw and finished silk, France has maintained up to the present time the old standard; the grain or denier (a copper coin weighing 1¼ grammes) being the unit of weight and the ell being the unit of length. The legal standard indicated by the law of June 13, 1866, and expressing the weight in grammes of a small skein of 500 metres has never been adopted by commerce.

Said M. Edouard Simon, Secretary of the Commission of Organization (italics mine):

"We have thought that there would also be an opportunity to modify, in conformity with the conclusions of the former Congresses, the French law of June 13, 1866, in accordance with which the standard of silk is represented by the mean weight expressed in grammes of a small skein of 500 metres, the sample being made upon 20 small skeins of the same length.

"*This legal standard has remained a dead letter.*"

Contrast this experience with the expectations of the pro-metric witnesses before the House Committee on Coinage, Weights and Measures, that our law will effect the transformation in from three to five years.

The secretary also read from a former opinion of M. De Pacher, as follows:

"It is certain that yarns divided and numbered after the metric system will be unsalable in the greater part of European markets as long as it is permissible to buy or sell yarns divided according to the old systems to which many generations have been accustomed."

Said the English delegate, Mr. Brigstocke:

"The international unification of the numbering of yarns based on the metric system, according to the opinion of the English Government, is not, under the present circumstances, acceptable with us, and I should add that this opinion is participated in almost unanimously by the English spinners themselves."

Contrast this with the opinion of so many (including Lord Kelvin), that if we will only jump into this bottomless pit England will be sure to follow.

THE GENERAL PERSISTENCE OF OLD UNITS IN FRANCE.

From M. Laurence V. Benét, artillery engineer for Hotchkiss & Cie., of Paris, I have the following:

"Outside of Paris, and the other large cities in France, the trades-people * consistently violate the law by using the old measures, the only exception being the locksmiths, bellhangers, etc.

"My experience has been, that every Frenchman, when questioned, will start out by saying that the metric system is universally used, and is giving perfect satisfaction, but when pressed closely will readily admit that among the lower classes, the old weights and measures still persist."

From M. L. H. de L'Espée, a French mining engineer and believer in the metric system who is now connected with the National Association of Manufacturers, I have the following:

"Of course, there is everywhere to be found a spirit of routine, and perhaps stronger in France than anywhere else. People who have been used to certain standards during their whole life, are not willing to change them at once. There is no doubt that old measuring standards are still largely in use in many parts of France.

"In the matter of length measurements, the size of a man will be expressed in pieds (feet) oftener than in metres, in the familiar language. The aune (1.20 metre) is still often used in measuring dry goods, in some provinces. The lieue (league) of 4 kilometres is often spoken of in computing distances. As to the mille marin or noeud (knot), the predominance of England in all matters pertaining to navigation is sufficient explanation for its retention in naval vocabulary.

"In the matter of area measurements, the arpent, equal to about $\frac{1}{2}$ hectare, is still largely used. However, its value is variable in the different provinces, which goes to show the usefulness of the hectare provided by the metric system. In Lorraine, the jour (one man's day work) is still the predominant unit in farm measurements.

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* I infer that this word refers to mechanics and not to merchants.

"For grain measurement, the bushel (boisseau) is still used in many provinces. For liquid measurements, there is still an endless variety of standards, the pièce of 228 litres and the tonneau of 4 pièces in the Bordeaux region; the feuillette of 105 litres in Burgundy; the mesure of 44 litres in Lorraine. Wine crops in Lorraine will invariably be computed in so many mesures par jour. Even in Paris wine is often retailed by the setier.

"For lumber and firewood measurements, the metric stère has never proved a favorite. Firewood is almost exclusively sold by the cord, and lumber is usually sold by the dozen of solives, madriers or planches, each of these denominations having fixed sizes as to length, width and thickness."

Following are extracts from a letter by an American engineer who has lived in Paris for some years and whose experience in Continental Europe dates from 1889. He is a graduate of the Massachusetts Institute of Technology, and occupies a leading position; but his connections are such that he desires that his name be not mentioned.

"It is rather singular that the decimal division and multiplication of the metre or kilogramme do not appear to suit various industries for widely different reasons. In order to give you a few examples of this I have extracted some paragraphs from a well-known and very useful handbook in the French language, entitled Formulaire de l'Electricien, edited by M. Hospitalier, who happens to be an authority on the subject we are now discussing.

"The most striking example and one which appears to provoke the wrath of M. Hospitalier is the Cheval-vapeur corresponding to the English horse-power. You will see that he considers the cheval-vapeur an empirical unit. M. Hospitalier's contention is that the Poncelet or 100 kilogrammetres per second, the metric and decimal unit of power and not the cheval-vapeur or 75 kilogrammetres per second, should be adopted. You will see that M. Hospitalier hoped to see this logically defined unit accepted by the International Congress of 1900. As he states, routine got the better of logic in the discussion, and the cheval-vapeur obtained the sanction of the Congress.*

"The other extracts concerning Elasticité and Unité de

* Fancy changing the value of the horse-power at this late date! The proposition is no more absurd than the proposition to change other established units, but it should assist engineers in classifying this movement as a simple fad.

Chaleur refer to the confusion resulting from the use of several industrial units. I have also extracted the paragraphs on Unité de Longueur and Unité de Masse since they very clearly set forth the difference between the theoretical metric units of length and mass and the arbitrary standards on which the metric system is based.

"I send you, by this same mail a copy of *Le Matin*, a Paris morning paper of good standing. If you will refer to the blue pencil marks you will probably be surprised to find so many industrial units of measure which are neither decimal nor metric.

"Of course, when it comes to making out a bill or any business document where the amounts of material are specified, it is necessary, according to French law, to use the units of the metric system in conveying this information. If this is not done you run the risk of a fine.

"On page 5 under the heading *Bulletin Commercial du 5 Janvier*, you will find short paragraphs on the trade in various merchandise. In the paragraph *Spiritueux* you will find the stock is 11,800 pipes and that the sales were 535 pipes. The pipe is, of course, an English measure, equivalent to 105 gallons. Whenever it is necessary to refer to its contents for the purpose of billing or measuring, the litre measure is of course employed.

"In the paragraph *Sucres* the trade unit is the sac, and under the heading *Depêches Commerciales*, you will find the sales of cotton given in balles, and of coffee in sacs. It is more than probable that the sacs of sugar and of coffee do not contain the same number of kilogrammes of material any more than they contain the same number of pounds. They are nevertheless non-decimal units and, like many others I could find, if I had the time, are sanctioned in French commercial affairs. It could not well be otherwise.

"I received recently an advertisement of a coal and wood merchant who classified his wood as follows:

$$\text{Bois (1) traits} = \frac{1.\text{m } 14}{2} = .\text{m } 57$$

$$\text{(2)} \quad \text{"} \quad = \frac{1.\text{m } 14}{3} = .\text{m } 38$$

$$\text{(3)} \quad \text{"} \quad = \frac{1.\text{m } 14}{4} = .\text{m } 28$$

$$\text{(4)} \quad \text{"} \quad = \frac{1.\text{m } 14}{5} = .\text{m } 23$$

"The industrial non-decimal unit in this case is the trait. The stère is the decimal unit of wood measure of the metric system, equal to one cubic metre, and measures 1.14 metres in length of wood by 0.88 metre by 1.0 metre. Consequently one trait refers to the piece of wood which is obtained by cutting the piece of 1.14 metres into two equal parts. The piece known as 2 traits is obtained by cutting the 1.14 metre piece into three equal parts, etc. Although the stere is the decimal unit of wood measure in the metric system, the manner of making up the cubic metre clearly indicates that the old-fashioned method of cutting wood to a length of 1.m14 has not been superseded by cutting to 1 metre lengths. The only thing to do in this case was to make the wood pile 0.m88 high to obtain the cubic metre or stere. It seems to me that this is an instance of adhering to an old well-established practice in spite of the supposed advantages of the decimal units of the metric system. The wood merchant has taken the precaution to give the lengths of his wood in metric measure 0.m57, 0.m38, etc., probably to avoid the fine.

"If you will refer to page 6 of the *Matin*, you will find several advertisements of wine dealers or producers. Four of them refer to the pièce and only one gives the contents, stating that his pièce contains 228 litres. Three offer their wine in quantities of 109, 215, 218 and 228 litres; the first figure representing the demie-pièce and the other three figures representing the pièce, the contents of which varies throughout France, and which is fixed in certain territories only. That is, a pièce of Bordeaux would contain (according to law) a certain number of litres and a pièce of Burgogne contains another number of litres. The content is evidently measured in litres, but these units of demie-pièce and pièce may be considered as non-decimal industrial units of liquid measure.

"Since writing the above I have visited one of my friends in the country, about one hour's ride on the railway from Paris. I find the following units in current use in this market town.

"The setier containing 156 litres is used for the sale of agricultural product, as grain, potatoes, etc.; the minot, equal to ½ mine or 39⅓ litres, for the sale of apples; the quarteron for the sale of eggs or nuts, equal to 26 of each; the feuillette of wine, containing 135 litres. For sale of land the non-metric units of perche and arpent are still used. Land is also measured in journaux (plural), journal (singular), non-decimal industrial units of land measure.

These words are used in the printed notices of sales posted up by the Notaries Public, and are always followed by the content in metric measure. I was shown some recent catalogues of brushes in which everything was sold by the ligne, the pouce and the douzaine. For that matter many things are sold by the dozen and gross in France and not by dizaines or 10's.

"If you will refer to stock exchange quotations in the *Matin* you will find a curious condition of affairs which can be easily explained. At bottom of page 3 under the heading *Change* you will find all values given in whole numbers and fractions, as $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ and $\frac{1}{32}$. Ditto for the New York and Chicago quotations in the same column. On page 5 after the heading Cloture des Bourses Européenes, you will find a mix-up of these fractional parts and decimals. One strange example is the "Exter Espagnols" quoted at $86\frac{3}{8}$ at Bruxelles. This same value under the heading Bourse de Paris (Rentes Etrangères) is quoted 87.95 and 88.02, that is, decimally. Evidently these are matters of custom but it goes to show that there is no great difference in the use of fractional or decimal values, since both are found indiscriminately on the same page.

"I enclose a paragraph which I have torn out of *Le Temps* for December 23, 1902, relative to one of the proposed types of French cruisers. You will see that the maximum speed of the cruiser is expressed in knots, and the maximum possible cruising distance, in sea-miles.*

"I have given you examples of a number of non-decimal industrial units with names which are, of course, not found in the terminology of the metric system of measures and weights. They are evidently old measures and old names and their values are expressed, whenever necessary (for special reasons to comply with the law on the obligatory use of the metric system) in the units of the metric system. Others are decimal and metric, but retain the old names for the industrial unit, as quintal for example, and not one of the series of prefixes characterizing the metric units as deca, hecto, kilo, myria, etc. Other units mentioned are supposed to be obso-

* Following is the paragraph in question: "Le cuirassé type *Patrie*, on le sait, a une longueur de 133 m. 80, une largeur de 24 m. 25 et un tirant d'eau de 8 m. 376, avec un déplacement de 14,865 tonnes. Sa vitesse maxima est de 18 nœuds, et sa provision de charbon, qui peut-être portée à 1,825 tonnes, lui donne une distance franchissable de 1,880 milles à la vitesse maxima." Note that this is a government, not a merchant ship.

lete or prohibited by law. All this tends to show that certain compromises have been made and that old industrial non-decimal units are respected in France, although their exact values are expressed in metric units whenever necessary. This is the situation some 65 years * after the adoption and use of the metric system was voted obligatory, and rather tends to show the difficulty experienced in introducing a new system of measures and weigths."

* The system was originally adopted in 1793. In 1812 this law was repealed, but was reënacted in 1837, and took effect in 1840. During the interval 1812–1840 the system remained the "legal system," but its use was not obligatory.

PERSISTENCE OF OLD UNITS IN GERMAN MECHANICAL INDUSTRIES.

In the *American Machinist* for May 3, 1900, is an article by Mr. Henry Hess, of Berlin, Germany, on metric screw threads. Mr. Hess is a personal friend and an accomplished engineer, a fact which is attested by his position. He was formerly with the Niles Tool Works of Hamilton, Ohio, and when that corporation established its great branch works in Berlin, under the name of the German Niles Works, he was selected to go to Germany, in order to carry American practice and American methods there, and form a connecting link between the two companies. Please remember that he is actively engaged in machine construction; not in a business capacity, but as a designer and constructor, and he knows the facts from the inside.

Mr. Hess writes (italics mine):

"To work with both millimetres and inches in the same shop, and not infrequently on different portions of a single piece, is too illogical an arrangement to maintain itself. A further complication is brought about by the fact that, though like in name, an inch is a widely varying quantity in different sections. In Germany alone there are at least half a dozen, of which two, the Rhenish and the English, are in such *very general use* as to cause great confusion."

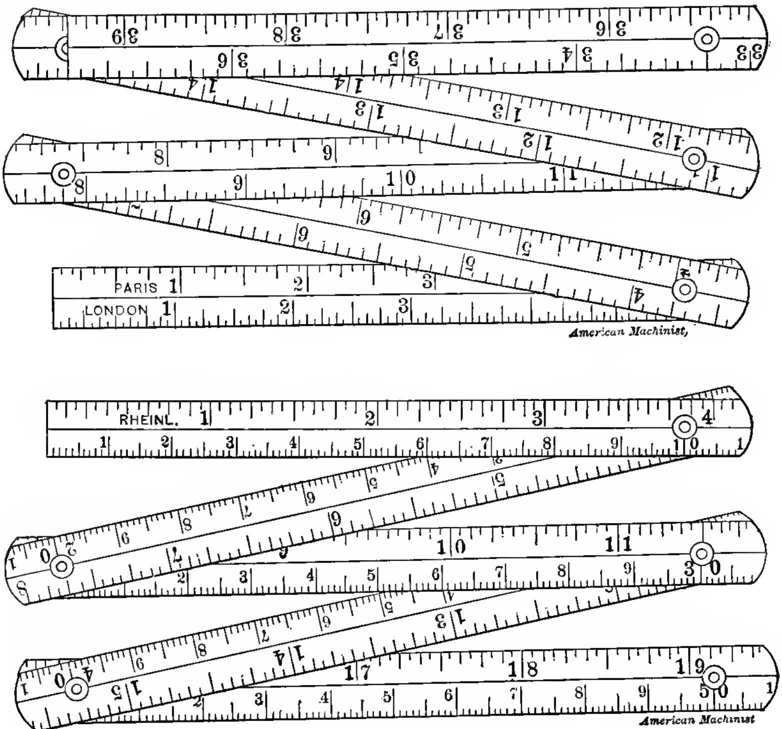
I have a personal letter from Mr. Hess dated at the German Niles Works, September 15, 1902, from which I quote the following (italics mine):

"It is quite true that the great majority of these [old provincial inches] are no longer in use; still it is to-day necessary to be very careful in using rules *that are purchasable in every hardware store,* to make sure whether the inches that are given on the reversed side are Rhenish or English inches.

"Nearly universally *the carpenters and other building mechanics use the Rhenish inch,* and we have occasionally found that men in our shops have made use of their private Rhenish foot-rules.

"As to this matter in France I cannot tell you very definitely, but I believe that similar conditions exist there, though not to as great an extent."

At my request Mr. Hess has sent me a collection of these German-made scales, which, in addition to the sacred millimetre, give upon their various edges the English, the Rhenish, and the French inch, the latter measuring 37 to the metre, as already ex-



A Collection of Inches.

plained. One of these scales is shown in the illustration. In an accompanying letter, after saying that the purchase was made "in one of the larger retail hardware shops in Berlin, located in the manufacturing district," Mr. Hess goes on to say:

> "In talking with the proprietor, I learned that *practically all of the small tradesmen* with whom he has to deal still stick to the use of the inch,* and when they want to sell them anything according to metres, they are informed that they are used to the inch and foot and do not wish to be bothered with the metre."

To understand the full force of this it must be remembered that to sell goods by other than metric measures in Germany is a finable offence, and Mr. Hess's informant has, in fact, paid such fines for acceding to his customers' demands.

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* Mr. Hess informs me that by this word he means mechanics, not merchants.

We have also the testimony of Mr. J. H. Linnard, a naval architect of the Navy Department, whose testimony before the House committee is referred to at length farther on. I have a letter from Mr. Linnard dated at Washington, September 5, 1902, in which, after saying, "I recently made a short trip to Germany," he goes on to say:

"The visit I made to Germany was in connection with visits to ship-building yards, and I did not come in contact with other merchants or manufacturers. I made inquiry, however, in the ship-building yards whether the use of the metric system was universal in Germany. I found that in all government work it was universal, but that two yards, one of considerable importance at Flensburg, and one at Hamburg, still use the English system of measurement for their ship work."

At the hearings of the House committee Prof. Elihu Thompson, in the course of his pro-metric testimony, read in abstract a letter from Mr. A. H. Moore (page 4), saying:

"Speaking from practical experience of the use of the metric standard in Germany, he says that the Whitworth thread is in almost universal use in Germany and central Europe. * * * * Others [other machines] were designed in Berlin and figured in millimetres, but in these the drill and tap holes were figured in inches. The peculiar reason for this was that, no good twist drills having millimetre dimensions were to be had, while American twist drills were very cheap."

The general use of English pitch threads in Germany is, of course, well known, but it will do no harm to take the fact from a metric advocate's mouth. The discriminating engineer will recall that English sized twist drills make English sized holes, and he will take the use of English sized screws and twist drills as additional evidence that the millimetre has not yet driven the inch from German machine shops, and that Germany is still in the transition period.

In *Zeitschrift des Vereines deutscher Ingenieure* for September 5, 1903, may be found the official report of the forty-fourth general meeting of the Society of German Engineers, June 30, and July 1 and 2, 1903. On page 1320 of this report may be found an action taken by the Society on Gas Pipe Threads wherein may be found the following:

"The following rules and figures for wrought iron, gas and water pipes have been presented by a committee consisting of representatives of the Society of German Engineers, the Society of German Gas and Waterworks Industries, The Society for Central Heating and the Syndicate of Tube Manufacturers:

Trade designation of the pipe according to inside diameter. English inches.	Outside diameter of pipe and thread. Millimeters.	Number of threads per English inch.	Diameter at the root of the thread. Millimeters.
1/4	13	19	11.3
3/8	16.5	19	14.8
1/2	20.5	14	18.2
5/8	23	14	20.7
3/4	26.5	14	23.2
1	33	11	30
1 1/4	42	11	39
1 1/2	48	11	45
1 3/4	52	11	49
2	59	11	56
2 1/4	70	11	67
2 1/2	76	11	73
3	89	11	86
3 1/2	101.5	11	98.5
4	114	11	111

A New German Pipe and Pipe Thread Standard.*

"In conformity with the Council the general meeting accepted the proposals of the committee."

And so this delightful hodge podge of inches and millimeters is the best pipe and thread standard which the Society of German Engineers ean evolve in this year of grace, 1903. The technical reader will of course recognize it as little more than the Whitworth standard which the German Engineers thus acknowledge they cannot change.

From Mr. R. T. Wingo, of the Browne and Sharpe Manufacturing Company, I have the following:

"My experience with the metric system in Europe dates from April, 1893, to August, 1895, while I was connected with one of the best known machine shops in Germany, as a mechanical engineer, and during that time I had considerable practical experience with the metric system in engineering. Before going to Europe I had been led to believe that the European countries were using the metric system entirely, but I soon found that such was not the case, as some of the old systems are still used. In the larger machinery manufacturing centres they have accomplished the most in the way of using the metric system, but even in these centres the people do not confine themselves entirely to it, as frequent use is made of the inch, foot, pound, etc. In the smaller towns and cities, and in the repair shops, there is a great confusion of systems arising, I suppose, from the fact that there are so many repairs that must be

* The table above is *complete.* The original contains no columns of metric equivalents for the English dimension columns.

made on old machines that were built according to the old systems of measurements, and I suppose that there are still enough of those old machines in use requiring repairs to keep up the old systems of measurements in this one case for an indefinite time."

The letter from M. Benét, of Paris, from which extracts were given in the previous section contains the following:

"In my own experience, I recently had to order a quantity of hardened steel balls from the Waffenfabriken at Berlin in metric Germany. The sizes of these balls were given in $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{16}$ inch, etc., and the balls delivered to me accurately gauged to English, and not to metric dimensions. To cap the climax, the quotations up to $\frac{3}{16}$ inch were so much per *gross*, after that so much per hundred."

Finally, recall Mr. Patterson's letter, which has already been given in correction of Mr. Stratton's mistake. While this letter uses the word *pipe* only, it is a fact that the National Tube Company have a large trade in France and Germany in both boiler tubes and pipe, which, as Mr. Patterson's letter shows, are made to English dimensions. This can only be interpreted as meaning that a good deal of boiler and pipe work is done in those countries on the inch basis.

Do not forget that this condition of things obtains twenty-eight years after the system was made compulsory in Germany.

Our manufacturing interests and methods are immensely more developed than those of Germany twenty-eight years ago, with a corresponding increase of difficulty in changing, and yet, with the change incomplete, in Germany after twenty-eight years, these people go to Washington and give it as their opinion that with us, and without compulsion, three to five years will do it all. We are told that we have three kinds of gallons and two kinds of pounds, and must therefore add the litre and the kilogram to the list, but how does our situation compare with 10 ells and half a dozen inches?

In the face of such facts as these what shall be said of such testimony as that of Mr. G. L. Cabot (page 135), that "in the case of Germany and Austria only between two and three years were required to make the complete change, and with highly satisfactory results"? What shall be said of the testimony of numerous United States consuls quoted at such length by Mr. Stratton (pages 163, 164)? A consul sees that the dry goods merchants have changed the tacks upon their counters with which they measure cloth and ribbon, that the grocers have metric weights alongside their balances, and that invoices and bills of lading are made out in metres and kilogrammes, and he concludes that the metric system is in universal use. He can know nothing of the production side of the matter, and a native of France or Germany in many walks of life need know no more. It is, however, on such evidence as this that this case largely rests.

Moreover, what shall be said of such negative testimony as that of Mr. Henning (page 600, vol. xviii., of the *Transactions* of the American Society of Mechanical Engineers): "I have been abroad some, but I have never heard of the English inch being used as a standard in any of the countries I have visited, except, of course, England." As one who is accustomed to weigh scientific data, Mr. Henning will be the first to see that, in view of the fact that others find inches in use everywhere, his own failure to find them counts for nothing.

THE PERSISTENCE OF OLD UNITS IN SCANDINAVIA.

At the annual meeting of the Engineers' Society of Western New York for 1902, Mr. Chas. H. Tutton read a paper upon this subject, and in discussing the paper, Mr. S. M. Kielland, a native of Norway, said:

"When I went over to Norway, Sweden and Denmark, a few years ago, after having been away about twenty-five years, I found the common or old measures as well as the metric measures in use by the common people, especially amongst the traders and peasantry. The most of their trade and dealing is done by the old system the same as they used to do before the metric system was adopted. Of course, if we want these difficulties and complications by the use of two or more systems which Mr. Tutton has so well pointed out, we can have them by making use of the metric system compulsory in the United States."

THE PERSISTENCE OF OLD UNITS IN GREECE.

In the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* for June 30, 1893, is an extended article entitled La Convention du Mètre et le Bureau International des Poids et Mesures. The article has several appendices, one of which is a "Résumé of Legislation Relative to Weights and Measures," from which are taken the following quotations relative to the persistence of old units in Greece, Turkey, Egypt and Central America.* Coming, as this testimony does, from the metric headquarters of the world, the metric advocates can scarcely question its accuracy:

"The metric system was made optional (in Greece), by a royal decree of 1836. The metric units have since then been used in the acts of the government at least for lineal ('*itinerary*') and superficial measurements, but among the people the decree has remained a dead letter. At various times since, the Greek government has discussed the advisability of making the system obligatory, but thus far it has retreated before the resistance of the rural population."

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* The last given for convenience of classification in the section The Persistence of Old Units in other Spanish American countries.

THE PERSISTENCE OF OLD UNITS IN TURKEY.*

" A law of the year 1886 rendered the metric system obligatory at Constantinople after an interval of five years. In consequence of this law the old measures were confiscated and destroyed in the capital, but no attempt was made to introduce the new system in the provinces. At Constantinople even the measures of the old system reappeared little by little, and in spite of an energetic attempt in favor of the metric system the Council of State, recognizing that it was impossible to use rigor, authorized anew the employment of the old Turkish system. At the present time the two systems are optional."

Thus it appears that this task, upon which our metric advocates would have our government enter so lightly, is one before which the despotic government of Turkey was compelled to confess defeat.

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* From the same source as the sections on Greece and Egypt.

THE PERSISTENCE OF OLD UNITS IN THE TREATY PORTS OF CHINA.

The following letter from Mr. L. Wing, Chinese Vice-Consul at New York, is a reply to a letter of mine asking the facts about the use of the metric system in the treaty ports of China. While the letter does not mention the treaty ports, it relates to them and to nothing else, because the letter to which it is an answer asked about nothing else.

"I can only state to my knowledge that the metric system is not used so much as it is supposed. Among our people the Chinese weight and measure are used; among the foreigners the English weight and measure, but when natives and foreigners trade with each other the Chinese standard of measurement is used if the merchandise is Chinese and *vice versa*. The tariff schedule is based on the Chinese standards of weight and measurement."

THE PERSISTENCE OF OLD UNITS IN JAPAN.

At the discussion of the Mechanical Engineers Mr. F. H. Colvin gave the result of an examination of recent volumes of the government publication Commercial Relations. Regarding Japan his findings from the reports of an American consul in Japan were:

"But Japan leads them all in mixing up custom and science, the past and the future (perhaps). The official table of imports into Yokohama gives a choice collection of piculs, kin, milles, tons, square yards, gallons, litres, square feet, gross, sho, etc., with piculs and kins in the lead, and litres notable by their scarcity.

"Building sites are also mentioned as being rented for from 5 to 8 cents per 'tsubo,' which equals 36 square feet. No 'centiare' about this.

"The consul also says: 'The Japanese have not abandoned their old weights and measures in favor of the metric system but have legalized the employment of the two side by side with the proviso that the Japanese weights shall be taken as the standard. The metric system has not come into general use. The engineers, mechanics and artisans of all kinds use the native measurements in preference.'"

This quotation from the American Consul was submitted to Mr. Sadazuchi Uchida, Japanese Consul General, New York, with a request for information regarding the accuracy of the statements, and for such further information as might be pertinent. The following is an extract from his reply:

"As to the system of weights and measures used in Japan the statement of your consul seems to be generally correct.

"By a law passed in March, 1891, shaku was determined as the unit of measure and kwan as the unit of weight, definitions being given to both these units. Although they had been in use for many years past they were not considered the units, and the making of these instruments was not strictly regulated by law until that year. The same law fixed the ratio of shaku and kwan to the metric system and *vice versa*, legalizing the use of the metric system.

"But in the ordinary trade and industries our own weights and measures are commonly used instead of the metric system, although in the army and navy they generally use the English or metric system.

"In our government statistical publications anything other than our own weights and measures is very rarely used.

"In our tariff schedules specific duties are mostly fixed by our own weights and measures, but some articles pay duties by gallons, feet, yards, litres, tons, etc."

An examination of the Japanese tariff schedule published by the Philadelphia Commercial Museum, and brought down to April 1, 1903, discloses a total of *nine* items in which the duties are levied in metric units, which items relate exclusively to alcohol, tinctures, wine, spirits and malt liquors. There are also five additional items in which the duties are levied by the case, but in which the size of the bottles is specified in litres. In the same schedule fifty-three items appear in which the duties are levied by the square yard. Neither meter nor kilogram appear in the schedule. The large majority of the specific duties are levied per kin or per 100 kin, the value of the kin being 1,325 pounds.

No better illustration of the simple credulity with which the metric advocates accept any statement favorable to their system could be given than the following from *The Coming of the Kilogram* by Mr. H. O. Arnold-Foster (page 122):

"It [the list of metric countries] contains the names not only of great and highly civilized countries but of countries that can hardly be called civilized, such as Turkey; it contains the name of Japan, the populous and busy country, etc."

THE PERSISTENCE OF OLD UNITS IN EGYPT.*

"A decree of the year 1875 introduced the metric system, in an optional way, in all the territory of Egypt. In 1892 further progress was accomplished by requiring the use of the system in all transactions of the government with individuals. The old agrarian measures have been preserved and the old units of mass are still in current use in commerce. The metric system is taught in the state schools."

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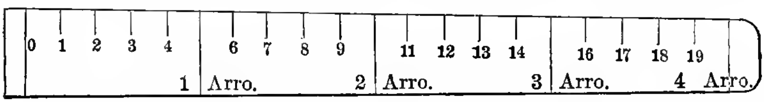
* From the same source as the sections on Greece and Turkey.

THE PERSISTENCE OF OLD UNITS IN THE PHILIPPINE ISLANDS.

The following are extracts from two letters from Rev. George D. Rice, who is chaplain of an American regiment in the Philippines:

In nearly every business house, manufacturing establishment and government institution here, scales are used with pounds on one side of the balancing arm and kilos on the other.

I find that this state exists everywhere in the islands. This is necessary because sometimes the metric system is required. The little railway of



SCALE BEAM IN COMMON USE IN THE PHILIPPINE ISLANDS.

Luzon will not receive goods unless the invoices are given with weights in kilos.

Yesterday I visited the Chinese scale makers of Manila. They have quite extensive works. I found them making most of the scales as per enclosure [a sketch of a scale beam, reproduced herewith]. The balance beam is marked with American pounds and with Spanish characters. There are five American pounds to each Spanish arro. These scales are cheap and extensively used in the shops, stores and plantations of the islands.

The reader will not fail to note the unconscious sarcasm of the word "sometimes." It is perhaps the best *bon mot* which this inquiry has developed.

THE PERSISTENCE OF OLD UNITS IN SPAIN.

From Mr. John H. Ball, of Barcelona, Spain, manufacturer of machine tools, I have the following:

"Your paper on the metric system is at hand and I cordially agree with your conclusions. . . . For the two countries [England and the United States] who do more trade between them than all the rest of the world put together, to take on the mixture of the so-called metric countries would be an absurdity.

"Spain is included among the countries whose legal weights and measures follow the metric system. As prior to the passing of the law, each province, and indeed, nearly every town of any importance had its own local scale, the unification of these numerous and bewildering scales by the introduction of the metric system to displace the oldest measures, was a step in the right direction. But between passing a law and compelling its carrying out, there is a wide gulf fixed. Thus while the metric system is universally understood, and nominally reigns, not more than half the everyday business transactions are carried out on a metric basis. Land continues to sell by the 'palmo' or span. Lineal and superficial measures include the 'palmo,' the 'vara,' or yard, which like most of the old measures differs with every province, the 'cana,' about 1½ metres, the 'destre' of from 2.829 metres to 4.214 metres. Oils and wines sell by the 'cuarto,' 'arroba,' 'cántara' and several other measures; cereals by 'fanegas' and 'ferrados'; coal and coke by the 'arroba,' 'quintal' or 'tonelada,' and the last mentioned is the only one of the lot that is approximately an exact metric measure, while there are about 20 different 'libras,' or pounds, in use, ranging from 0.350 kilogram to 0.579 kilogram, each of which is common to its town or province.

"The rule generally used in the shops is a many-jointed folding 'metro' of wood, which carries metric and English measures, but there are large numbers sold also of French make, and which carry the French inches in addition to the English and metric. In regard to the change from English to metric measures proposed in the United States and being agitated in England, it surely would be a great pity to throw deliberately away the uniformity at present reigning in those countries. However great may be the theoretical advantage of the metric system, the matter resolves itself entirely into one of use or practice. After four and a half years in a professedly metric country, the English system is still to me the easier, owing to the greater number of years of practice I have had with it. After some forty or more years of metric system in this country the mixture is, after all these years, an abominable mixture still, and bids fair to continue so for very many years more.

"As evidencing the nuisance now caused, I may quote the following: I recently bought a French lathe, constructed in Paris, and nominally of the latest model. The lead screw is 4 per inch, the gearing cut to Brown & Sharp formula, all outside bolts are English pitch, but the countersunk screws in the saddle are $\frac{5}{8}$ diameter by $1\frac{1}{2}$ mm. pitch, which cannot be cut by any combination of gears supplied with the lathe, so that, one being lost, I have either to make a 127-tooth wheel, or get a special screw from the makers of the lathe."

THE PERSISTENCE OF OLD UNITS IN MEXICO.

The most recent star example of quick change in weights and measures to which the metric advocates point is Mexico. Mr. Troemner testified before the House Committee on Coinage, Weights and Measures (p. 11): "Only recently, within the past two weeks, I talked with the Commissioner of Mines of Mexico, who visited me, and he told me the metric system was working magnificently in Mexico and that they had made the jump at once from one standard to the other."

Following is an extract from a letter from the Superintendent of Machinery of the Mexican Central Railway—Mr. Ben Johnson. The letter is dated at Mexico City, October 7, 1902:

> "We use nothing whatever but American measurements in the work of the mechanical department. Our drawings of locomotives and cars and our shop tools are all in American measurements, and as far as my information goes, this is the case with nearly all railroads in Mexico."

The Mexican Commissioner of Mines has, it is clear, no knowledge of the practice of Mexican railroads. What reason is there for supposing that he has any knowledge of other interests outside his immediate personal experience?

In the journal of the Franklin Institute for November, 1902, I find a letter from Mr. R. C. Canby, who has lived in Mexico for four and a half years, where he is in charge of the works of the Montezuma Lead Co., of Santa Barbara, Chihuahua. From this letter I make the following extract:

> "About a year ago I was sent by the company to the State of Chihuahua to superintend some new metallurgical operations, and it is surprising to me at this time to see the Babel of standards. The survey of the land upon which the works are built, as well as all levels, are in the metric system. The plans for all buildings and machinery are in the American system. A building so many feet long and so many feet wide is on such and such a metre level. All lumber ordered from Texas or from the mills in the Sierra Madre is ordered so many inches by so many feet in customary United States sizes. Local dealers sell you so many metres of such or such inch pipe, and the bill so reads. All valves and fittings come in inches. Of merchant iron you buy so many kilos of the dimensions given in inches, and I have a list-card from one of the *Mexican manufacturers* of bar and

sheet-iron giving the dimensions in $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ and $\frac{1}{16}$ of an inch, that would suit the most conservative of your correspondents. Obliging salesmen in the stores can always give you the price in 'metros' or 'varas.' Your cordwood has to be converted from 'cargas' and your hay or straw from 'arrobas.'"

My friend and former associate in the business of the Rand Drill Company—Mr. V. M. Braschi, now and for twelve years in the mining machinery and supply business in the city of Mexico—tells me the same story as that given in Mr. Canby's letter. He sells, for example, so many metres of $\frac{5}{8}$-inch wire rope. The dimension which the merchant measures off, and by which he sets his price is metric, but other dimensions may be in any unit which may be convenient. What a tremendous saving of time in calculations this must lead to!

Mr. J. Parke Channing, President of the Tennessee Copper Company, who, as a mining engineer, has seen much of Mexican mining and smelting practice, furnishes the following account of the method of determining the value of a lead ore carrying gold and silver in Mexican smelters:

"When the ore contains 5 per cent. or more of lead it is paid for at 1 cent U. S. currency per pound when soft Spanish lead is quoted in London at 13 pounds sterling per ton of 2,240 pounds. For each advance or decline of 1 shilling, 3 pence in the London quotation, 1 cent U. S. currency per 100 pounds for lead contents will be added or deducted.

"The ore, however, is weighed and deliveries are made in kilos and assays are reported per metric ton of 1,000 kilos.

"The silver is paid for at $90\frac{1}{2}$ per cent. of New York quotation which is in U. S. currency per troy ounce. The gold, however, is paid for at $0.6269 U. S. currency per gram.

"Freight and treatment charges are $24.50 Mexican currency per ton of 2,000 pounds avoirdupois."

Mr. Channing also informs me that in Mexico lumber is sawn to English dimensions in length, breadth and thickness, but that the bill for a purchase of lumber will call for so many square metres of one-inch boards.

And all this is in Mexico, where the metric system is "working magnificently," and where it has been illegal to use any other weights and measures since January 1, 1884.

THE PERSISTENCE OF OLD UNITS IN CUBA.

From a letter by Mr. Alberto de Verastegui, formerly Cuban agent of the Babcock and Wilcox Co., to Mr. H. F. De Puy, secretary of that company, I extract the following regarding the conditions in Cuba:

"The metric system was established [in Cuba] by the Spanish government as a standard for the payment of custom house duties and for all official purposes, but was not made obligatory for trade, and the consequence was the greatest confusion, because every trade stuck to its old custom. So the hardware people used the English foot as a standard of length, and the Spanish pound as a standard of weight, while the dry goods people buy their goods by the yard in England and the United States, by the metre in France, and retail them in Cuba by the Spanish yard.

"In the sugar industry, although in buying land they are compelled by law to use the metric system as a standard, they are not forced to use it in private transactions, and the consequence is that as they cannot see as yet in their minds what an hectarea represents, they stick to the old unit called caballeria, which is equivalent to about 33½ acres.

"In buying and selling cane in the eastern part of the island, the ton is the standard of weight, but by a ton they mean 2,500 Spanish pounds, while in the western part the truck-load is the unit.

"In selling sugar in the Cuban market, the standard is the Castilian arroba, of 25 Spanish pounds, and the quotations are made in reales, an obsolete coin equivalent to 12½ cents in gold, and to the American market it is sold in dollars and cents of American money."

The above quotation shows, of course, how promptly the people follow the lead of the government in these matters, and how the adoption of the system by the government introduces "uniformity."

In the *Report on Cuba*, made by Mr. H. D. Dumont as a delegate of the Merchants Association of New York, the output of plantations is given in hogsheads and tons,* and again in arrobas per caballeria, the size of tobacco plantations in caballerias, the price of tobacco at Cienfuegos in hundredweights, coffee production in quintales, the production of cacao in quintales per caballeria, of malagas in arrobas per acre, and the profit on pineapples and bananas is calculated per caballeria. Nowhere in the report is there a reference to any metric unit.

* Note that by the previous letter a ton means 2,500 Spanish pounds.

THE PERSISTENCE OF OLD UNITS IN OTHER SPANISH-AMERICAN COUNTRIES.

The conditions in Brazil are thus explained by M. de L'Espée, who has already been quoted regarding conditions in France:

"In South America, the progress with the general public has been slower, as could have been expected. In Brazil, a country I know well,* outside of the large cities metric units are in but little use, and the variety of standards is practically unlimited. Most books give such units as vara, etc., which I never saw employed. Those I saw in use are the following:

"Length: The pollegada (inch); the palma (the old French palme of 22 centimeters); the pé (foot); the braca (brasse); the legua (league) of 6,600 metres.

"Area: The alquiere, containing 8 salamis, and varying widely in size from one place to another; it is equal to 2.2 hectares in Minas Geraes.

"Volumes: The alquiere of 33 litres is used for grain, as well as the carro, or load of a bullcart. For liquids, the pipa of some 600 litres, and the cargueiro or mule load, consisting of 2 small barrels of 40 litres each.

"Weights: The arroba of 15 kilos is generally used, to such an extent that the Rio Janeiro Exchange has to mark coffee quotations in arrobas, whereas the Santos market gives quotations per 10 kilos. Gold is uniformly sold by the oitava ($\frac{1}{8}$ oz.)

Following are extracts from a letter by Mr. D. S. Iglehart, of the export house of W. R. Grace & Co. He lived for a time in Peru, and has fortified his recollection of the facts by consulting the Peruvian Consul General:

"I have to-day seen the Peruvian Consul-General, who advises me that the metric system of weights and measures was established as the legal standard in Peru, November 29, 1862.

"As regards the system used in length measurements among merchants, the standard almost universally employed is the vara (.836 metres). This is especially true of the retail trade. Among wholesale merchants the metre is at times employed, as is also our yard. Feet and inches are used in connection with the vara.

"What I have said regarding Peru is more or less true of Chile, although I think that there the metric system is a little more extensively employed."

At the Indianapolis (1892) meeting of the National Associa-

* M. de L'Espée lived four years in Brazil.

tion of Manufacturers I had a long conversation with Mr. Rudolf Dolge, who, as a representative of that association, has travelled extensively in Europe, China, and Venezuela, in which last country he has lived for four years. He has acted in almost every conceivable commercial capacity for almost every conceivable kind of business, having had charge of the warehouse of the association at Caracas, Venezuela, and his opportunities for observation have thus been unique. His story is the same as that of Mr. Iglehart—in Venezuela the metre is practically unknown, the old vara being the commercial unit of length. He reports the same condition in China, where he lived for two years. For the claim that the metre is, in any real sense, established as an international unit he has nothing but contempt.

As I read the testimony of Mr. Iglehart and Mr. Dolge, the dry-goods merchants of Peru and Venezuela have not yet changed the tacks upon their counters wherewith they measure ribbon.

In the article, La Convention du Mètre et le Bureau International des Poids et Mesures, published in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* for June 30, 1893, is the following statement of the conditions prevailing in Central America:

"The metric system is little employed in Central America. The governments of Guatemala, Costa Rica, Nicaragua and San Salvador have introduced it in the customs and made it optional, but the law has remained without great effect in commerce. Honduras has remained thus far a stranger to the system."

The case against the metric system in Spanish America is completely confessed by the Monthly *Bulletin of the International Bureau of the American Republics*, which publishes regularly, apparently from standing type (for instance, page xvii of the issue for September, 1903), and with the usual metric units, a table of forty-seven non-metric units, some of which are credited to every Spanish-American country. The caption of this table reads: "The following table gives the chief weights and measures in commercial use in Mexico and the Republics of Central and South America."

THE PERSISTENCE OF OLD UNITS IN METRIC COUNTRIES GENERALLY.

In Special Consular Reports, vol. xvi., issued by the Bureau of Foreign Commerce of the State Department, Washington, I find a table of "Equivalents of Domestic and Foreign Weights and Measures as Established by Law or Custom." Following is an abstract of as much of this table as relates to *non-metric units used in metric countries.**

NON-METRIC UNITS USED IN METRIC COUNTRIES.

COMPILED BY THE DEPARTMENT OF STATE, WASHINGTON.

Denominations.	Where used.	American equivalents.
Aam (wine)	Amsterdam	41 gallons.
Aam (oil)	....do	37.73 gallons.
Aam	Antwerp	57.5635 gallons.
Do	Rotterdam	40.559 gallons.
Achtel:		
Dry	Austria	0.2181 bushel.
Solid	Prussia	0.2083 bushel.
Ahm (liquor)	Amsterdam	40.00 gallons.
Do	Hamburg	38.1473 gallons.
Do	Hanover	41.4395 gallons.
Do	Leipsic	40.0769 gallons.
Ahm (liquor)	Lubeck	39.5739 gallons.
Almude	Canary Islands	0.1481 bushel.
Do	Lisbon	4.3697 gallons.
Do	Oporto	6.731 gallons.
Do	Sicily	4.896 gallons.
Aln	Sweden	0.6494 yard.
Alqueire (dry)	Brazil	1.1042 bushels.
Alqueire	Lisbon	2.1848 gallons.
Alqueire (dry)	....do	0.3837 bushel.
Alqueire	Oporto	3.3128 gallons.
Do	Portugal	2.1848 gallons.
Alqueire (dry)	....do	4.75 bushels.
Am or ahm	Sweden	41.4432 bushels.
Amola	Genoa	0.2175 bushel.
Anker	Amsterdam	10.25 gallons.
Do	Hamburg	9.5368 gallons.
Do	Riga	10.333 gallons.
Do	Rostock	9.562 gallons.
Do	Rotterdam	10.1392 gallons.
Do	Sweden	13.3608 gallons.
Do	Alexandria	7.6907 bushels.
Do	Cairo	5.1649 bushels.

* Examination of this table will show that strict accuracy in the selections is not easy. Owing to this difficulty, I have endeavored to resolve all doubts in favor of the metric system and following this policy have omitted all Russian and Danish units. In spite of this policy it is possible that the table may contain a few units which should have been excluded; but for every such unit there are not less than three which belong in the table, but which because of the above named policy have been excluded. The reader will note the numerous German units.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Arratel	Brazil	1.019 pounds.
Do	Portugal	1.012 pounds.
Arroba	Argentina	25.32 pounds.
Do	Bolivia	25.3537 pounds.
Do	Brazil	32.38 pounds.
Do	Buenos Ayres	25.36 pounds.
Do	Canary Islands	4.245 gallons.
Do	Cuba	25.4375 pounds.
Do	....do	4.1 gallons.
Do	Mexico	25.365 pounds.
Do	Chile	25.365 pounds.
Do	Portugal	32.38 pounds.
Do	Spain	25.36 pounds.
Do	....do	4.2630 gallons.
Arsin	Hungary	0.6392 yard.
Aune	Basel	1.2833 yards.
Do	Belgium	0.7611 yard.
Do	France	1.25 yards.
Do	Geneva	1.25 yards.
Bambou	Madagascar	0.0576 bushel.
Barile	Argentina	20.0768 gallons.
Barile (oil)	Genoa	17,0835 gallons.
Barile (wine)	....do	19.61 gallons.
Barile	Malta	11 gallons.
Do	Mexico	20 gallons.
Do	Naples	11.5732 gallons.
Barril (honey)	Havana	6 gallons.
Barril	Lisbon	78.655 gallons.
Barril (raisins)	Malaga	50.6 pounds.
Barique (wine)	Bordeaux	60 gallons.
Do	Nantes	63.405 gallons.
Do	Rochelle	46.04 gallons.
Batman		
Do	Constantinople	19.132 pounds.
Boccale	Bologna	0.346 gallon.
Do	Leghorn	0.301 gallon.
Do	Milan	0.208 gallon.
Do	Venice	0.267 gallon.
Bota	Portugal	113.631 gallons.
Do	Spain	127.89 gallons.
Botta	Messina	108 gallons.
Do	Naples	128.879 gallons.
Do	Rome	246.6 gallons.
Box:		
Raisins	Malaga	44 pounds.
Do	Deiaa and Valencia	56 pounds.
Braccio	Basel	0.5951 yard.
Do	Leghorn	0.6383 yard.
Do	Milan	1.0936 yards.
Caban:		
Cocoa	Manila	83.50 pounds.
Rice	....do	133 pounds.
Canada	Bahia	1.8727 gallons.
Do	Rio Janeiro	0.3641 gallon.
Canna	Genoa	2.4518 yards.
Do	Leghorn	2.553 yards.
Do	Messina	2.3111 yards.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Cantara (maximum)	Spain	4.8714 gallons.
Cantara (mean)	....do	3,3753 gallons.
Cantaro	Cairo	95.0312 pounds.
Do	Constantinople	140.3008 pounds.
Do	Cuba	4.1 gallons.
Cantaro (grosso)	Genoa	115.31 pounds.
Cantaro (sottile)	....do	104.83 pounds.
Carga (raisins)	Malaga	177.5 pounds.
Carga (raisins)	Valencia	338.44 pounds.
Carga (wine)	Barcelona	31.8493 gallons.
Carga (oil)	....do	32.6524 gallons.
Carrata:		
Marble	Carrara	2,240 pounds.
Solid	....do	7.1268 cubic feet.
Carreau (stone)	Franee	3.632 cubic feet.
Carro (dry)	Naples	56.3258 bushels.
Do	....do	257.757 gallons.
Catty	China	1.3333 pounds.
Do	Japan	1.3085 pounds.
Do	Java	1.356 pounds.
Cavezzo	Florence	3.8257 yards.
Do.	Veniee	2.2818 yards.
Centner	Bremen	127.5 pounds.
Do	Norway	110.11 pounds.
Do	Nurnberg	112.43 pounds.
Do	Prussia	113.44 pounds.
Do	Sweden	112.512 pounds.
Do	Vienna	123.4677 pounds.
Chenng	Canton	4.1007 yards.
Do	Pekin	3.6458 yards.
Chik or Chih	China	0.3917 yard.
Corba	Bologna	20.7618 gallons.
Dry	....do	2.2317 bushels.
Coupe	Geneva	2.2036 bushels.
Covid	....	....
Do	China	0.3907 yard.
Do	Java	0.75 yard.
Cubic foot (marble)	Carrara	185 pounds.
Cubic foot (onyx)	Mexico	215 pounds.
Cubic palmo (marble)	Italy	0.555 cubic foot.
Derah	Cairo	0.708 yard.
Dirhem	....	....
Do	Constantinople	49.5 grains.
Drachma	Cairo	48.6 grains.
Do	Hungary	48.62 grains.
Do	Vienna	67.69 grains.
Dragma	Amsterdam	59.32 grains.
Dreiling	Vienna	448.5741 gallons.
Duim	Holland	1.094 yards.
Eimer	Austria	14.9526 gallons.
Eimer (beer)	Bavaria	18.0751 gallons.
Eimer (wine)	Bavaria	16.9444 gallons.
Eimer	Berlin	18.1464 gallons.
Do	Hamburg	7.6295 gallons.
Do	Leipsic	20.0384 gallons.
Do	Nurnberg	18.2233 gallons.
Do	Prague	16.9515 gallons.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Eimer	Rostock	7.6506 gallons.
Eimer (lauter-mass)	Zurich	28.9275 gallons.
Eimer (trüber-mass)	....do	30.866 gallons.
Ell	Holland	1.094 yards.
Elle	Austria	0.8522 yard.
Do	Basel	1.2337 yards.
Do	Bavaria	0.911 yard.
Do	Berlin	0.7293 yard.
Do	Bremen	0.6438 yard.
Do	Dresden	0.6196 yard.
Do	Frankfort-on-the-Main	0.5986 yard.
Elle (silk)	Hamburg	0.6266 yard.
Elle (wool)	....do	0.7562 yard.
Elle	Munich	0.911 yard.
Do	Prague	0.6496 yard.
Do	Rostock	0.6325 yard.
Do	Zurich	0.6563 yard.
Embar	Sweden	20.7327 gallons.
Emmer	Antwerp	8.8059 gallons.
Estado	Spain	1.8547 yards.
Fanega	Buenos Ayres	3.75 bushels.
Do	Chile	2.838 bushels.
Do	Havana	3.1102 bushels.
Do	Maderia	1.601 bushels.
Do	Mexico	1.5473 gallons.
Do	Montevideo	3.868 gallons.
Do	Spain	1.5753 bushels.
Do	Valparaiso	2.5753 bushels.
Fanga	Azores Islands	1.36 bushels.
Do	Lisbon	1.5347 bushels.
Do	Oporto	1.9374 bushels.
Do	Rio Janeiro	1.5347 bushels.
Fass	Berlin	60.497 gallons.
Do	Bohemia	64.56 gallons.
Fass (oil)	Hamburg	38.2556 gallons.
Fass (dry)	....do	1.4941 bushels.
Fass (wine)	Leipzig	100.1737 gallons.
Fass (beer)	....do	95.4052 gallons.
Fass	Prague	67.806 gallons.
Fass (dry)	Rostock	0.2758 bushel.
Fass (wine)	Vienna	153.2629 gallons.
Fass (beer)	....do	31.7727 gallons.
Fjerding	Finland	8.2931 gallons.
Do	Sweden	8.29 gallons.
Fjerding (dry)	....do	0.5196 bushel.
Fot	Sweden	0.9714 foot.
Frasco	Brazil	0.5625 gallon.
Fuder	Berlin	217.7883 gallons.
Do	Copenhagen	237.3375 gallons.
Do	Frankfort-on-the-Main	227.3462 gallons.
Do	Hamburg	229.7791 gallons.
Do	Leipzig	240.4612 gallons.
Do	Rostock	229.5178 gallons.
Do	Sweden	258.8028 gallons.
Do	Vienna	478.479 bushels.
Fuss	Antwerp	0.3123 yard.
Do	Berlin	0.3432 yard.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Fuss	Bremen	0.3163 yard.
Do	Frankfort	0.3113 yard.
Do	Hamburg	0.3133 yard.
Do	Hungary	0.3457 yard.
Do	Munich	0.3192 yard.
Do	Vienna	0.3457 yard.
Hok (dry)	China	1.0887 bushels.
Ikje	Japan	2.3165 yards.
Ink	Japan	2.0785 yards.
Kan	China	1.3333 pounds.
Do	Holland	0.2642 gallon.
Kande	Norway	0.5104 gallon.
Kanne	Batavia	0.3939 gallon.
Do	Hamburg	0.4782 gallon.
Do	Leipzig	0.3181 gallon.
Do	Rostock	0.4349 gallon.
Kanne (butter)	Saxony	24.7344 pounds.
Kanne	Vienna	0.1873 gallon.
Kasten	Wurtemberg	4.0047 bushels.
Knital	Constantinople	124.564 pounds.
Klafter	Basel	1.2893 yards.
Klafter (solid)	Basle	128 cubic feet.
Klafter	Berlin	2.0595 yards.
Klafter (solid)	....do	117.907 cubic feet.
Klafter	Bremen	189.77 yards.
Do	Hamburg	1.8799 yards.
Do	Leipzig	1.8547 yards.
Klafter (solid)	....do	100.49 cubic feet.
Klafter	Vienna	2.0742 yards.
Do	Wurtemberg	1.88 yards.
Klafter (solid)	....do	119.583 cubic feet.
Kong-pu	China	0.3347 yard.
Kopf	Zurich	0.9643 gallon.
Korb	Zurich	10.538 bushels.
Kumme	Berlin	26.841 cubic feet.
Kwan	China	40 pounds.
Lagel (steel)	Prussia	103.1156 pounds.
Landfass	Berne	264.971 gallons.
Last	Amsterdam	85.2457 pounds.
Last	Bremen	329.718 pounds.
Last (dry)	....do	84.078 bushels.
Last	Hamburg	89.8163 bushels.
Do	Prussia	112.292 bushels.
Lastre	Argentina	58.404 bushels.
Legger (arrack)	Amsterdam	153.752 gallons.
Do	Batavia	160 gallons.
Leung	China	0.0833 pound.
Libbra	Bologna	0.7984 pound.
Libbra (old)	Italy	0.8146 pound.
Libra	Chile	1.0141 pounds.
Do	Cuba	1.0161 pounds.
Do	Mexico	1.01465 pounds.
Do	Peru	1.0143 pounds.
Do	Spain	1.0143 pounds.
Do	United States of Colombia	1.0143 pounds.
Do	Uruguay	1.0143 pounds.
Do	Venezuela	1.0143 pounds.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Libra	Porto Rico	1.0161 pounds.
Lispund	Norway	17.6158 pounds.
Lispund (metal)	Sweden	14.9965 pounds.
Lispund (viktualie)	....do	18.7457 pounds.
Litra	Greece	0.2642 gallon.
Livre	Antwerp	1.037 pounds.
Do	Bordeaux	1.1024 pounds.
Do	Brussels	1.0311 pounds.
Do	Geneva	1.2142 pounds.
Livre (silk)	Lyons	1.0118 pounds.
Maas	Austria	0.373 gallon.
Do	Bavaria	0.2824 gallon.
Maat (salt)	Amsterdam	1.745 bushels.
Mallal	Barcelona	3.9812 gallons.
Malter	Baden	4.2567 gallons.
Do	Prussia	18.7164 bushels.
Do	Zurich	9.4416 bushels.
Mass	Austria	0.373 gallon.
Do	Bavaria	0.2824 gallon.
Medida	Brazil	0.7331 gallon.
Metical	Constantinople	74.25 grains.
Metze	Austria	1.7454 bushels.
Do	Hungary	1.774 bushels.
Mezzaruola	Genoa	39.2172 gallons.
Mina	Genoa	3.4257 bushels.
Do	Greece	2.2046 pounds.
Do	Milan	2.6418 gallons.
Moggio	Venice	9.081 bushels.
Moio	Lisbon	23.0202 bushels.
Monkelzer	Persia	0.7836 yard.
Monme	Japan	3.750 grammes.
Mudde	Holland	2.8378 bushels.
Muid	French Guiana	70.8552 gallons.
Do	Brussels	8.032 bushels.
Do	Paris	53.1579 bushels.
Mutt	St. Gall	2.344 bushels.
Do	Zurich	2.3304 bushels.
Ocquich	Cairo	0.1504 ounce.
Ohm	Baden	39.6267 gallons.
Do	Basel	13.4459 gallons.
Do	Berlin	49.8197 gallons.
Do	Bremen	38.2965 gallons.
Do	Frankfort	37.891 gallons.
Do	Lubeck	38.4394 gallons.
Oka	Cairo	2.7771 pounds.
Do	Constantinople	2.8342 pounds.
Do	Egypt	2.7235 pounds.
Do	Greece	3.3714 pounds.
Do	Hungary	3.0817 pounds.
Orcio (oil)	Florence	8.8315 gallons.
Ottingkar	Finland	4.1476 gallons.
Outava (precious stones)	Brazil	0.1307 ounce.
Oxhoft	Berlin	54.4391 gallons.
Do	Dresden	53.43 gallons.
Do	Hamburg	57.221 gallons.
Do	Hanover	62.1593 gallons.
Oxhoft (brandy)	Leipsic	60.1153 gallons.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Oxhoft (wine)	Leipsic	53.4358 gallons.
Oxhoft	Rostock	57.3822 gallons.
Oxhufwud	Sweden	62.1980 gallons.
Palme	Belgium	3.937 inches.
Palmo	Brazil	8.5592 inches.
Palmo (marble)	Carrara	9.592 inches.
Palmo	Leghorn	11.4884 inches.
Pecul	China	133.3333 pounds.
Do	Japan	130 pounds.
Do	Malacca	135 pounds.
Do	Manila	140 pounds.
Pfund	Austria	1.2347 pounds.
Do	Baden	1.1024 pounds.
Do	Basel	1.0792 pounds.
Do	Bavaria	1.2347 pounds.
Do	Berlin	1.0312 pounds.
Do	Bremen	1.0991 pounds.
Do	Brunswick	1.0296 pounds.
Do	Frankfurt	1.1141 pounds.
Pfund (zoll)	Germany	1.1025 pounds.
Pfund	Hamburg	1.0679 pounds.
Do	Hanover	1.0794 pounds.
Do	Leipsic	1.0306 pounds.
Do	Prussia	1.0312 pounds.
Do	Rostock	1.1205 pounds.
Do	Vienna	1.2347 pounds.
Do	Zurich	1.1651 pounds.
Pfundschwer	Bremen	329.57 pounds.
Do	Cairo	0.7404 yard.
Do	Constantinople	0.7317 yard.
Pié	Argentina	0.3159 yard.
Do	Cuba	0.3091 yard.
Do	Curaçao	0.3090 yard.
Do	Mexico	0.3091 yard.
Do	Spain	0.3091 yard.
Do	Venice	0.3803 yard.
Ping	China	17.4186 bushels.
Pipa	Canary Islands	120 gallons.
Do	Lisbon	135 gallons.
Do	Madeira	110 gallons.
Do	Rio Janeiro	132.089 gallons.
Do	Sweden	124.3961 gallons.
Pipe (brandy)	Bordeaux	99.5951 gallons.
Do	Cognac	152.7821 gallons.
Pond (Brabant)	Amsterdam	1.0371 pounds.
Pond (Troy)	....do	1.0847 pounds.
Pot	Antwerp	0.363 gallon.
Pot (beer)	Brussels	0.3435 gallon.
Pot (wine)	....do	0.3578 gallon.
Pott	Basel	0.1051 gallon.
Do	Denmark	0.2552 gallon.
Do	Norway	0.2552 gallon.
Quardeel (oil)	Amsterdam	98.1421 gallons.
Quarto (oil)	Genoa	4.2709 gallons.
Quene	Burgundy	106.2841 gallons.
Quilate (precious stones)	Brazil	3.075 grains.
Quintal	Argentina	101.27 pounds.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Quintal	Brazil	130.0604 pounds.
Do	Chile	101.6097 pounds.
Do	Mexico	101.6097 pounds.
Do	Peru	101.6097 pounds.
Do	Spain	101.6097 pounds.
Do	Valencia	109.7285 pounds.
Raza (salt)	Oporto	1.2509 bushels.
Raziere	Antwerp	2.2597 bushels.
Rebeb	Alexandria	4.4582 bushels.
Rjoo	Japan	0.1659 pound.
Rotl	Cairo	0.9804 pound.
Rottel	Turkey	1.247 pounds.
Rubbio	Leghorn	7.7767 bushels.
Do	Rome	8.3553 bushels.
Ruthe	Bavaria	3.1919 yards.
Do	Bremen	5.0604 yards.
Do	Leipsic	4.946 yards.
Do	Prussia	4.119 yards.
Do	Zurich	3.296 yards.
Do	Geneva	2.204 bushels.
Sac (wheat and flour)	Paris	5.9987 bushels.
Sacco	Leghorn	2.0746 bushels.
Do	Milan	4.151 bushels.
Do	Nice	3.4054 bushels.
Do	Turin	3.2635 bushels.
Sack	Basel	3.8781 bushels.
Salma	Naples	40.2726 gallons.
Salma (oil)	do	42.1667 gallons.
Salma (wine)	Sicily	22 gallons.
Salma (dry)	do	7.8 bushels.
Salma (grosso)	do	10 bushels.
Sals	Japan	0.3314 yard.
Saum	Austria	275 pounds.
Do	Basel	40.3377 gallons.
Do	St. Gall	44.371 gallons.
Do	Switzerland	441.8293 pounds.
Do	Vienna	339.5357 pounds.
Scheffel	Bavaria	6.31 bushels.
Do	Bremen	2.102 bushels.
Do	Dresden	2.9485 bushels.
Do	Hamburg	2.9884 bushels.
Scheffel (barley)	do	4.4823 bushels.
Scheffel	Leipsic	2.9485 bushels.
Do	Prussia	1.5597 bushels.
Do	Weimar	2.1841 bushels.
Do	Wurttemberg	5.0292 bushels.
Schepel	Holland	0.2838 bushel.
Schifflast	Berlin	4,124.72 pounds.
Schiffpfund	do	340.4114 pounds.
Do	Bremen	318.7274 pounds.
Do	Hamburg	299.0082 pounds.
Schippond	Amsterdam	326.742 pounds.
Do	Antwerp	310.974 pounds.
Schoppen	Basel	0.0991 gallon.
Do	Frankfort	0.1184 gallon.
Schragen	Leipsic	301.47 cubic feet.
Schuh	Basel	0.331 yard.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Sei	China	3.4716 bushels.
Sextingkar	Finland	2.0733 gallons.
Shik:		
Tsong	China	160 pounds.
Shi	....do	2.1773 bushels.
Sjoo	Japan	0.4591 gallon.
Skalpund	Sweden	0.9361 pound.
Skeppund:		
Metal	....do	299.931 pounds.
Viktualie	....do	374.9136 pounds.
Stab	Frankfort	1.3124 yards.
Do	Hungary	1.7285 yards.
Do	Leipsic	1.2365 yards.
Do	St. Gall	1.3124 yards.
Stajo	Leghorn	0.6916 bushel.
Stajo or staro	Naples	2.6163 gallons.
Stang	Sweden	5.181 yards.
Steekan	Amsterdam	5.1251 gallons.
Stein	Berlin	22.686 pounds.
Stein (flax)	Bremen	21.9812 pounds.
Do	Hamburg	21.3577 pounds.
Do	Rostock	24.65 pounds.
Stein	Vienna	24.65 pounds.
Sten	Sweden	29.993 pounds.
Stop	Sweden	0.3454 gallon.
Strich	Prague	2.6562 bushels.
Stückfass	Frankfort	303.1283 gallons.
Stütz	Neufchatel	4.0246 gallons.
Talanton	Greece	330.607 pounds.
Tam	China	133.3333 pounds.
Tass (figs)	Portugal	33 pounds.
Tercio (tobacco)	Cuba	160 pounds.
Tomolo	Naples	1.5646 bushels.
Tonelada	Argentina	29.202 bushels.
Tonne (beer)	Berlin	30.2484 gallons.
Do	Bremen	43.8361 gallons.
Do	Germany	2,204.6212 pounds.
Do	Hamburg	45.7771 gallons.
Do	Rostock	30.6192 gallons.
Tun (oil)	Malaga	2.233 pounds.
Tunna	Sweden	33.1596 gallons.
Dry	....do	4.1571 gallons.
Uper	Belgium	0.9075 gallon.
Urna	Hungary	14.3053 gallons.
Vaam	Holland	2.0594 yards.
Vara	Argentina	0.9478 yard.
Do	Chile	0.9164 yard.
Do	Cuba	0.9271 yard.
Do	Mexico	0.9139 yard.
Do	Peru	0.9164 yard.
Do	Portugal	1.203 yards.
Do	Spain	0.9141 yard.
Do	Venezuela	0.9141 yard.
Velt	Antwerp	2 gallons.
Velt (brandy)	France	2 gallons.
Velt	Paris	1.9683 gallons.
Viertel	Amsterdam	1.9524 gallons.

NON-METRIC UNITS USED IN METRIC COUNTRIES—*Continued.*

Denominations.	Where used.	American equivalents.
Viertel	Basel	1.5028 gallons.
Do	Bremen	1.9148 gallons.
Do	Hamburg	1.9074 gallons.
Do	Rostock	1.9137 gallons.
Viertel (beer)	....do	7.6548 gallons.
Viertel	Vienna	3,7361 gallons.
Wispel (rye)	Hamburg	29.8811 bushels.
Yin	China	2.6667 pounds.
Zak	Holland	2.8378 bushels.

Regarding the use of these units and of this table, I quote as follows from three letters from Mr. Emory, Chief of the Bureau of Foreign Commerce, whose opportunity for obtaining information on this subject is unique.

It [the table] is in daily use in this Bureau in the reduction of foreign weights and measures to United States equivalents.

While the metric system is legal in the countries you mention [my reference was to metric countries in general], the old units are also very widely used. In the statements of imports and exports, the metric system is commonly employed; in business transactions in the interior, the other units.

In South American countries especially, although the metric system has been introduced and is in use for customs transactions, the non-metric units, native to the countries, are often employed in domestic transactions. These units frequently appear in the reports of Consular Officers, and I will mention a few.

The Spanish or Castilian quintal of 101.61 pounds is used in Chile (Commercial Relations, 1900, vol. i., p. 789); the measure "zeroons" (meaning unknown) occurs in the same volume, p 823; the arroba, the cuadra, and the lino are used in Paraguay (Commercial Relations, 1899, vol. i., page 687), meaning 10,000 square yards, 25 pounds, and 100 yards, respectively. The quintal in Guatemala, in the export of coffee, is "about 100 pounds" (Commercial Relations, 1898, volume i., p. 650); the finca is used in Costa Rica to designate "any area of land" (Commercial Relations, 1896–97, p. 531). The cantar is employed in Sicily in the export of sulphur; it is equivalent to 175 pounds (Commercial Relations, 1901, vol. ii., p. 429). These are only some instances that I happen to recall; a search through the Consular Reports would show many others. See also the Statesman's Year Book, 1902, p. 481: "The French metric system . . is used in official departments (in Brazil), but the ancient weights and measures are still partly employed. They are the libra, the arroba, the quintal, etc." Page 492: "The metric system is legally established in Chile since 1865, but the old Spanish weights and measures are still in use to some extent." Page 517: "The metric system was introduced into the Republic (of Colombia) in 1857; in custom house business, the kilogramme . . . is the standard; in ordinary commerce the arroba, carga, etc., are generally used." These quotations could be multiplied. I send you copies of the Commercial Relations, above referred to, and would repeat that an examination of the volumes will show other instances of the use of native weights and measures.

The examination of *Consular Relations* suggested by Mr. Emory has been made by Mr. F. H. Colvin, using the latest obtainable volumes, those for 1900 and 1901, and with the following results which were given at the discussion of the Mechanical Engineers:

Among the South American countries, which are held up as shining examples of knowing a good thing in the way of scientific measurements when they see it, I first found a report from the statistical office of Bolivia. The compiler had evidently overlooked the fact that this was a metric country, for railroad extensions were given in miles, mine products in pounds and tons, and the height of mountainous mines in feet.

Reports from Peru give lumber in feet, mine products in tons, while the detailed report of the superintendent of the Central Railway, concerning his road, gives everything in English measures.

Official reports from Uruguay are metric, but judging from the Consular reports, the native units are used in every-day life. There is also an exhaustive statement by the large house of Hufnagel, Plattier & Co., in Paysandu, Uruguay, as to the imports and exports, in which feet, kilos and pounds are hopelessly mixed.

From Venezuela there are reports from Maracaibo and Puerto Cabello, and not a mention of metric measure in the lot.

Consular reports from Mexico fail to mention metric measures in a single instance except when quoting government reports, indicating that its use is entirely official instead of popular. Railroad extensions and similar measurements are always given in feet.

Going to Spanish reports we find a quotation from a Valencia paper pointing out the increased competition of American fruit in their home market, and in France as follows: "Their oranges, apples, peaches, etc., reach Paris after traversing 6,000 *miles*, in a more attractive condition than ours after a journey of only 490 *miles*." Not kilometres but *miles*.

Consul-General Hay from Barcelona says, "that to gain this trade we must print catalogues in Spanish, as the Germans and English do"—but he entirely neglects to mention the necessity or advantage of having metric measures. Raisins are quoted in "arrobas" of 25 pounds each.

A report of navigation from Trieste, Austria, is in tons, rates in shillings per ton, battle-ships in tons displacement. Now these may be metric tons, and as the harbor improvements are given partly in feet and partly in metres, you can decide either way you like. Length of railways is given in miles, while the rates are in kilogrammes. The imports are in quintals, pounds and tons—makes a scientific system.

Belgium makes a bad showing for those advocates who think it can be assimilated in two or three years. Government reports are metric as a matter of course, but commercial houses give imports in pounds, cords and gallons. Crop reports in the Antwerp district are given in bushels and tons of 2,240 pounds. Lumber, however, is given in metres, while imports of cereals are in bushels. Another table giving the crops per hectare (2.471 acres), as follows:

Wheat (in bushels)	66.21
Potatoes (in kilogrammes)	38,911

(Note the inconveniently large figures owing to the unit being so small.)

Beet roots and tobacco are also honored with the scientific system, while all the rest must be content with the old units.

Imports of wood, both from America and other countries are given in cubic metres, while imports of rubber are in pounds. Both systems are used all through, lumber being given in cubic yards in one place.

Swedish reports give tables with pounds, metric tons, bushels, long tons, gallons, pounds and hundredweight. Other reports use kilos and pounds.

Germany.—In mentioning Agrarian legislation, bushels and hectolitres, English tons and metric tons all seem to have equal chance. Structural iron and steel are quoted in sixteenths and eighths of an inch. Textiles are quoted in hundredweights.

Italy.—Imports at Leghorn are given in hundredweights and tons, in other places in kilos. Exports are largely in pounds. Wine is quoted at so many "lire" per cask of 100 quarts.

In reports from Chile, Valparaiso, do not mention metric, but figures are given in pounds, tons and quarts. In Iquique prices are given in shillings per hundredweight, and Spanish quintals are also mentioned.

In the report from Bogota, United States of Colombia, yards and pounds are used, and there is also a quotation from a French paper regarding the mines of Muzo and Cosconeg, in which the distances are given in yards and miles. Still another report uses metric and English measures indiscriminately.

From Holland the annual circular of the Hide, Skin and Leather Co. gives imports of hides in "piculs," and translates it into pounds, although official reports use kilogrammes. Harbor improvements are given in metres in some places, and feet in others.

These examples can be multiplied many times by those who have the time to examine the records. It should also be noted that these are not old reports but the latest obtainable. I may also add that no cases have been mentioned where there was any chance of confusing the English and metric ton, or other measurements as in tonnage of shipping in ports of metric countries.

It has been assumed that consuls give the units in use in the country as there is nothing to indicate any translations, and consuls, as a rule, are not given to translating page after page of dry statistics. In the cases where native units are given, this is ample proof that there was no consular interference, for if translating it would be into English and not into native units.*

Among mechanical engineers no name stands higher as a collector and publisher of exact engineering facts and data than that of D. K. Clark, whose *Manual of Rules, Tables and Data for Mechanical Engineers* is a monumental collection of that kind. In his *Mechanical Engineer's Pocket Book of Tables, Formulæ, Rules and Data*, third edition, 1903, beginning on page 165, may be found a section giving in the severely brief manner of an engineer's reference book the leading facts regarding the weights and measures of many countries. The statements made substantiate what has been given above regarding China, Greece, Turkey, Japan, Egypt, Spain, Mexico, Cuba, Brazil, Venezuela, Peru, Guatemala, Costa Rica, Nicaragua, San Salvador and Honduras.

The following quotations give Mr. Clark's statements regarding some of these countries:

China.—"The chih of 14.10 English inches is the legal standard in the tariff settled by treaty between Great Britain and China," etc., followed by the values of many Chinese units, including those of surface, capacity and weight, none of which are metric.

Spain.—"The old system continues largely in use."

Turkey.—A table of Turkish weights and measures is given but no mention is made of the use of the metric system.

Japan.—This country is treated precisely like Turkey.

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* That the English units used are not consular translations is shown by the publication of page after page of government reports of imports and exports in metric units without any attempt at translation.

Egypt.—"In the old system in general use the pik is the unit of length," etc.

Costa Rica.—"The old weights and measures of Spain are in general use."

Cuba.—"The old weights and measures of Spain are in general use."

Guatemala.—"The old weights and measures of Spain are in general use."

Honduras.—"The old weights and measures of Spain are in general use."

Mexico.—"The old Spanish measures are still in use."

Nicaragua.—"The system of weights and measures is that of the old weights and measures of Spain."

Peru.—"The French metric system was established in 1860 but is not yet in common use except for the customs tariff."

Venezuela.—"The system in general use is the same as that of Colombia."

The following extracts relate to countries that have not previously been mentioned:

Bolivia.—"The vara = .927 yard; the gallon = .74 imperial gallon; the arroba = 25.36 pounds avoirdupois; the arroba for wines and spirits = 6.7 imperial gallons; the ounce = 1.014 ounce avoirdupois; 16 ounces = 1 libra = 1.014 pound." (Mr. Clark has nothing to say about the use of the metric system in Bolivia.)

Chile.—"The French metric system has been legally established in Chile; but the ancient weights and measures are still in use. These are the same as those of Bolivia."

Colombia.—"The French metric system is legally established in Colombia. In custom house business the kilogram is the standard of weight. The old weights and measures continue in use in ordinary commerce." [And then follows a list of the old units.]

St. Domingo.—The old Spanish weights and measures are in general use. The French metric system also is in use."

Uruguay.—"The French metric system has been officially adopted but it is not in general use. The old weights and measures are the same as those of the Argentine Republic."

Portugal.—"The French metric system is the legal standard. The old measures principally still in use are: the libra = 1.012 pounds; the almude of Lisbon = 3.7 gallons; the almude of Oporto = 5.6 gallons," etc.

Roumania.—"The French metric system is in force in Roumania. Turkish weights and measures are largely in use by the people."

Switzerland.—"The French metric system has been generally adopted in Switzerland with some changes of names and sub-divisions:

Length:	10	zoll = 1 fuss (3 decimetres)*
	6	fuss = 1 klafter *

* Note the strictly decimal ratios: 1 fuss = 3 decimetres; 1 klafter = 18 decimetres; 1 square fuss = 9 square decimetres and (save the mark!) 16 ounces = half a kilogram! ! !

	10	fuss	= 1	ruthe
	1,600	ruthen	= 1	lien
Surface:	100 sq.	fuss	= 1	sq. ruth
	400 sq.	ruthen	= 1	juchart
Weight:	16	unzen	= 1	pfund (½ kilogram)." *

Java.—"The legal weights and measures of Dutch India are those of the Netherlands. In Java other measures are in common use. The duim = 1.3 inches; the ell = 27.08 inches; the djong of 4 banu = 7.015 acres" [etc., etc., for measures of weight and capacity].

Additional facts regarding the use of old units in metric countries are given in the following letter from the Collector of the Port of New York:

I have to state that this office is in receipt of a large number of invoices received trom France, wherein the measurements of the textile fabrics covered by said invoices are expressed in aunes, and also from Switzerland covering embroideries wherein the measurements are expressed in aunes.

I have caused to be taken from the files of this office a number of invoices from Spain, Italy, Holland and Belgium, and find as follows: From Spain, 233 invoices, thirty-seven of which the weights are expressed therein as pounds, the remainder being made out according to the metric system; from Italy, fifteen invoices, the weights therein expressed in the metric system; from Holland, fifty-five invoices, fourteen of which the weights are expressed therein as pounds; eleven of the fourteen are expressed as pounds avoirdupois, and the other three invoices not stating the kind of pound, the remainder of the invoices being made out according to the metric system; from Belgium, one hundred and twenty-six invoices, fourteen of which the weights are expressed in pounds, thirty-one in feet or inches, two in yards and one in gallons, the remainder being made out according to the metric system.

In conclusion, I have to state that in many of the invoices received at this office from countries in South America, the weights are made out in the old Spanish pound.

And now, kind reader, how much remains of that imposing list of forty-three "metric" countries given on page 22 ? Those in which the old units have been shown to be in use are indicated by a dash at the left. Those that are unmarked remain for future investigation.

Is it not perfectly clear that the metric advocates have drawn on their imaginations for supposed facts, that the claims made for the universality of the system are based, to use the most

* See note on preceding page.

charitable possible construction, on simple assumption and credulity?

The fatal mistake of the metric advocates and the weakness of their case lies in their assumption that the statute book is an index of the practice of the people.

The arguments for the saving of time in calculation, for the simplification of our weights and measures and for the saving of time by school children are all based on the tacit assumption that the old units are to disappear. As they have not done so elsewhere they will not do so here, and every one of these arguments falls to the ground. The whole metric case is riven into shreds by the simple fact that these old units will not die.

Shall we carry our heads in the clouds of speculation, or shall we consult the experience of others? Shall we join in the chase of this will-o'-the-wisp which no nation has ever caught? That and that only is the metric question of the hour. Arguments based on the "beautiful interrelation and correlation of the units" have little more application than a philosophical speculation regarding the appearance of the back side of the moon.

REASONS FOR THE FAILURE OF COMPULSORY LAWS.

The reasons why compulsion has failed and must always fail to do more than bring about a superficial use of the system, and thus, in the words of John Quincy Adams, "increase the diversities which it was the intention to abolish," are not far to seek. The law may undoubtedly prescribe the units of weight and measure that, in the absence of understanding to the contrary, shall be used in commercial transactions, just as it may prescribe the units of value that shall be used in the same transactions, but in any country in which the individual has any rights whatever it can have no jurisdiction over measurements made in factories in advance of the sale of the product. In the case of manufactured goods made for the open market they are, during manufacture and until sold, the property of the maker. There being no transaction between individuals, the goods may obviously be made according to the maker's own sweet will, provided the future customer will accept them. In the case of machinery made for the open market, the law may require that such particulars as appear in contracts relating to the capacity, the weight and the over-all dimensions shall be given in certain units, but it can have no control over the many-fold greater number of constructive measurements made while the machine was the property of the maker and that do not appear in any contract. In the case of machinery made to order a greater number of dimensions usually appear in the contract, but even these are few compared with the dimensions of constructive details, and hence, even in such cases, the jurisdiction of the law is extremely narrow. Thus we see the explanation of the apparent anomaly that the fabrics that are sold over the shop counters of Paris by the metre are made in the mills of Lyons by the aune.

Again, the thousands of measurements made by mechanics in the erection of buildings do not appear in any paper connected with the contract for the erection of the buildings, or with the sale thereof. It is manifestly of no importance to the owner whether the dimensions of the bricks, the thickness of the lumber or the cross sections of the timbers be measured in metric or other units, and hence we see the reason why, as stated by Mr. Hess (page 39, *ante*), German building mechanics "nearly universally use the Rhenish inch."

Again, even in commercial transactions the law may specify those units only which are used in the measurements made by the merchant. In the sale of one-inch bar iron by the kilogram in Mexico we see the effect of the law in compelling the merchant to sell his iron by the kilogram instead of the pound. The figure for the weight forms the multiplier which must be multiplied by the price per unit in order to obtain the amount of the charge. This unit the law may regulate, but it can do no more. The figure for the diameter is merely descriptive of the goods, and over it the law does not extend.

The use of English screw and pipe standards in Germany is another illustration of the same kind. The purchase of these commodities must be by the kilogramme and the metre, but their dimensions may be in any units that are satisfactory to the consumer. The distinction that runs through all these illustrations is that while the commercial units are metric the mill units are not.

It is thus plain that while the law may force the new units into use, it cannot force the old ones out of use. Its effect, therefore, is merely to add to whatever confusion may have prevailed before its action was invoked.

We thus see why, in the words of John Quincy Adams, "The legislator finishes by increasing the diversities which it was his intention to abolish, and by loading his statute books only with the impotence of authority and the uniformity of confusion."

REASONS FOR THE LENGTH OF THE TRANSITION PERIOD.

An essential feature of the scientific method is the explanation of the facts as found, and it is easy to show why the period of transition must be so long. The pamphlet containing the testimony before the House committee contains a letter from the Brown & Sharpe Manufacturing Company, which contains a sentence embodying more wisdom and knowledge of the subject than all the pro-metric testimony. I quote (page 190): "The question of weights deals rather with the future, but . . . linear measures are tied irrevocably to the past." The man who wrote that sentence was inspired, and for a time it will become my text.

If this system were made compulsory to-morrow, and the people were to receive it with enthusiasm, the gas pipes in the ceilings of our homes alone would keep the old system alive for fifty years. In the following pages it will be shown that the metric system necessitates metric sizes. Now make the gas tips which we replace so often with metric threads, and there isn't a chandelier in this country that will take them. Make the chandeliers with metric threads, and there isn't a gas pipe end projecting from a single ceiling in this country which will take them. A fair question to ask here is, how long does it take on the average for a gas pipe to wear out? Our friends tell us that for a time we will use transition fittings with English threads at one end and metric threads at the other, but this begs the whole question. The transition fittings must be made. The length of the pipe does not alter the thread or the tools for making it. The tools and the equipment must be preserved. But why make a transition fitting at extra cost and serving no purpose except to furnish an added joint to leak? We may be sure that so long as pipes with English threads endure in our ceilings, chandeliers will be made with English threads to fit them. Why is this? Because "measures of length are tied irrevocably to the past."

In the discussion before the Mechanical Engineers, Mr. Gus

C. Henning endeavored to minimize the change in gas pipe standards by showing how trifling a thing is a transition nipple, thereby acknowledging that the change is to be made.

There is no better illustration of the confusion of the transition period than that furnished by pipe fittings, because not only must we have two standards of threads and fittings on our hands, but a third and far more numerous set of transition fittings as long as existing pipes endure. Our existing fittings are numerous enough, but they must not only be duplicated in metric fittings but more than duplicated in transition fittings. It is easy to make light of a transition nipple, but the proposition involves transition ells, tees and other fittings. For each straight tee of which we now have one, we should require during the transition period the following combinations:

M M	E E	M M	E E	M E	E M
M	E	E	M	M	E

For each simple reducing bushing we would require four combinations thus: English inside and outside; metric inside and outside; English outside and metric inside; and English inside and metric outside. For each plain ell that we now have we should need three and for each reducing ell, four. If the reader will go to a pipe-fitting factory or store, note the number of fittings necessary to make an assortment and reflect that during this transition period this number will be multiplied by not less than three and probably by four, he will recognize what Mr. Henning's playful suggestion grows into. I have often said, and I believe it to be true, that all the advantages of the metric system combined would not recompense us for the confusion of changing our standard of pipes and pipe threads alone.

The fact that actual pipe sizes are other than the nominal sizes is a favorite citation of the metric advocates but it has no application whatever. *The trouble lies in changing an established standard.* Entirely apart from the discussion of this subject, a friend once remarked, "Our pipe and pipe-thread standard is, *per se*, about as bad as it could be, but, established as it is, the man who would attempt to change it deserves to be hung."

Every factory contains overhead lines of shafting which with the pulleys to fit are a standardized line of manufacture. With standard fits pulleys may be changed from place to place by simply removing and replacing. Put up a metric line shaft, and not a pulley in this country will fit it, nor will any metric pulley fit an English line shaft. A line of shafting was scarcely ever known to wear out. I know one which is forty years old, and it was, I believe, second-hand when I made its acquaintance. So long as existing shafts endure we may be sure English dimension pulleys will be made to fit them. Why? Again, because "measures of length are tied irrevocably to the past."

They tell us that we may continue to use the old units in repairs. Consider the couplings which connect the air-brake hose on all railroad cars. A new coupling on one car connects with the old one on another car. The time will never come when that can be changed, unless they are all changed at once. Why? Because "measures of length are tied irrevocably to the past."

At the hearings of the House committee a curious fact was developed (Mr. Buck, page 145). The older part of Philadelphia was laid out by a defective surveyor's chain which, instead of being 100 feet long, was in reality 100 feet 3 inches, and in that part of the city to-day 100 feet 3 inches is legally 100 feet. By a curious process of reasoning this was made to appear as an argument for the metric system, though how the adoption of that system is to change the layout of the streets I do not quite see. Why does this anomaly, this nuisance, persist, and why is it impossible to get rid of it? Because "measures of length are tied irrevocably to the past."

There is, however, another possible explanation of the fact that the people continue to use the old units after, in France, a century of experience with the new, namely that they prefer the old.

These two explanations exhaust the possibilities—either the change is too difficult to be made or a century of experience has not sufficed to demonstrate the superiority of the metric system. Of these two possible explanations the metric advocates may take their choice.

SCIENTIFIC AND INDUSTRIAL MEASUREMENTS.

Nothing is more important at this stage of the controversy than an explanation of the undoubted fact that while scientific men favor the metric system manufacturers and constructors oppose it. This explanation lies in the fundamentally different character of scientific and industrial measurements:

The scientific use of measurements consists in measuring existing things; the industrial use of measurements consists in making things to a required size.

A typical illustration of the scientific use of weight and measure is found in the chemist's balance. The chemist places a substance on one pan and proceeds to balance it with his weights and rider. This is the exact opposite of the grocer's use of his scales. The grocer places his *weight* in the scale pan first and then proceeds to balance it with a required amount of material. The chemist finds the weight of a given mass of material; the grocer finds the mass of material which shall have a given weight.

Because of this difference the grocer has but few weights. He deals with halves and quarters of a pound or ounce as the case may be, and *with no other fractions whatever.* The chemist, on the contrary, must be prepared to deal with all possible fractions and with the same degree of facility in all cases.

This difference runs through all scientific and industrial applications of weight and measure. As in the case of the chemist, the scientist must always be prepared to handle all possible quantities within the range and capacity of his apparatus. In manufacturing, on the contrary, as in the case of the grocer's few weights, it is the starting point of all organized industry that of the immense number of possible sizes but few shall be actually used. Thus, measuring to thousandths only, we might have, between one and two inches, a thousand diameters of screw threads, whereas, in point of fact, of standard threads we have but eight, while of standard shafting we have but four, and of gas and water pipe but three.

This limitation of manufactured things to a few only of many possible sizes characterizes all branches of manufacturing and has always done so. We see it in our wearing apparel. Collars, cuffs, shoes, hats and gloves all illustrate the same principle.

Moreover, the comparatively few sizes which are thus used in manufacturing are the result of deliberate selection. That is, the constructor deliberately chooses the sizes which he shall measure while the scientist has no choice, for, as has been stated, he is quite as likely to be called upon to measure one size as another. When we inquire into the sizes which in this exercise of choice have been selected for use in manufacturing we find that mankind has always and everywhere selected those parts of units which are obtained by successive halvings, a striking feature of which is that they are expressed more clearly and more simply by vulgar fractions than by decimals, as will be seen by the following illustrative table:

$\frac{1}{4} = .25$	$\frac{3}{4} = .75$
$\frac{1}{8} = .125$	$\frac{3}{8} = .375$
$\frac{1}{16} = .0625$	$\frac{3}{16} = .1875$
$\frac{1}{32} = .03125$	$\frac{3}{32} = .09375$

The vulgar fractions are the simpler, whether we regard them from the mechanical standpoint of the number of figures involved or whether we regard them from the much more important standpoint of the clearness of the impression which they make upon the mind. The vulgar fractions impress their meaning upon the mind at once while the decimals do not until after a distinct mental effort. The average man makes no attempt to form a mental impression of the value of the decimals, but reads them mechanically as the proofreader does, thus: "point naught three one two five," giving up the attempt to form a mental picture of their value in advance.

The reason why the vulgar fractions are the simpler is that they are in their lowest terms while the decimals are far from their lowest terms. When we say that we will use nothing but decimals we simply deny to ourselves the right to reduce fractions to their lowest terms. We say in effect that we will use no denominator between ten and a hundred and none between a hundred and a thousand.

Even in addition, in which decimals possess an undoubted superiority over vulgar fractions in general, they have a close competitor in binary fractions which, among vulgar fractions, form a class by themselves. The chief reason why decimals possess this superiority in addition is that they avoid reduction to a common denominator, but this is equally true of binary fractions, the addition of which is closely analogous to the addition of decimals, the chief difference being that we carry by twos instead of by tens, as every draughtsman knows.

It may be said with perfect truth that if we used the decimal scale we would not have the above expressions. This, however, does not meet the point. Mankind prefers to use in construction not the decimal scale but the binary scale, and for the sizes thus obtained the vulgar fractions are the simpler. Certain sizes are expressed more simply by decimal than by vulgar fractions while others are expressed more simply by vulgar fractions than by decimals. The former are preferred for measuring things while the latter are preferred for making things.

The reason for the difference in the attitude of the two parties is now clear. With the miscellaneous quantities with which he must deal the scientist would find vulgar fractions almost unmanageable, and he is practically driven to the use of decimals, while the constructor, through his power of choice, selects such sizes that decimals may be avoided.

This limitation of manufactured things to a few of many possible sizes has many important results. Having but few sizes, it is possible to spend an amount in standardizing each one that would be impossible if the number were largely increased, and we thus have the feature of standardization which is entirely foreign to scientific measurements—such a thing as a standard weight or measure being exactly what the scientific measurer does not expect to find. Again, with this introduction of standard gauges workshop measurements came to be as they are to-day, essentially *the duplication of standards,* to which again there is nothing to compare in the scientific use of measurements.

The further the comparison is pushed the more unlike do scientific and industrial measurements become.

The constructor's exercise of choice in the measurements which he shall make explains the difference between the experiences of constructors and of scientists in the comparative economy of time in calculations due to the use of the two systems. In a succeeding chapter we shall see the experiences of Mr. Linnard, Mr. Hess, Mr. Reed and Mr. Reymann, who with unexcelled opportunities for making comparisons, have been unable to find the saving of time in engineering and mechanical calculations which is claimed for the metric system, while the testimony of scientific men is uniformly to the contrary. With the quantities with which he has to deal, the scientific man finds great economy of labor by the use of decimals, especially in the addition and averaging of data from observations, of which he has much to do, while the constructor, exercising the liberty of choice in the sizes with which he deals, selects those in the handling of which decimals, even in addition, give no appreciable advantage. Again, the interrellations and correllations of the units are of some importance in the laboratory, while they are of little or no importance in the engineer's office.

"For practical purposes the relation of the specific gravity of water to the units of weight and measure is, for all purposes outside the laboratory, of about the same practical application as the relation between the metre and the circumference of the earth."

Much use has been made of the employment by civil engineers of decimal divisions of the foot. This use is limited to surveying —that is, measuring—and to calculations based thereon. In bridge and structural work the civil engineer divides his foot into inches. His work comprises to an unusual degree the two functions of measuring and making. For the former he follows the practice of the scientist, while for the latter he follows the practice of all other constructors. So far from his practice being an indorsement of decimal divisions, it serves only to emphasize the distinction between measuring and making.

Whatever may be the explanation of the preference of mankind for binary divisions, the fact is universal. To the scientific man who looks upon survival in the struggle for existence as at least presumptive evidence of fitness, and upon failure to survive as presumptive evidence of unfitness, it would appear to others to be a little difficult for him to reconcile his belief in the superiority of decimal divisions with the fact that no one can be induced to use them in construction except by the force of law.

SCIENTIFIC AND INDUSTRIAL DIFFICULTIES.

The scientific man being, from our present standpoint, essentially a measurer, we should expect him in this discussion to give undue prominence to the difficulties of the measurer, and we find that not only is this the case but that, more unjustly still, he substantially ignores all other difficulties.

The chief difficulty which the measurer has to face is the psychological difficulty, that is, learning to think in a new set of units, and he uniformly considers this as the chief difficulty which others have to face, although it is, in fact, near the bottom of the constructor's list.

The chief difficulties which the scientific man must face in connection with this change are those growing out of a change in the set of units with which he measures things. The constructor, on the contrary, must face not only these but the thousandfold more important difficulties growing out of a change in the set of sizes by which he makes things. In scientific work this change involves a change in measuring instruments only, while in industrial work it involves also a change in the thing measured—that is, in the sizes of the things made.

This change in the set of sizes to which things are made is the physical difficulty of the manufacturer, and it is this which all scientific discussions of this subject substantially ignore.

No better illustration of the manner in which scientific men imagine their own chief difficulty to be also the chief difficulty of others could be given than the following statement made by Professor Stratton at the hearings of the House Committee (page 153):

"Let us take for example the most serious objection of all, which is that we have learned to think in the old system of weights and measures."

Again Dr. Pritchett, at the discussion of the Mechanical Engineers, said:

"The argument for the preservation of old and inconvenient standards rests on no other basis than this inertia of the general mass of mankind."

Again Lord Kelvin has said:

"I believe that in a fortnight people would become so accustomed to the perfect simplicity and easy working under the metrical system that they will feel that, instead of its being a labor to pass from one system to the other, it will be less than no labor."

What the above shows in small compass may be seen in much larger compass in "*The Metric System of Weights and Measures*," by Dr. F. A. P. Barnard, which, from beginning to end, is a measurer's argument. There could scarcely be a better illustration of the manner in which a man may discuss a subject to the end as he thinks with scarcely so much as a recognition of the chief point at issue.*

The chief difficulty of this change lies in the changing of constructive sizes of which all scientific discussions fail to recognize not only the importance but, as a rule, even the existence. The proposition before the country is that we adopt this system in making things. It should be settled by those who have the problems to face and the bills to pay. The attempt to bring about a change in the system of factory measurements by those who have no knowledge of the difficulties involved is a simple impertinence. The attempt to foist this thing upon the industrial world by the scientific and political worlds will yet be looked upon as *the* monumental piece of assurance of the nineteenth century.

Much effort has been expended in showing that workmen experience little difficulty in using metric scales, and there is no reason why they should. The psychological difficulty from the designer's standpoint—that is, the formation of mechanical judgment of dimensions in millimeters, is, however, another matter. Thus Mr. Henry Hess tells me that after four years constant use of the system as the chief designer in the drawing office of a German machine shop, he still found himself without such judgment, and Mr. J. H. Ball (page 54, *ante*) says, "After four and a half years in a professedly metric country the English system is still to me the easier."

The magnitude of the psychological difficulty in another aspect is completely confessed by at least one metric advocate. In the

* The same remark applies to "*The Coming of the Kilogram*" by Mr. H. O. Arnold Foster, which ignores the real difficulties of the problem in a manner that is really sublime.

Procès-Verbal de la Séance du 1er Mai, 1893, of the Société des Ingénieurs Civils de France, I find Captain Mahan's remarks reported thus:

"Although he is an earnest partisan of the system, which he has used freely for thirty years, he always finds difficulty in thinking in the system. Stating resistances in kilogrammes per square centimetre conveys no meaning to his mind; it is necessary to convert the expression into pounds per square inch."

THE ADOPTION OF THE METRIC SYSTEM NECESSITATES ABANDONING MECHANICAL STANDARDS.

As has been pointed out, the leaders of this movement have no knowledge of mechanical standards nor of the difficulty of changing them, and there is no doubt that, so far as they have considered the matter at all, they expect existing standards to be retired as a matter of course. Thus Mr. Shaffroth, in questioning Admiral Melville at the hearings of the House Committee (pages 118, 119) said (the admiral's answers are omitted):

> Do you not think that a truly international system of screws, nuts, bolts, etc., would be desirable? Is not the absence of such a universal system at present due to the fact that England and America have not yet adopted the metric system? Would not the adoption of the metric unit as the basis of the dimensions of screw threads, and the adoption of the American form as the standard, be a fair concession from both sides?

Again, Mr. Stratron testified (page 155):

> A change to the metric system of weights and measures would undoubtedly bring about, in time, a change in our system of screw threads, but only at the suggestion and convenience of manufacturers and engineers, as heretofore.

This "convenience of manufacturers" will be reached when the use of a mixed system has become no longer tolerable, for this country will not change its screw threads until compelled to do so. Of all the difficulties of the subject, the greatest centre about screw threads, and our friends show here a distinct disposition to "hedge." Their action, however, is nothing but convenient postponement and evasion, which will not do. They draw pictures of the danger of delay (Mr. Shaffroth, page 44). They point out how much easier the change would have been twenty years ago than now, and how much more difficult it will be twenty years hence than now. If that is true of the general proposition, it is equally true of screw threads. The problem is made no easier by relegating the worst of it to the indefinite future. When we contemplate the adoption of the metric system we must contemplate the *adoption of the metric system*, for the ultimate result is the same, no matter how easy the approach nor how thin the entering wedge.

Among the few converts to the system from the ranks of constructors the value of standards is of course better appreciated. The plan which is usually offered by them for the preservation of standards is that we continue to use existing sizes but measure them in metric units. The best statement of this is perhaps that of Mr. Geo. S. Morrison at the discussion of the Mechanical Engineers:

"The question is not of changes of sizes or standards but it is a question of adopting another method of measuring existing standards."

In other words they tell us that the difficulty of changing the adopted set of sizes used in construction is to be met by not changing them—the sizes now used being continued but measured in millimetres instead of inches.

Obviously but two courses of action are open—we must change existing sizes or not change them. The scientific advocates of the system expect us to change, while those who understand the difficulties expect us to make no change. No intelligent constructor can seriously contemplate the scientific plan of retiring existing standards. If existing standards are to be retained they must be measured either in inches or in millimetres. Since the object of this movement is to retire the inch, the irreducible minimum of the metric case is this plan of measuring existing sizes in millimetres, the feasibility of which becomes, therefore, the dividing line of all intelligent opinion upon this subject. The shop case for the metric system rests absolutely on the answer to the question: Is it or is it not feasible to measure existing sizes in millimetres?

The basic feature of the use of any system of measurements in construction is the use of such sizes as are represented by the lines on scales graduated in the system used. English sizes are not and cannot be thus represented by the lines on metric scales.

This is the essential difference between the practice of France and Germany on the one hand and of England and the United States on the other. This is the essential difference between the injector department and the other departments of William Sellers & Co., as it is the essential difference between the old and new engines made by Willans and Robinson. The experience of American machine tool builders in fitting their tools for foreign trade with metric measuring and adjusting screws and of the Brown and Sharpe Manufacturing Company in connection with small tools is of the same kind. The fact that stands out above all others is that to the extent which these manufacturers have adopted the metric system *to the same extent have they been compelled to abandon English sizes and English standards.*

If this metric equivalent plan is such an easy solution of the problem, why is it not used? The practically universal use of English pitch screw threads in France and Germany is well known. Of more importance from the present standpoint is the fact that not only do the French and Germans use English threads but that they measure them in inches. This use of English threads shows the difficulty of changing established standards while the use of the inch in measuring them shows the necessity of preserving the inch in order to measure standards based on the inch. The fact that the Germans not only use English threads but that they regularly measure them just as we do is beyond controversy. I have the fact from Mr. Henry Hess and Mr. H. B. Bartlett, both of whom have been connected for years with German machine shops, and in leading capacities.

Now if this plan is so feasible, why do not the Germans use it? We are expected to use it with all established standards. Why do not the Germans use it with one? That metric countries need metric threads to go with metric measurements generally is shown by their efforts to get them—efforts which are thus described by Mr. Hess in the communication to the *American Machinist* which has already been referred to:

"Finally various engineering societies took up the matter and appointed delegates to draw up and sift proposals. The work occupied a number of years, and in the fall of 1898 culminated in the adoption by a congress of delegates from Germany, France, Switzerland, Italy, and other countries using the metric system of measurements, of a shape of thread and pitch to which they assigned the name of Système International, generally known by the abbreviation S. I. or S. J."

We are told that we are to save our screw thread standards by measuring them in millimetres. If an English thread can be so easily converted into a metric thread why do not the nations of metric Europe follow the plan instead of making these tremendous efforts to obtain a metric standard?

Referring to page 42 *ante* the reader will find the recently adopted pipe and pipe thread standard of the German Society of Engineers, and he will note that the only dimensions commonly used by merchant, draughtsman or mechanic are given in English inches. Why are they not given in metric equivalents? Our metric advocates point especially to our pipe and pipe thread standards as two which are to be saved by the use of metric equivalents. *Why do not the Germans use them?*

With characteristic inverted logic, we are told that Germany does not use metric screw threads because she does not need them (Mr. Christie, page 7).* On the contrary, the need is shown by the effort put forth; the lack of accomplishment is a measure of the difficulties encountered. Germany fails to use metric screw threads, *not because she does not need them, but because, with all her effort, she cannot get them.* Her continued use of English pitch threads is but another illustration of the difficulty of changing a unit of length and of the length of the period of transition—that period which, I will again remind the reader, the metric advocates assure us will, with us, occupy but three to five years.

With one breath these gentlemen tell us how quickly we can make this change and in the next they point with pride to the fact that Germany has not yet changed her screw threads, and yet they have to be told that the second statement stultifies the first.

Had Germany adopted metric threads our metric friends would point to the fact at once and say: Behold how easy is the change! Germany has not adopted metric threads, and now they point to *that* and say: Behold how easy is the change!

Much has been made of the example of Willans and Robinson, of Rugby, England, and of the fact that they use inches and millimeters side by side. The significant thing in this connection is that the inches are used in the older sizes of engines which were designed before the introduction of the metric system. If this plan for the use of metric equivalents is so feasible, why do not Willans and Robinson adopt it and so make their works a pure metric works? By changing the figures on the drawings and restamping the sizes on the shop tools the change could, were this plan feasible, be completed almost at a stroke, instead of spending the years which have already elapsed and those which are still to come. *Why is not the plan adopted?*

In Part II. of this book will be found numerous citations of the use of various kinds of inches in the textile industries of metric Europe. Were this plan feasible, the millimetre would become

* This and the succeeding page references of this chapter are to the pamphlet proceedings of the House Committee.

the universal solvent of them all and they would disappear. *Why is the plan not used?*

The reason why the Germans do not use metric equivalents for English pitch screw threads and English sized gas pipe, and why Willans and Robinson do not use metric equivalents for English sizes is not difficult to discover. Will the reader please glance at the following table of metric equivalents of a few of the usual fractional sizes of an inch.

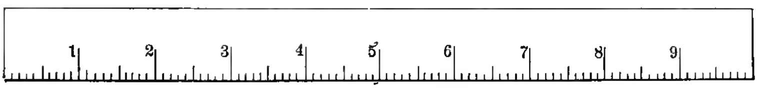
Inches.	Metric Equivalent.	Inches.	Metric Equivalent.
1	25.4	2	50.8
$1\frac{1}{8}$	28.57	$2\frac{1}{8}$	53.97
$1\frac{1}{4}$	31.75	$2\frac{1}{4}$	57.15
$1\frac{3}{8}$	34.92	$2\frac{3}{8}$	60.32
$1\frac{1}{2}$	38.10	$2\frac{1}{2}$	63 5
$1\frac{5}{8}$	41.27	$2\frac{5}{8}$	66.67
$1\frac{3}{4}$	44.45	$2\frac{3}{4}$	69.85
$1\frac{7}{8}$	47.62	$2\frac{7}{8}$	73.02
		3	76.2

Is not the point obvious at a glance? While the law of the series is simple enough, it is not obvious to the eye, and *the man does not live who can memorize the list.* Only two inches of the range are given, and even then only to eighths; but remember that no combination of figures repeats itself until 10 inches is reached, while there is nothing in the above list to correspond to any even inch between 10 and 20 except 15, nor between 20 and 30 except 25. The load which such a table places upon the memory is limited only by its length.

Imagine this table to be a bolt list. A farmer has broken a 28.6 millimetre bolt and wants a larger one, but *he nor any one can tell what size to call for without calculation or consulting a list.* Are we all to carry a list of bolt sizes in our pockets? Will some one point out the gain due to calling a $1\frac{1}{8}$-inch bolt a 28.6 millimetre bolt, or give any reason which should lead any one to use the metric figures?

In a certain stock-room the interval between the sizes of bar iron carried is $\frac{1}{4}$ inch. Two of the sizes in stock are $2\frac{1}{2}$ and $2\frac{3}{4}$ inches. The metric equivalent of the former is 63.5 millimetres. Will some metric enthusiast, without calculation, kindly name the next metric size? Will he name *any* metric size upon the list except those corresponding to even inches? Will he say if he ever expects to be able to name one-quarter of the sizes used in every tool and stock room? If he thinks he can memorize the table as given, does he think he could do it after the sixteenths are added? If he does, how will the matter stand after the table is extended to, say, ten inches? If he finally gives up the task of memorizing the table, will he say if he intends to carry a list of equivalents in his pocket, or, failing that, whether he expects to use a lead-pencil or a slide rule whenever he has occasion to call for a tool or a bar of iron? *He must do one or the other, or else use the English figures.* Do the metric enthusiasts really think that during the "transition period" any one will calculate metric dimensions which cannot be memorized when he can use English dimensions which memorize themselves?

If the intervals were, say, one millimetre up to 50 mm., two from 50 to 100 and so on, a metric list of sizes could be memorized as easily as our own, but with the intervals determined by



SCALE OF MILLIMETRES.

the English scale it is hopeless to try to memorize the metric equivalents. If they cannot be memorized they will not be used, and this is the end of the metric equivalent scheme.

Moreover we have an excellent illustration of the impracticability of using such a series of decimal sizes as that given in the foregoing table. The metric advocates are fond of citing the fact that the actual sizes of standard pipe are different from the nominal sizes, but this, like most of their citations, turns against them. Why do we use the nominal and not the actual sizes? *Because the actual sizes are expressed by a series of decimals that cannot be remembered.* And yet those metric advocates who believe in saving standards by the use of millimetre equivalents propose that we shall translate these and all other standardized sizes into metric decimals that are just as impossible of remembrance, and that we save existing standards by using them.

If the reader has any doubts about the necessity for memorizing this table let him imagine a draughtsman equipped with a metric scale as in the illustration and attempting to use it in laying down a $\frac{7}{8}$-inch bolt, a $1\frac{1}{4}$-inch pipe or a $2\frac{3}{16}$-inch shaft. Let him attempt to lay down these sizes with this scale and he will find himself entirely at sea, and he will remain at sea until he has memorized this table. And to carry out this specious scheme it is necessary that not only draughtsmen but all working mechanics shall perform this impossible feat of memory.

A suggestion which is occasionally heard was put on record by Mr. Christie (page 6, italics mine):

"I would make no immediate change in any of the tools, simply taking them as they are and naming them *to the nearest convenient metric unit.* For instance, call 1 inch 25 millimetres, and so on, with the multiples and subdivisions of the inch." Would he call 3 inches 75 millimetres? Its value "*to the nearest convenient unit*" is 76. Would he call it 76? Then, 3 times 1 inch is not 3 inches. Would he call 10 inches 250 millimetres? Its value is 254. This suggestion falls by its own weight.

Another suggestion of Mr. Christie's (page 7) is that "The various pitches of screw thread are entirely arbitrary, and we could distinguish the different pitches from each other by the letters of the alphabet if we chose, or any other nominal distinction that is convenient." I suggest that Mr. Christie draw up such a table of symbols, and then contemplate the task of memorizing it. According to Mr. Christie (page 9) one of the great advantages of the metric system is that it avoids any "undue strain on the memory." Does Mr. Christie think that draughtsmen will prefer arbitrary symbols to areas and diameters when figuring strengths?

In the discussion before the Mechanical Engineers, Mr. Gus C. Henning put Mr. Christie's suggestion in more definite shape, thus:

"Now let us take up the argument of the table of metric equivalents of values of parts of inches, increasing by eighths.

"This is again an extravagant misrepresentation of difficulties.

"If the values of $\frac{1}{8}$ inch between 1 to 3 inches be given in the nearest quarters, or $\frac{25}{100}$ millimetre, not one of the figures given will vary from the true value by more than $\frac{5}{1000}$ of one inch, which is a matter too small to observe by any person except he be provided with a micrometre caliper. The table will then read:

1	25.5	1½	38.00	2	51.0	2½	63.5
1⅛	28.5	1⅝	41 25	2⅛	54.0	2⅝	66.75
1¼	31.75	1¾	44.5	2¼	57.25	2¾	69.75
1⅜	35.0	1⅞	47.5	2⅜	60.25	2⅞	73.00
						3	76.25

"In this shape the figures can be memorized by an effort, and they will be accurate for practical purposes. Let me ask the same question as the author. 'Is not the point obvious at a glance?' All I can say is, 'None so blind as those who do not want to see.'"

Mr. Henning's table of equivalents does not look to me to be so easily memorized as it seems to look to him, and if he will add the sixteenths, which must be done, it will look less easy still to both of us. It has, however, the fatal defect of all approximate tables—they are accurate enough for some purposes, but not for others. This table is accurate enough for bar iron, but not for reamers and many other tools. Reamers could not be ground to his figures nor could they safely have the figures stamped upon them. For accurate work we must have an accurate table. That is, an approximate table is only an additional or supplementary table which does not simplify matters, but on the contrary, makes them still worse, and, moreover, opens wide the door for limitless mistakes.

It is, moreover, clear that while deceived by their own specious argument, the metric advocates themselves instinctively reject it.

Metric literature is full of statements tending to show that the change will cost but little if done "gradually" or "little by little." We are told that tools and gauges are perishable, and that we will have to do little more than replace them as they wear out with metric tools and gauges. Every reference to such expedients is a tacit acknowledgment that existing sizes are to be changed. In one breath they tell us that there is to be no change and in the next they tell us that the change will not cost much if done gradually.

I do not, of course, wish to be understood as trying to prove that the use of metric equivalents for English sizes is physically impossible. Very possibly it can be shown that the German people, *who have this thing on their hands and must get along with it in some way,* use equivalents in a limited way and in special cases. The habitual use of sizes, of which the list cannot be memorized and nearly all of which are not indicated by any mark on the scales in use, is, however, unthinkable.

It is then clear that the retirement of the inch involves the retirement of all mechanical standards based on the inch.

And what is it all for? The metric advocates can answer best. Mr. Christie (page 9) * tells us:

> I think one of the greatest advantages is its convenience in computation: I think that is unquestionable. The next is, convenience for memorizing; it is a system, which the mind can grasp and readily retain without undue strain on the memory. These, I think, are the two great advantages.

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* The page references are to the pamphlet proceedings of the House Committee.

Dr. Wiley (page 50) says:

> Now when you see the beautiful relations which exist between the unit of length, weight and capacity . . Then there is the direct relation between the unit of length and the unit of weight and we have the measures of capacity that come directly from it.

In answer to the question, What would be the advantage to the general public—the plain people—throughout the country by the adoption of this system? Professor Newcomb answered (page 73, italics mine):

> The advantage would simply be that of simplicity. . . . *So far as every day purposes are concerned I do not know of any particular advantage.* . . .

Dr. Geddings (page 75) says:

> It is simple, elastic, scientific, and on the whole a beautiful structure, and the interrelation and the beautiful correlation which exist between its measures of weight and measures of capacity, and its measures of length and area, I think only require a very limited consideration to appeal to anyone who is desirous of getting into the ranks of the progress of the age.

And so on to the end of the wearisome chapter. Was there ever such a case of sacrificing the greater to the lesser? Was there ever such a case of distorted perspective? Was there ever such a case of rainbow chasing? As an epitome of the reasons for making this great change this pamphlet is pitiful. Are we a nation of dreaming idealists and transcendentalists that we should be swayed by such considerations?

The most terse, concise and truthful words into which the littleness of the metric case was ever condensed are those of Napoleon: "*It is a tormenting of the people for mere trifles.*"

THE VALUE OF MECHANICAL STANDARDS.

If what has preceded has proven anything whatever, it is that the idea of using metric equivalents for English dimensions must be given up. If this idea must be given up, the inevitable conclusion is that the abandonment of the inch will involve the destruction of our existing standards.

The destruction of our existing standards! A few words, not even a complete sentence. They are easily spoken, but does any one who reads this paper appreciate their appalling meaning, the industrial chaos to which their destruction would consign us? Established industrial standards are among the most priceless of material possessions, and the man who would destroy them deserves to be placed in the pillory and held up to the scorn of men.

The man who can estimate or indicate in words the value of mechanical standards to this country and the loss due to their destruction does not live, and I shall not attempt it. The pamphlet containing the testimony before the House committee is full of questions and of testimony from the metric advocates, the purpose of which is to show that the cost of changing standardized tools is, after all, not very serious, if done gradually, but nowhere is there anything to indicate that these people have any idea of the value of a standard as such. For their benefit, therefore, I will explain that while the value of standardized tools in this country runs into unnumbered millions of dollars, the value of a standard is not chiefly or even largely represented by such tools.

The chief value of a standard lies in the fact that it is adopted, that it has become a part of our daily lives, and works so smoothly that we are scarcely aware of its existence. For example, the value of pipe-thread standards is not represented by the taps and dies in the hands of pipe makers and fitters, but by the fact that because the threads are standardized pipe fittings can be made by the million, at trifling cost, and that when we need a fitting we can buy it for a few cents with the assurance that it will fit, instead of having to get it cut to order to suit an odd size of thread. Similarly the cost of attempting to change air-brake hose couplings is not represented by the value of the tools for making the couplings in the Westinghouse Works, but by the infinite confusion of the railroads in getting from one standard to another. The value of the tools in this case is not many dollars, but the cost of the change cannot be found upon any inventory, nor can it be measured by any scale.

In this matter of air brake hose couplings, what would be thought of a "gradual" change* or of a change made "little by little" as has been suggested? What would be thought of the idea that the air brake factories and repair shops equip themselves with metric tools and gauges as the existing tools and gauges wear out?

Is it not perfectly plain that air brake hose couplings must not be changed at all, and does not this simple illustration show that the above and all similar suggestions regarding all standardized things are beside the mark? What we have to find is not a means by which such things can be changed, but a means by which such changes may be avoided, and such changes may be avoided by preserving the inch and by no other means whatever.

Again in this illustration of a change in air brake hose couplings, how much of an application do we see of Professor Stratton's statement that "the most serious difficulty of all is that we have learned to think in the old system," or of Dr. Pritchett's statement that "the argument for the preservation of old and inconvenient standards rests on no other basis than the inertia of mankind"? There could be no better illustration of the manner in which these suggestions fall to the ground whenever they are applied to a concrete case.

Similarly again, the cost of changing our pipe-thread standard is not represented by the cost of new taps and dies, but by the confusion involved in getting from one standard to another—a confusion which will last until existing steam, water, and gas pipes have disappeared, and which will not be lessened by putting off the change until it is brought about "at the suggestion and convenience of manufacturers."

Similarly again the value of shafting and pulley standards lies in the fact that by reason of them shafting and pulleys may be made in large quantities and therefore cheaply; that because their fitting is insured, they can be made in advance and sold

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* See the succeeding footnote.

from stock as needed, instead of being made to order at increased cost and delay; that pulleys can be changed about as needed, and if thrown out of use become again available for any shaft of their size, whenever wanted. Who would think of estimating the value of shafting standards to the country, by the value of the turning and boring tools and gauges in pulley and shafting factories? Nevertheless, that is exactly what the metric advocates do in their references to the gradual change of shop tools.* *Every reference to the cost of new tools tacitly assumes that present standards are to be abandoned.*

It is because of our standards and our standardized methods that American mechanical industries are great. It is in this that we lead, and by this sign we conquer. It is this that distinguishes us from the remainder of the world, and having the lead which such things give us, we are asked to abandon it and line up in the race afresh. And this in the name of progress.

In this matter of existing standards these people blow hot with one breath and cold with the next. In the report of the House committee they assure us that no change is contemplated, but when driven into a corner they can only suggest that we abandon the old standards and establish new ones, which will be so much better, you know. Thus Mr. Stratton (page 155), quoting from

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* The circular letter of inquiry sent to manufacturers by the Franklin Institute contained this question (italics mine):

"If the metric system were adopted within a few years in your business would its *gradual adoption* entail great expense?"

To this the Cincinnati manufacturers of machinery replied in part as follows:

"To adopt the system gradually would involve making machines for years with part English and part metric dimensions, with constant change as the English dimensions are dropped—that is, until the transition is complete. During this period there could be no standardized production, but constant change. We cannot regard the use of both systems on the same machine as a thing to be tolerated, much less deliberately encouraged. To continue existing units on old machines while adopting the metric units on new ones helps matters but little, as in all lines of machines many parts are common to different sizes. Moreover, the whole question is based on the idea that the sacrifice of the change is measured by the cost of buying new small tools. On the contrary, the chief sacrifice is in the changing of standardized things—in the throwing away of standards, the value of which we will not know until we lose them. Into the loss due to the destruction of standards the element of time does not enter, and we therefore regard the idea of a gradual change as simply postponing and refusing to face the difficulties of the problem."

Mr. Sellers, to the effect that the cost of throwing away old taps when the Sellers system of threads was introduced was a judicious expenditure, added:

> Does not this argument apply with still greater force in connection with a universal system of screw threads which this measure does not contemplate, but which is greatly to be desired, and a change to the metric system of weights and measures would undoubtedly bring about in time a change in our system of screw threads, but only at the suggestion and convenience of manufacturers.

In the above, Mr. Sellers describes the discarding of a miscellaneous assortment of taps in order to adopt a standard; Mr. Stratton proposes to discard a standard, which has consumed forty years in becoming such, in order to start a new one. In this he shows that he has so little knowledge of the value of standards, of the time required to get them adopted, and of the confusion involved in changing them, that he takes the inauguration of a standard as a precedent for discarding it.

This has been quoted before, but it will stand it again. It is difficult to be patient or to use temperate language regarding such a proposal. Why not throw away our standards and adopt new ones? Why not cut down the trees in Central Park and set out saplings in their places? There is no doubt that, *give him time*, a capable landscape architect could improve the Park. The answer to each question is the same. With trees and standards alike, a generation of time is required for them to take root and grow and become integral with the soil. Moreover, the old standards cannot be cut down. The new must grow up in the shadow of the old, and saplings transplanted to the depth of an old forest are not apt to thrive. Destroy our standards for the sake of new ones that are no better, and that can only become really standard after a generation of confusion. This is the metric programme of simplicity, progress, and reform. And, again, what is it all for? How much compensation will there be in the "beautiful interrelation and correlation of the units"?

"THE GOVERNMENT WILL PAY THE COST."

A favorite assertion of the metric advocates is that through the operation of the proposed law, individual manufacturers will be relieved of the cost of the change because the cost of new tools and gauges will, they say, be included in estimates for goods supplied to the Government, and manufacturers will thus gradually accumulate a stock of such tools and gauges at the expense of the Government. In this way, we are told, the cost of the change will be distributed among the whole people and not be a burden on individual manufacturers.

This found expression in one of the points on which the bipartisan committee of the American Society of Mechanical Engineers were able to agree, although the anti-metric half of that committee has since withdrawn their approval of this point. The point in question as it appears in the report of the committee is as follows:

> "Recognizing the well settled fact that the consumer does and must pay all necessary cost of production, we believe that if the Government specifies such dimensions as will materially increase cost of production, the Government and not the bidder will have to pay such increased costs, it being self-evident that a bidder, not compelled to bid, will not bid except at a price which will afford him a profit."

The same idea found expression in the *American Machinist* for March 20, 1903, in the following words:

> "Director S. W. Stratton of the National Bureau of Standards * * * believes the present bills are beneficent because they provide that after a certain date the United States Government shall become a large buyer of tools and machinery made in accordance with the metric system. Of course, the Government will pay for this work, and all who bid upon it will be upon an equal footing, so far as the use of the metric system is concerned, and can make their estimates and bids in accordance with whatever extra expense may be entailed thereby. Thus, then, manufacturers will be paid by the Government for the equipment that Mr. Stratton and many others believe will become increasingly necessary or important to the American manufacturer in carrying on his foreign trade."

When after the passage of this bill the Government calls for bids for any manufactured article for the first time, the manufacturers will include the cost of new tools and gauges in their estimates and the Government will pay for them as claimed. When, however, the Government calls for that article a second time those who bid upon it will *not* "be upon an equal footing so far as the use of the metric system is concerned," since the first successful bidder will have his tools and gauges on hand free of cost to himself while the others will not. Should the first successful bidder take advantage of this and include as much of the cost of his tools and gauges in his second bid as he thinks safe, and, by a slight difference obtain the contract, he will be paid nearly twice for his tools and gauges. Should he include their entire cost, and should the contract go by a slight difference to another bidder, that bidder will have his tools and gauges paid for by the Government. After that the conditions will be those of free competition. At the most two manufacturers in each line of goods will have their tools and gauges paid for by the Government, and others will buy and pay for their own. It is more probable, however, that the first successful bidder will exclude the cost of his special equipment from all bids but the first in order to make certain the obtaining of later contracts, and thus the natural operation of the law will be for the Government to equip *one* manufacturer in each line of goods with special equipment for Government work. This is scarcely up to the American idea of even-handed justice.

It will be observed, moreover, that the assertion that the Government will pay the cost of new tools and gauges assumes *that standards are to be changed*, and like all the pro-metric discussions of this phase of the subject it ignores the value of standards as such and the infinite confusion due to changing them. The reader will compare the assertions of some of the metric advocates that existing standards are to be preserved by the use of metric equivalents with the repeated assertion that the Government is to pay the cost of new tools and gauges. Why should new tools and gauges be required if standards are not to be changed?

THE INACCURACY OF THE METRE

It is, of course, well known that the metre is not what it was intended it should be—a ten-millionth part of the quadrant of the earth's meridian. The metric advocates insist that this inaccuracy is of no importance. In a letter from Captain F. A. Mahan to *Engineering News* for April 16, 1903, the following may be found:

> "Now what are some of the objections made to the metric system?
> "That the metre is not 1-10,000,000 of the length of the quadrant from the north pole to the equator. That is granted, but to what extent does that affect the system? Not in the slightest."

Professor Stratton, speaking before the Western Society of Engineers at their May, 1902, meeting, said:

> "Subsequent measurements of the earth's surface have shown that the metre as constructed is not exactly the length as defined and this fact has sometimes been used as an objection to the metric system. This, however, is of little importance since the metre and kilogramme as now constructed are as permanent as it is possible to make material standards."

Again Dr. F. A. P. Barnard wrote (*The Metric System of Weights and Measures*, page 107):

> "I accept the metre as it is, not because it is the ten-millionth part of the French quadrant but because it is the actual base of an admirable system of weights and measures."

These quotations are but illustrations of the manner in which the metric advocates apologize for the fact that the metre, like the yard, is an arbitrary standard, and as such no better than the yard. If it was to be no better than the yard why was not the yard adopted and units thus obtained which at least would have been commensurate with the old? If the accuracy of the survey of the meridian was of no importance why was it undertaken?

Read again the story of the conferences, discussions and deliberations of the French Academy of Sciences, assisted by representatives from Spain, Italy, the Netherlands, Denmark and Switzerland, and of the conclusion that the ten-millionth part of the earth's quadrant should be the base of the system. Read again the story of the seven years' survey prosecuted at the risk of life and liberty,* and resulting in the imprisonment and ultimate death of Menchain.† Read again the story of the manner in which the calculations were verified by a committee of the National Institute, and how high heaven was called upon to witness to their accuracy. Read again the story of the ceremonious delivery of the original standards into the national archives of France. Read, in short, the story of the tremendous importance attached to the derivation of the original metre and then contrast this with the present day assertions of the metric advocates which say, in effect, that all this infinite effort was mere pother; that the inaccuracy of the metre does not affect the system "in the slightest." Does not this impress the reader as rather severe criticism of the good sense of those who went to these infinite pains *for nothing?* Well may the shades of the originators of the system say, "Save us from our friends."

No ridicule by either party of the position of the other can equal the biting though unconscious sarcasm of the metric advocates in asserting that the inaccuracy of the metre is of no importance. As a matter of fact they thus show how little they understand the principles of their system in its integrity.

Nor is the matter helped by the retreat of the metric advocates behind the fact that the metre may be reproduced from the known length of a wave of light, since that method may be applied equally well to the reproduction of the yard. By no subterfuge of logic can the metre in the present emasculated condition of the metric system be shown to be in any respect superior as a standard to the yard.

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* The Spaniards believed the engineers to be spies or engineers of an invading army of France.

† Not from violence, however.

THE ABANDONED PORTIONS OF THE METRIC SYSTEM.

Many are not aware that what is now called the metric system is but a fragment of the system as it was originated, and that portions of it are not only abandoned as failures but are well-nigh forgotten. These portions relate to the divisions of the year, the day, the circle and the mariner's compass, and of these the divisions of the day and the circle are not mere side issues but integral and essential portions of the system.

Linear and angular measurements are interrelated through measurements of the earth's surface, especially in navigation. In the English system linear and angular measurements are connected by the fact that the marine mile is a minute of arc of a great circle of the earth's surface.*

The originators of the metric system included in it a system of angular units in which the quadrant was divided into 100 degrees, and it was intended that a kilometre should equal a minute of arc of the earth's surface by the new angular units just as an English marine mile equals a minute by the old.† In order that this should be the case accuracy in the determination of the metre was imperative. No other unit was possible as the base of the system and inaccuracy in the survey was a fatal defect.

Measurements of angles and of time are again interrelated through differences of longitude and of time. In the old system we have the simple and, to the navigator, highly important relation that one hour difference of time corresponds to fifteen degrees of difference of longitude. The originators of the metric system divided the day into ten hours ‡ intending thereby to intro-

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* This is a relation which is of real, and not imaginary importance, as is the connection of measures of length, weight and capacity through the medium of water.

† A quadrant was to equal 100 degrees of 100 minutes each, that is 10,000 minutes, and the same quadrant was to equal 10,000,000 metres, that is 10,000 kilometres.

‡ The use of the ten-hour day was compulsory in France for a year and a half.

duce the relation of one hour difference of time to forty of the new degrees of longitude.

These interrelations of the units of length, of angles and of time will be seen to be of fundamental importance to the navigator—and it was at this point that the new system promptly broke down. The French people refused to have the ten hour day. The French navigator then found himself with the combination of the twenty-four hour day and the four hundred degree circle on his hands, giving the relation of one hour difference of time to 16° 66′ 66⅔″ difference of longitude. It did not take him long to decide between this and the ratio of one hour to 15 degrees by the old system, and he promptly discarded the 400 degree circle. He then found himself with the combination of the kilometre and the 360 degree circle, giving the relation one kilometre = .5396 minute of arc. Again, it did not take him long to decide between this and the old system in which 1 marine mile = 1 minute of arc and the kilometre as a measure of sea distances followed the ten hour day and the 400 degree circle to the limbo of discarded things.

We thus have the striking fact that because the French people a hundred years ago refused to have the ten hour day the speeds of the ships of the French navy are to-day measured in English knots and sea distances in English miles.

With that remarkable insight into all phases of the subject which characterizes his report, John Quincy Adams referred to this topic as follows:

> "All navigation is admeasurement * * * Yet a system of weights and measures which excludes all geography, astronomy and navigation from its consideration must be essentially defective in its principle of uniformity.
>
> "But if the metre and its decimal divisions are not to be applied to those operations of man for which it is most especially adapted; if those who circumnavigate the globe, in fact, are to make no use of it and to have no concern in its proportions; if their measures are still to be the nonagesimal degree, the marine league, the toise and the foot; it is surely of little consequence to the farmer who needs a measure for his corn, to the mechanic who builds a house or to the townsman who buys a pound of meat or a bottle of wine to know that the weight or measure which he employs was standarded by the circumference of the globe."

It is obvious that we cannot have one system of latitude and longitude for the sea and another for the land. If the 360 degree circle is to be continued in navigation it must be continued in all terrestrial geography. If continued in geography it must be continued for all other purposes, and we see at once how puerile are the repeated predictions of the recrudescence of the 400 degree circle.* It is safe to say that the navigator will not use the kilometre until he has the 400 degree circle, and that he will not use the 400 degree circle until the people of the earth have accepted the ten hour day. The reader may judge of the time when this is likely to be done. When it is done it will be in order to revise the length of the metre in order that a kilometre may equal a centessimal minute of arc.

With their plan worked out to include interrelated units for the measurement of linear distances, of angles and of time, the founders of the system had some reason for proclaiming it as fit to become a universal system. Since the failure of these latter portions of the system their successors have had none.

When beaten at all other points of the controversy, the final reserve argument with which the metric advocates seek to silence all opposition to their system is the desirability of uniformity.

Throughout the world and throughout all history peoples of all nationalities, races and tongues have divided the circle into 360 degrees. This and the division of the day into 24 hours are the two existing examples of absolute uniformity. The logic of the metric advocates may be equal to reconciling their great aim of uniformity with their advocacy of the 400 degree circle, but that of ordinary mortals is not.

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* In his letter to *Engineering News* for April 16, 1903, the chief difficulty which Capt. F. A. Mahan can see to prevent the "more rapid advancement" of the 400 degree circle is that "The tables of sines and tangents for the centessimal system have not yet been prepared with the great care and accuracy which have been bestowed on those of the 90 degree system."

THE "CONFUSION" OF OUR WEIGHTS AND MEASURES.

The metric advocates are fond of dwelling upon a supposed confusion of our weights and measures which exists in their imagination only. They refer to our different pints, pounds, quarts, gallons, and tons as productive of a babel of confusion. Except for our two tons (of which more presently) these different units *produce no confusion because they are used for different and perfectly well understood purposes.* Was any reader of these pages ever confused in the slightest because the quart by which peanuts are sold differs from that by which milk is sold? The difference between our liquid and dry measures is a favorite subject of ridicule, but it loses its point in the face of the fact, which is shown in preceding pages, that the French people still use their old dry and liquid measures.

Few of the readers of these pages have ever seen, as I have never seen, a troy pound weight, for the reason that it is practically non-existent. Troy weight is used for weighing gold and silver, and for nothing else. Moreover, for that purpose (see any statistical report of the production of these metals) the pound is never used—gross amounts being given in thousands of ounces, never in pounds. The use of the troy ounce for this purpose is strictly analogous to the use of the carat for weighing gems which, as has been shown, is universal in France and Germany as it is here. The apothecary's weight again is a special system, used by physicians and druggists alone, and does not enter into the life of the average citizen, not one in a thousand of whom knows or needs to know the signs for designating the apothecary's weights. If the physicians and druggists prefer to use a special system of weights for their own purposes it concerns no one else, and confuses no one else, while if a change would be to their advantage no action of Congress is needed to bring it about.

Regarding the confusion which undoubtedly exists between our two tons, will it be any less among three? Will it be any easier to get rid of our long ton after the adoption of the metric ton of 2,204 pounds than now? The persistence of our long ton is an object lesson in the persistence of old units even when, as in this case, the two units are acknowledged by all to be a nuisance. If, after a half century of effort, we are unable to get rid of our long ton, what prospect is there that we will ever get rid of all our other units? The long ton is a standing object lesson of the difficulty of changing units of weight and measure.

It is not, however, our only object lesson. The illustration below is a facsimile reproduction of the caption of a recent map of Angelina County, Texas, issued by the Angelina Orchard Company of Boston.

ANGELINA COUNTY

TEXAS.

Scale 8000 varas to the inch

1 varas equals about 3 ft.

TITLE OF A TEXAN MAP.

Texas was ceded to the United States by Mexico in 1845 but land is still measured there by the Spanish vara.*

The above instances may be legitimately cited as examples of confusion in our weights and measures. The sensible method of getting rid of such superfluous units is to discontinue their use, while the metric plan is to get rid of them by adding others. Stripped of all its sophistries the metric programme says that because these few cases show the enormous difficulty of changing a few things, therefore let us change everything.

In a broad sense the "confusion" of our weights and measures is an absolute fiction—a figment of the metric imagination. There is but one inch, one foot, one yard, one commercial pound, one liquid and one dry quart,† used throughout this country, and as has been stated above, the liquid and dry quarts produce no confusion because they are used for distinct and perfectly well understood purposes. For illustrations of wide-spread confusion we must go to so-called *metric* countries.

This has been shown in previous pages, but one feature of it should be emphasized—the existence of numerous units of the same name and used for the same purposes, but having different

* This map is not the only evidence in my possession of this fact. The vara is also a legal unit of measure in California.

† The dry gallon does not exist. No American reader of these pages ever bought or sold anything by the dry gallon.

values in different districts and even towns. This condition of things may fairly be called confusion, and to it this country is, and always has been, a stranger. Numerous examples of this may be found in the table of Non-Metric Units Used in Metric Countries (page 60 *ante*). The well known book, *Commercial Trade Requirements*, published by Louis Scribner & Co., contains a table of foreign units of about twice the length of the Government table from which my own was drawn.

It was this condition in France which originally led to the conception of the metric system as it was this which has led to its adoption wherever it has been adopted—a statement which is especially and conspicuously true of Germany—a country which is held up to us as our great exemplar, but the example counts for nothing. When the German Empire was formed the various States had each its own units, which still survive, as has been pointed out. The necessity of getting rid of such a condition of things was obvious. State jealousy made the adoption of the system of any one State impossible, and, as the only way out, the country turned to the metre. *Germany adopted the metre in order to do away with confusion; our adoption of it will only make confusion.*

The facts are thus expressed by M. de L'Espée, who has already been quoted in connection with the conditions prevailing in France and Brazil:

> "The third advantage of the system, viz., the substitution of a uniform, unchangeable standard for the endless confusion of standards that prevailed in France and in other countries prior to its adoption, is well known to have been the main cause for its creation.
>
> "It is not necessary here, as was the case with France a century ago, to introduce order and uniformity in an inextricable confusion of provincial standards. There is as full, complete, scientific and uniform a system in existence as could be wished for: the foot, the pound, the acre used in Liverpool, are identical with the foot, the pound or the acre used in New York or San Francisco. Thus the advantage of uniformity which France, Germany, Brazil, etc., could not secure until they had adopted the metric system, has already been secured here under the present system, and this all-important reason in favor of a change is lacking."

Every such condition favored the change in Germany; every such condition opposes it here. We have seen a little of the task which the system has laid on Germany, but that task is as nothing compared with ours. Comparison between the development of German industries thirty years ago and our own day there is none, and every added industry, every mill, every machine, every material thing we have, is another kedge anchor to the inch. If some of our units are redundant and hence confusing the common-sense method of improving matters is to drop them and retain the others. The metric proposition, on the contrary, is to get rid of redundant units by the addition of more units. The metric advocates expect to secure uniformity by introducing diversity—to obtain the results of subtraction by the process of addition.

The change which elsewhere it was vainly hoped might do away with confusion can only produce confusion here. The reasons which have led other nations to adopt the system are thus exactly the reasons which should lead the Anglo-Saxon nations to have nothing to do with it. So far as our metric advocates are concerned, the uniformity which they seek to establish is the very thing which they will in fact destroy, the confusion which they seek to destroy they will in fact establish.

The metric advocates are fond of pointing to the practice of weighing grain as an evidence of the confusion of our weights and measures. Thus at the hearings of the House Committee Mr. Shaffroth (page 14) said:

> "The number of pounds vary which go into a bushel. Some States have 56 pounds to the bushel and others have 60 pounds to the bushel and it varies all along the line; also the number of pounds of oats to the bushel varies."

The farmer naturally, and indeed necessarily, measures his grain. When it gets on the railroads and in the elevators, however, it is as necessarily weighed. Since the density of different grains varies, the weight allowed per bushel varies accordingly, and likewise, since the density of the same grain grown in different sections varies, the allowance per bushel varies in the different States—these allowances being simply attempts to average the weight per bushel in the various States. This practice is incident to the conversion of a primary market measure of capacity into one of weight, and it could not be affected by the adoption of the metric system.

The criticism of the English system because different grains and the same grain from different localities possess different weights per bushel is as rational as would be a criticism based on the fact that iron and copper possess different weights per cubic inch.

THE COMPLICATIONS DUE TO A MIXTURE OF UNITS.

Among those who really believe that there is an appreciable saving of time in making calculations by the metric system it is customary to assume that with the spread of the system the gain will be progressive—a partial use of the system giving a portion of the gain. Nothing could be further from the fact. The mixed use of two sets of units involves repeated conversions from one to the other with a great resulting loss.

Consider the mixed use of units due to the selling of English sizes of bar iron by the kilogramme, as described in Mr. Canby's letter from Mexico (page 55 *ante*). Suppose it is desired to calculate the weight in kilogrammes of a certain number of metres of 1½-inch bar iron. In no English and in no metric table can the weight of 1½-inch bar iron per metre be found. The size of the bar must be converted into millimetres to use a metric table, or the metres of length to feet in order to use an English table. If the former course be followed the resulting metric size cannot be found in any metric table, because English and metric sizes are not the same. The second course will therefore naturally be followed, and an English table will be consulted where will be found the weight of the bar per foot. This must then be multiplied by the ratio between the foot and the metre, and the result by the ratio between the pound and the kilogramme in order to obtain the weight in kilogrammes per metre of length. That is, two multiplications are involved in finding the weight per unit of length—a quantity that is found directly from the tables when either system is used alone.

Again it is desired to find the size of rolled I beam to carry a given load, the span being in metres and the load in kilogrammes, but the beam to be used is to be taken from existing American sizes. No table exists in which the capacity of an American size beam can be found in kilogrammes. The dimensions of the cross section of the beam must be converted into millimetres or the span must be converted into feet and the load into pounds. If the former course be adopted the resulting metric cross section cannot be found in any metric table and the latter course must be resorted to. That is, the designer will convert his metric data into English units and use his English tables as he does now, these conversions representing so much added labor.

The above illustrations relate to the simplest of cases. What the use of a mixture of units actually involves may be seen from Mr. Dale's description of the calculations which are to-day being made in Germany in order to determine the cost of a piece of worsted cloth (page 25 *ante*).

The above illustrations show the futility of the suggestion made by Mr. Christie at the discussion of the Mechanical Engineers:

> "The works of French and German engineers are at least as voluminous as ours and we would need to do little more than reprint their tables."

This suggestion is especially unfortunate. A German table of the flow of water in pipes is applicable to German—that is, metric—sizes of pipe only, and similarly, a German table of the strength of beams is applicable to German—that is, metric—sizes only. These tables could not be used in connection with our sizes of pipes or beams. If we are to express volumes of water and loads on beams in metric units, and continue our existing standards of pipes and beams, we must have new tables. When our pipes and beams are changed to metric dimensions we shall need a third set of tables, and during the transition period we shall have repeated use for all three sets. This whole subject of technical literature leads to the most hopeless confusion.

The above paragraph illustrates the fact, which has been enlarged upon by Mr. Wm. Kent in *Engineering News* for February 19, 1903, that during the transition period we must have a system of transition technical literature—a suggestion which alone is sufficient to demonstrate the hopeless impracticability of the scheme.

The case for technical literature was never better, albeit unconsciously, expressed than by Dr. F. A. P. Barnard—in his lifetime the leader of the American pro-metric forces. In excusing the failure of the centessimal division of the quadrant he said (*The Metric System of Weights and Measures*, page 85):

> "To change the law of circular division was to introduce diversity where uniformity prevailed before and also to destroy the usefulness of

a vast scientific literature which had been founded on the sexagessimal division." *

So also to change the law of linear division will destroy the usefulness of a vast technical literature which has been founded on the English system.

It is not, moreover, necessary to go to technical sources for these illustrations. Imagine a retail merchant to buy his goods in metres and kilogrammes, and to sell them in yards and pounds, or a wholesale merchant to sell to some customers by the metric and to others by the English system, or a manufacturer to make his goods by one system and to sell by the other—*as textile manufacturers are doing to-day throughout metric Europe.* One or all of these conditions must arise during the transition period, and all would give rise to endless transformations between the systems, all of which represent so much *added* labor.

The inevitable mixture of units negatives also the persistent assertions of the metric advocates that the adoption of the system is to save a valuable portion of the school life of all children. If the old units are to endure for an indefinite period, as all experience shows they will, they must be taught in the schools. The learning of the metric system will therefore represent so much *added* labor as the learning of the relations of the two systems will represent still more. The work of the school children will, therefore, be *increased*, not diminished.

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* This is by no means the worst of Dr. Barnard's inconsistencies. His *Metric System of Weights and Measures* contains in an appendix a discussion of "The Unification of Moneys." To this Dr. Barnard was opposed, his argument being based *on the difficulty of the change*, and this in spite of the fact that, according to John Quincy Adams, a change in currency is "a revolution by all experience known to be infinitely more easy to accomplish than that of weights and measures."

EXAMINATION OF THE CLAIMS OF SUPERIORITY FOR THE METRIC SYSTEM.

The keynote of my argument for a time will be that the whole matter is a bagatelle; that, in short, the trifling advantages, if, indeed, there be any advantages at all, to be obtained by the adoption of the metric system are not for a moment to be compared with the enormous cost of making the change. Every thinking man knows that a duodecimal system of numbers would be better than the present decimal system, but no one is so foolish as to seriously propose a change, and the cases are exactly parallel.

On its merits, then, I claim that the metric system is a bagatelle. Admit all, for the sake of argument, that the metric advocates have claimed regarding the fundamental superiority of the system and we admit nothing. The pro-metric argument is that the decimal basis and the interrelation of the units of length, of capacity, and of weight greatly simplify and abbreviate calculations. That is all, for when it comes to actually measuring things no one claims that it cannot be done just as readily by the English system; and, in fact, if there is any argument from this standpoint it is that the English system is better than the French system.

In support of this claim of superiority for the purposes of calculation, the standard illustration relates to the calculation of the volume and weight of a tank of water; and, in fact, at the close of the pamphlet giving the testimony before the House committee—a pamphlet which, as a matter of duty, I have read from the first page to the last—are some comparative tables showing the number of figures involved in such calculations by the two systems. Now the weak point of this exhibit is that to very few people is the weight of a tank of water of any consequence whatever. Of the members of this society of engineers I doubt if 10 per cent. ever had to determine the weight of a tank of water or the pressure on its bottom. This illustration is contemptible in its littleness. The calculations of this nature which engineers have to make relate to the weights of masses of the materials of construction—iron, steel, brass, masonry, etc.—and the procedure is the same by either system; we multiply the length by the breadth and the thickness, and then multiply the product by a constant for the material. With the metric system that constant is the specific gravity, and with the English system it is the weight per cubic inch. That is all, and when summed up the difference in the procedure is simply that between tweedle dee and tweedle dum.

When it comes to the claim that this metric system reduces the labor involved in the calculations of every-day life enough to be *a matter of public moment whatever*, it simply is not so.

No dimension on a machine drawing above 9 millimetres (about $\frac{3}{8}$ inch) is ever expressed by a single digit, and none above 9 centimetres (about $3\frac{1}{2}$ inches) by two digits. In English units 9 feet may be expressed with one figure, and 99 feet with two. Talk about simplicity. A metric drawing is a wilderness of figures.

Even the assumed simplicity of decimal fractions is to a large degree fictitious. Compare the following table of equivalents:

$\frac{1}{3} = .3333 +$	$\frac{1}{60} = .0166 +$	$\frac{1}{16} = .0625$
$\frac{1}{4} = .25$	$\frac{1}{70} = .0143 +$	$\frac{1}{32} = .03125$
$\frac{1}{5} = .2$	$\frac{1}{80} = .0125$	$\frac{1}{64} = .015625$
$\frac{1}{6} = .1666 +$	$\frac{1}{90} = .0111 +$	$\frac{1}{350} = .0028 +$
$\frac{1}{7} = .1428 +$	$\frac{1}{200} = .005$	$\frac{1}{450} = .0022 +$
$\frac{1}{8} = .125$	$\frac{1}{300} = .0033 +$	$\frac{1}{550} = .0018 +$
$\frac{1}{9} = .1111 +$		

Read some of these expressions aloud. One-eighth equals one hundred twenty-five thousandths; one sixtieth equals one hundred sixty-seven ten thousandths; one thirty-second equals three thousand one hundred twenty-five hundred thousandths. Can any one say that the decimal equivalents give as clear a mental picture of their value as the vulgar fractions? They never do, except where the decimal is small, and this explains why people insist on using vulgar fractions.

The superiority of the decimal system as applied to currency is largely due to the great amount of adding to be done. With day book, journal, ledger, cash book, trial balance, balance sheet, invoice inward and invoice outward alike, it is add, add, add, and then add some more. The amount of adding to be done in connection with money is both relatively and absolutely out of all comparison with that involved in connection with weights and measures. When it comes to multiplication or division, vulgar fractions are often the simpler. The comparisons drawn between currency and weights and measures will not bear examination.

Some very striking testimony on the subject of the comparative labor of calculations by the two systems was offered before the House committee by Mr. J. H. Linnard, a naval architect of the Navy Department, who learned his profession in France, where he spent four years studying naval architecture in the metric system, which profession he has practised since 1887 in this country, where, of course, he has used the English system. Here is a man who may fairly be said to know what he is talking about, and, moreover, one would expect his predilections to favor the metric system, as, in his schooldays, naval architecture and the metric system were part and parcel of the same thing. Nevertheless he testified (page 183): "As far as calculations in the matter of shipbuilding are concerned, it is just as convenient in every way, shape, and form to use English measurements as French."

Such testimony cannot be ignored. It is worth more than all the essays and *a priori* arguments that can be written from now until doomsday. There is probably no branch of engineering which involves so many or such laborious calculations as ship designing. It may be regarded as the crux of the whole matter. Moreover, in connection with many of the problems of the naval architect the pet tank of water illustrations would seem to apply directly, but, unfortunately, the naval architect has to deal with salt water, which has a greater specific gravity than fresh water, and so these pretty illustrations fail to apply even here. If the Creator would kindly make the earth over again and fill the seas with distilled water the case might be different.

The following testimony from another article by Mr. Hess, published in the *American Machinist* for October 16, 1902, is even more striking, because Mr. Hess, before his practical experience with the metric system, was an advocate of it:

> Some years since I was asked to sign a petition to Congress asking that the metric system of measurements be officially adopted as the legal American standard. In common with many others I complied, under the impression that the ease of reckoning with decimals and the convenience of a logically harmonious system would be sufficient to compensate for all troubles, fancied and real, incidental to the change. Since then actual experience with the metric system has led to a revision of views, so that to-day I am decidedly "on the fence."
>
> That the metric system is a really satisfactory solution of the problem is, to say the least, doubtful. The convenience of its units as to size is debatable;

but it is very likely that no series of units can be generally satisfactory. The requirements of the various arts and sciences are far too varied for that. The best unit, or series of units, is one that does not involve large figures.

That argument of the advocate of the metric system that its unit, the metre, is a natural one, a certain definite portion of the earth's diameter [*sic*], may be at once dismissed; it has already been proven that the metre's relation to the earth's diameter is, or was, not reliably known.

There remains the other chief claim—convenience in reckoning, owing to the metric system having been built up on the decimal plan. This is really a very alluring claim, but will not bear close scrutiny. The decimal system is only in part more convenient than a binary system, but not wholly so, or even more so. It is in fact more uncertain in arithmetical operations than the decidedly faulty English system. This statement, directly opposed to my preconceived notions of a few years ago, is advanced as a result of direct experience with the metric system, extending now over three years. Having been gradually led to this conclusion I determined to put it to a practical test. A certain problem—not made up specially for the occasion, but cropping up in regular practice—was submitted to seven draughtsmen and designers, some of them of more than average attainments, and all of them thoroughly familiar with the metric system, through having used it almost exclusively in their practice and schooling. The correct result was arrived at by only three of the seven men.

The problem was at first given to but one man, and only the obviously wrong result led to its being handed over to the others. The difficulty lay in the correct location of the decimal point; with one exception all had the correct numerals, but the men were apparently lost in the maze of decimal figures.

The same problem with equivalent values in English units was then handed out. The correct result was arrived at by six out of seven men in an average of two-thirds the time taken for its solution in the metric system, showing that the percentage of error was very much less and the time considerably less with the binary system, notwithstanding the relative unfamiliarity of the men with the units of the binary system.

A decimal system is not as convenient as a binary system in mathematical, draughting-room or shop work at least so far as mechanical engineering is concerned.

Additional testimony adverse to the claims for the saving of time in calculations are given in the following extract from a letter from Mr. A. M. Mattice, chief engineer of the Westinghouse Electric and Manufacturing Company:

For a number of years I have had more or less occasion to have drawings made in the metric system. My experience has been that foreign draughtsmen who were originally brought up in the use of the metric system, and later come to this country and worked in theEnglish system, and have become as skilled in the use of the latter as in the use of the former, will work more rapidly on drawings in English measures than on those where the metric system is used. One of the reasons for this is the greater ease of using an easily sub-divided system like the English. Another reason is the greater ease of quickly picking out a dimension on scales in the English system.

The following incident is of interest in this connection: During a visit to Europe last summer, a party of us v sited the Oerlikon Electrical Works in Switzerland. We were shown over their works by their chief draughtsman, Mr. Leon von Muralt, who was for several years with the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa., and is thoroughly acquainted with American practice. One of our party asked Mr. von Muralt the result of his experience in the English and metric systems. He replied without hesitation that "for drawings and shop use he considered the English system the more practical, but for calculations the metric system had the advantage." As calculations form a very small part of an industrial establishment, and as the greater part of commercial calculations are nowadays made by the slide rule or other calculating iustruments. the advantage cited by Mr. von Muralt would not be appreciable.

I might mention another instance, as follows: The chief engineer of our French Company (Société Anonyme Westinghouse), Mr. W. E. Reed, was transferred from the parent company to the French company about three years ago. All the construction work of this company is necessarily done in the metric system. Mr. Reed, is, of course, thoroughly conversant with the metric system and is brought into contact with it hourly. Notwithstanding this, Mr. Reed makes all his calculations, except those in connection with transformers, in the English system, and simply translates his final results into metric measures. He does this for the reason that all of the formulæ and constants which he uses were learned in the English system, and it is easier to continue the use of them than to relearn them in the metric system. In the case of transformers, all the formulæ and constants which he uses have been worked out by him since he joined the French company, and for convenience he worked them out in the metric system. This case is an example of the difficulty of attempting to break loose from an existing system, where the new system does not offer sufficient advantages to induce one to make a change. If, after three-years' experience in the metric system, Mr. Reed had found that he could work more rapidly by calculating in the metric system, he would undoubtedly have done so.

Another example: Mr. Otto C. Reymann, mechanical engineer of the same company, is a German and received his technical education at Charlottenburg and Zurich, where, of course, the only system of measures used was the metric. Mr. Reymann spent about six years in practical work in this country, where he became accustomed to the use of the English system. He has now been with the French Westinghouse Company nearly five years, where he is daily brought into contact with the metric system. Notwithstanding this, he does all his thinking and calculating in the English system and translates his final results into the metric system.

Messrs. Reed and Reymann are both on a visit to this country at the present time, and I have to-day talked with them about this matter. I had previously heard that Mr. Reed still worked in the English system and he has confirmed that understanding. It was not until to-day that I knew that Mr. Reymann was also using the English system. In his case it would be natural to suppose that, having been brought up in the use of the metric system, when he went back to Europe he would have gone back to the use of that system if it possessed the great advantages which are claimed for it by its advocates.

Against such experiences as these should be placed a sample of the sort of stuff that passed as testimony at the hearings of the House Committee. Said Mr. Candler (page 79):

"Some gentleman testified here the other day that in making calculations in the two systems the time required is about fifteen minutes in one system and about two hours in the other system. That is about the proportion."

The foregoing testimony comes from such sources that it cannot fail to command respect. Ignore it all, however, and what does the pro-metric argument for the saving of time in calculations amount to? Suppose the labors of naval architects and engineers generally were appreciably lightened by the use of the metric system, what would it amount to? What is the proportion of engineers to the public at large, and how much would the aggregate saving amount to? Figure up the aggregate if it can be done, and then divide it by the number of the population, and how many seconds per day for each man would be obtained? This explains what I meant in saying that if the arguments of the metric advocates be admitted the admission amounts to nothing. As an economic factor in the life of this people, I insist that the saving of time due to the use of the metric system in calculation is an absolute bagatelle. No microscope ever magnified material things to the extent that the importance of this matter has been magnified. I cannot express my contempt for the argument that, in order to lessen the labor of a man here and there throughout the country, this nation should be put to the confusion and turmoil involved in tearing up by the roots the most fundamental feature of its commercial and industrial life. The proposition is unthinkable. Talk about special legislation; the words do not describe it. The only field in which the interrelation of the units cuts any considerable figure is the electrical field. This narrows the issue still more. Shall we do this for the electrical engineers?

Again, *what is it all for?* Such a change as this is justifiable only in case of great and manifest advantages. Why, then, should we embark on this movement, the end of which no man can foresee, when its advantages, granting them to exist, are so slight and so elusive that—with unexcelled opportunities for comparison—the gentlemen quoted above cannot find them?

In this connection I wish to call attention to another matter. Engineers are no longer subject to the drudgery of calculations. For the past twenty years an instrument for this purpose has been growing in use, until it has become almost universal among engineers below middle life, its use being taught as a matter of course in our engineering colleges. I refer to the slide rule, which has become almost as familiar a thing on an engineer's desk as well as on those of many commercial men, as a lead-pencil or a pair of dividers. It performs all the ordinary calculations of life, except addition and subtraction, so quickly that there is nothing left for the metric system to save, and as an economic factor in the life of the American people it is worth twenty metric systems. These people consider us a lot of mossbacks and old fogies. As a matter of fact, it is they who are twenty years behind the times, for they do not know that the drudgery of calculations is already a thing of the past.

For instance in calculating constructive weights, no one to-day would do it except by the slide rule. For this the small numbers due to the large units of the English system are distinctly superior to the large numbers due to the small French units. With the former we determine the decimal point instinctively, while with the latter we must keep tab on the decimal point.

Putting the little slide rule alongside the great *systeme universelle* may appear to some like standing Jack the Giant Killer alongside his victims, but do not forget the final result.

Moreover, the entire argument for this saving of time in calculation is based on the tacit assumption that the old units will become extinct since, if they are to be used, they must appear in calculations. When, as in French and German textile industries, the old and new units are used conjointly, there is an actual loss of many times the theoretical gain.

Witness the closing of the grave over a century of delusion regarding a wonderful saving of time in calculations, to be obtained by the adoption of the metric system.

THE FOREIGN TRADE ARGUMENT.

As a matter of public policy the only view of this question which is of any moment, is that which asserts that the adoption of the metric system is necessary in the interests of foreign trade. If this view were true as a general proposition—which I shall show it is not—it would still be no sufficient reason for governmental action. There are a few parts of one line of machines which it is important to have made in accordance with the system of measurements employed by the user. In making such machines for countries using the metric system, our manufacturers have adapted themselves to this fact, and if they are half as astute as we all believe them to be, they may be depended upon to so continue. A manufacturer is certainly in far closer touch with his customers than any government can be, and this subject, which is so interwoven with all business interests, is the last one in which what has been called "the clumsy hand of legislation" should interfere.

The machine-building industry is the foundation industry of modern life, while the machine tool-building industry is the footing course of the foundation. It is by these machines that all machines—including themselves—are made. In this distinction they stand apart from all other products of human skill, and when one is in a machine tool-building shop, he may be very sure that he is witnessing the primal industry of our time. This is the absolute zero of modern industry.

The man who buys machines of this class does so in order to make other machines. By them all parts of all machines are made to the required size.

If this assertion that export trade requires the adoption of the metric system were true at all, it would, for this reason, be doubly true in connection with machine tools. What, however, are the facts? Of all the developments of our export trade in the last half-dozen years, none has been more pronounced than in this class of machines. In number and variety those sent abroad have been legion, and of all countries of the world Germany has been our best customer, with France not far in the rear. I have made it my business to inquire how many and what changes machine tool-builders have found called for by their foreign customers, and the answer settles this contention. I have said in the appendix that one of the Cincinnati milling machines contains 18,300 dimensions; of these that company has found occasion to make two to metric dimensions, these being the pitches of the traversing and elevating screws of the milling machine table. These two screws are distinctly measuring screws, and the need of their being made to metric pitches is obvious to any mechanic. The lead screw of lathes is a similar measuring screw, and this likewise in many—though by no means all cases—must, when sent to metric-system countries, be made to metric pitch. *These three screws comprise all the parts of the hundreds of parts of the thousands of machine tools sent abroad that have needed change,** while in steam engines, mining, agricultural, and other lines of machinery no changes whatever have been called for.

That there may be no possible doubt about the facts being as stated, I refer to the action of the Cleveland (October, 1902) Convention of the National Machine Tool Builders' Association, which condemned the bill now before Congress, among other reasons

> "Because the sale of many million dollars' worth of machine tools has been made abroad by members of this association, especially to France and Germany, without requirement or request by the purchasers for changes in general construction to conform to metric measurements, the only changes being in adjusting and measuring screws, the great majority of machines needing no changes whatever."

At the discussion of this subject before the Mechanical Engineers, letters in confirmation of the above facts were presented from:

Bullard Machine Tool Co.,
Denver Engineering Works,
Gould & Eberhardt,
Laidlaw-Dunn-Gordon Company,
Lane & Bodley Company,
Lodge & Shipley Machine Tool Company,

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* This should be understood as meaning that these are all of the changes that I have been able to find. No doubt there are, here and there, in machine tools, adjusting screws analogous to those named which have needed changing, but the essential fact is that the changes have been absolutely infinitesimal, and that, so far as general construction is concerned, no changes whatever have been needed.

Cincinnati Milling Machine Company,
Lunkenheimer Company,
American Tool Works Company,
Baldwin Locomotive Works,
Cincinnati Machine Tool Company,
Cincinnati Shaper Company,
I. & E. Greenwald Company,
Cincinnati Planer Company,
Deats Machine Tool Company,
Northern Engineering Works,
Greaves Klusman & Co.,
Cincinnati Punch & Shear Company,
Bradford Machine Tool Company,
Fosdick Machine Tool Company,
J. H. Day Company,
Aurora Tool Works,
Sabastian Lathe Company,
Schumacher & Boye,
Belmar Machine Tool Company,
John Steptoe Company.

Letters were received in indorsement of the metric system from the following:

Godfrey L. Cabot, Boston, Mass.

E. W. Lyttle of the College Department, University State of New York.

Rufus P. Williams, Pres. New England Association of Chemistry Teachers.

Elihu Thomson of the General Electric Company.

Of those who thus indorsed the system the first and last only are manufacturers.

Further confirmation of these facts is found in the letter by M. Benét, of Hotchkiss & Cie, Paris, of which portions have already been given. He says:

Practically the question has no personal interest for me, as we of course work in our own shops to the metric system, and this has in no way prevented us from doing a large business with the Governments of the United States, England, Russia, and other countries. We are using a very large amount of American machinery in our works, and the fact that this was all built to English measures has given no difficulty. Of course the leading and cross feed screws are supplied to metric pitch, but, as you say, this involves two dimensions out of the many thousands that enter into the drawings of a machine. All of the newer and most up-to-date establishments in France, including all of the Government establishments, are largely equipped with American machinery, and I know of no case where the fact of the machines being built to English measures affected their sale ability.

I believe that the passage of the proposed bill will be the cause of much loss of accumulated wealth, of much confusion, and that the adoption of the metric system will in no way affect the trade of the United States for the better.

I have one fact to add which is still more striking. The Chandler & Taylor Company, of Indianapolis, build saw-mills, which they export largely, having specially large markets in Central and South America—metric using countries, according to our friends of the other side—and for whom Chandler & Taylor have issued a Spanish catalogue. A saw-mill has a feed works composed of levers, gears, etc., by which the log is fed forward after each cut, and by this gear the thickness of the boards is determined, this feed gear being regularly made to cut the boards to English dimensions Six years ago the Chandler & Taylor Company inserted in their Spanish catalogue a statement that, on request and without extra charge, they would make this gear to cut the boards to metric dimensions, but, unless otherwise specified, they would furnish the English gear, and up to April, 1902, not one inquiry or request for the metric gear had come in.

The statement that goods must be made to metric dimensions in order to sell in metric countries is as broad as it is long. It simply asserts that in order to sell, goods must be made in accordance with the system of measurements used by the purchaser, and from it it follows that in order to sell here, goods must be made in accordance with the English system. What, however, are the facts? For forty years the Sellers' injector has been made to metric dimensions (excepting always the screw threads), and no one was ever heard to object to it on that account. There are a dozen other American makers of injectors, all of whom, I believe, use the English system, and no one can say that at least some of them do not make good injectors. A purchaser who objects to the metric dimensions of the Sellers instrument can certainly satisfy his wants elsewhere, but I am not aware that any one has ever been heard to raise the objection.

Another illustration is found in the Willans and Robinson engine which, in the newer sizes, is made to metric measurements *for sale in England.* If metric engines sell in England why will not English engines sell in metric countries? The adoption of the metric system by the metric party for the manufacture of engines for sale in England is a striking refutation from their own mouths of their constant assertion that goods must be manufactured in accordance with the system of measurements used where they are to be sold.

We may, however, take a broader view of the matter. From the *Monthly Summary of Commerce and Finance*, published by the Treasury Department, I learn that during the year ending June 30, 1902, there were imported into this country $480,000,-000 worth of manufactured and semi-manufactured goods, which sum does not include $265,0000,000 worth of "articles of voluntary use, luxuries," etc., *some* of which were probably manufactured.

According to our metric friends all of these goods, except those from England and her colonies, are from metric countries, and perforce must be made in accordance with the metric system. I am unable to determine the percentage of metric goods from the tables given, but did any one ever hear of a single instance in which such goods were objected to because they were not made in accordance with the English system?

In buying a machine, for example, the customer needs to know certain facts, and these facts should be given him in language he can understand. Among such facts are the weight, the length, width, height, and the capacity. If the machine is a planer, for example, the customer must be told the largest size of work which it will do, as well as its weight and over all dimensions, in his own language, which includes his system of weights and measurements. To give such facts in the metric system no more involves the adoption of the system than the furnishing of a catalogue in the German language involves the adoption of that language. That the foreign customer should care whether the working parts—the shafts, the gears, the levers, etc.—are made to metric dimensions or not is ridiculous. Machines are sold by their operating qualities, the price, and the time of delivery, and not by the fact that a certain shaft is 25 millimetres in diameter instead of 1 inch.

Just as the idea of using metric equivalents for existing dimensions has misled many mechanics, so this need of the foreign purchaser for such information in units with which he is familiar has misled many commercial men. They imagine that because a foreign buyer needs such leading weights and measurements as would be given in a specification or in a letter describing the article offered for sale in metric units, that therefore it is necessary to adopt the metric system in factory operations. The use of metric units in this descriptive or specification way when writing to a prospective German customer, for example, is exactly analogous to use of the German language under the same circumstances. Both serve to put the information which the customer wants in terms which he can readily understand.

The experience of a century has shown that the idea of a universal system of weights and measures is an "iridescent dream." We must make up our minds to get along with divers systems of weights and measures in the world as we do with divers languages and systems of currency. Translations between them must be made and, as regards commercial information of all kinds intended for foreign buyers, the question is who shall make them? Shall the manufacturer do it like a sensible man or shall he require his customer to do it and therefore jeopardize his trade? This matter of giving commercial information in the customer's own language of weights and measures is all that remains of the many calls from our foreign consuls for the adoption of the metric system.

"But," say the metric advocates, "why not adopt the system in manufacture and so save the labor of these conversions?" which is equivalent to asking, why not climb a mountain to avoid stepping over an ant hill? To make these conversions involves nothing in manufacturing, plant, method, or equipment; it involves nothing but the occasional use of conversion tables by comparatively few people, while the alternative involves an upheaval and reorganization of industries at a cost which pen can not picture nor words describe.

At his notable inaugural address as rector of St. Andrew's University, Scotland, Mr. Andrew Carnegie urged upon the nations of Europe the necessity of an alliance against this country, and told them bluntly that unless they agreed to something of this kind, all they could look forward to was to

> Revolve like so many Lilliputians around this giant Gulliver, the American Union.
>
> Can Europe, as long as she remains divided into hostile camps, ever hope to conquer foreign markets or even to repel the American invasion? Never.
>
> America now makes more steel than all the rest of the world. In iron and coal her production is greatest, and it is also so in textiles. She produces three-quarters of the world's cotton. The value of her manufactures is about triple that of your own. Her exports are greater, and the clearing-house exchanges at New York are almost double those of London.

If the metric system is necessary in the interests of foreign trade, as the metric advocates assert, why has the "American invasion" made such progress in the continent of Europe? Why have our exports of manufactured goods increased during the past half-dozen years at a rate which is unexampled in the history of the world?

ANALYSIS OF THE BILL.

Following is the text of the bill as reported to the House of Representatives by the Committee on Coinage, Weights and Measures.*

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That on and after the first day of January, nineteen hundred and four, all the Departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system; and on and after the first day of January, nineteen hundred and seven, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States.

The Attorney-General has given it as his opinion that the terms of the bill do not make the use of the system compulsory in general business transactions, and the thoughtless may, therefore, conclude that there is no cause for alarm.

No one can read the pamphlet to which I have referred so often without seeing behind this whole movement the spirit of compulsion.

Thus after Mr. Christie had deprecated compulsion, Mr. Shaffroth said (page 8): "I will state that it is about the only way it has been introduced. Germany adopted it by compulsory statute of the Reichstag, and I do not see how you can do it any other way." (And he was quite right.) Again Dr. Stratton (page 153) was asked by Mr. Gaines: "You would make the law compulsory?" to which he replied (italics mine): "*That would depend upon the time allowed for its adoption.*"

The belief by the metric advocates that this bill will bring about the general use of the system by the people at large illustrates the beginnings of metric legislation everywhere. In the sections on the persistence of old units in various countries it has already been shown that the plan of this bill—the adoption

* The text as given is from the *Journal of the Western Society of Engineers* for August, 1902.

of the system for government purposes—has already been tried in Cuba, Guatemala, Nicaragua, Costa Rica, San Salvador, Greece and Egypt, and in no case has the adoption of the system by the people followed. Nowhere has the system been introduced among the people except by compulsion. The difficulty of the change has been ridiculously underestimated and law after law has been passed to make previous laws effective. The inclusion of English yarn counts in the German tariff schedule, of which particulars have been given, represents the defeat of an attempt to make previous laws effective by compelling the exclusive use of the metric system in German textile industries. The interests adversely affected made such an outcry as to defeat the bill as originally drawn.

The article by M. Lamoitier, from which extracts have been given in the section relating to the persistence of old units in France, closes with a strong appeal for another law to compel the use of the system in French textile industries. And this in France after a century of the metric system! He has, it may be added, the same cheerful confidence in the sufficiency of one more law to accomplish the purpose that our metric advocates have in the sufficiency of the bill now before Congress to bring about this great change among us in from three to five years.

The objectionable feature of this bill is that it is a compulsory measure as regards all who do business with the Government, and that it can do nothing but create endless confusion in our weights and measures.

Studious attempts to minimize the bill were made at the discussion of the Mechanical Engineers. Thus Mr. Southard said:

"It does not mean anything in a compulsory way. There is not a word in this bill looking to compulsion. Compulsion was not thought of in connection with the matter."

Mr. Southard was, however, submitted to a cross examination by the members with the following result:

Q. You tell us, Mr. Southard, that this is intended for the regulation of the business of the departments of the Government?

A. Yes.

Q. Does that mean the internal business of the departments, or all transactions, including those with parties outside the Government service?

A. It means that in *all* transactions of the Government requiring the use of weights and measures the metric weights and measures shall be used.

This I take it is a sufficient admission that the bill is compulsory so far as those who deal with the Government are concerned. Any other conclusion is plainly absurd. The case is exactly parallel with that of the Eight Hour Bill. That bill is intended to compel all manufacturers who supply the Government with goods to employ their workmen eight hours only, and the Metric System Bill is likewise intended to compel those same manufacturers to use the metric system. No one will pretend that the Eight Hour Bill is not compulsory, and no one can rightly claim that the Metric System Bill is not, in the same way and to the same degree, compulsory. To claim that it is not thus compulsory is more than untrue; it is ridiculous—each bill says in effect, " Do this or withdraw from Government business."

The metric advocates are loud in their protestations that they do not believe in compulsion, and they thus occupy the unique position that while they disclaim compulsion they favor a compulsory law.

It is not easy for a layman to determine the meaning of the term " legal standard." Judging by the words of those who ought to know (for example, Mr. Shaffroth, page 8 of the proceedings of the House Committee), the phrase means that after January 1, 1907, the metric system is to be used in all actions-at-law into which weights and measures enter.

> " Productions could be made to any desired standard, but in the courts, for instance, testimony would refer to metric measurements. If work was done according to any other standard, dimensions would have to be converted to a metric standard in the event of legal testimony being required."

As I have said, the effect of the bill, so far as any real adoption of the system is concerned, is certain to be abortive, and its real effect, so far as the general public is concerned, will be to compel the use in actions-at-law of a system of weights and measures with which neither witnesses, jurymen, lawyers, nor judges will be familiar.

As regards the adoption of the system in the Government business, it is uncertain what is meant by it, except that the metric advocates are determined that all Government purchases shall bear the metric label. If this provision of the bill means that Government purchases of machinery are to be made in good faith to the metric system, as that term is understood in France and Germany, then in many lines the Government will go without machinery altogether, and it will pay exorbitant prices in others. If, under the stress of these circumstances, enforcement of the law is relaxed, and we do with the Government as we now do with foreign customers—give the weight, over all dimensions, swing and extreme length of work a lathe will take in, for example—and call that the *adoption of the metric system,* then the Government will be the manager and the Government officials the actors in the greatest farce-comedy of recent years.

That the metric system can become our real factory system of production within any reasonable time the experience of other countries abundantly proves to be impossible, and the requirement that the system be used in all Government work can do nothing more than to force the adoption of a special system for that work; in other words, and in the name of simplification, compel the use of two systems where we now have one.

THE OBJECT OF THE BILL.

Until the discussion at the December, 1902, meeting of the American Society of Mechanical Engineers, it was assumed as a matter of course that the object of the Metric System Bill which was reported to the 57th Congress was to bring about the general adoption of the system in the commerce and industries of the American people. This was plainly the object in the minds of those who appeared before the House Committee, as may be seen from the extract from their statements given in the section on The Pro-Metric Argument. It was also plainly the object as understood by Mr. Shaffroth, the Member of Congress who introduced the bill, as is shown by the following remark by him (page 30):

"The bill which I introduced names the 1st day of January, 1903, for the Government to adopt it and the 1st of January, 1904 * when the people would have to adopt it."

At the meeting of the Mechanical Engineers the metric advocates represented the purpose of the bill as entirely different from this.

Mr. J. H. Southard, Chairman of the House Committee on Coinage, Weight and Measures which reported the bill said that:

"The purpose of this bill is to secure uniformity in Government transactions, and for the further purpose of having, as far as possible, some kind of a trial of the merits of the metric system, without seriously involving the public at large. For one bureau to use it and another bureau not to use it, would not do. For instance, for the Internal Revenue Bureau to use it and the Customs Bureau not to use it, would result in greater confusion than we now have."

Against this statement by Mr. Southard should be placed the following extracts from the report of the committee of which he is chairman, by which report the bill was returned to Congress and its passage recommended:

"Again and again has the necessity for a change in our system of weights and measures been urged upon the attention of Congress. * * *

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* These dates were subsequently changed to 1904 and 1907 respectively.

The failure of these efforts to bring about the adoption of a better system of weights and measures has been due, etc. * * * The advantages to be gained by the adoption of the metric as compared with the one in present use are far greater than the benefits derived from the adoption of a decimal system of coinage. * * * Certainly any effort to replace this conglomerate system with a simple logical one like our monetary system is worthy of the consideration of Congress. * * * The benefits to be derived from the adoption of the metric system by the educational interests of the country are perhaps the most important, etc. * * * In the case of textile fabrics, materials of construction, package goods and almost all kinds of manufactured products, a change would no doubt involve some inconvenience, but, etc. * * * The use of the old system not only involves great loss of time in making computations but places our merchants at a great disadvantage, etc. * * * The necessity for an improvement in the weights and measures of the country is nowhere more apparent than in the ordinary business transactions of daily life. * * * Your committee believe the time has come for the gradual retirement of our confusing illogical irrational system and the substitution of something better." *

Following the same line of thought, Professor Stratton said (italics mine):

"The Government has never enacted laws in reference to standards, except in connection with its own work, and if the Government sees fit to use the metric system of weights and measures in some or all of the branches of its work, it has a perfect right to do so. *This would involve its use only in such work as originates in the departments. If the metric system becomes the system in common use in this country it will be, through laws enacted on the part of the different States*, and the States have not fixed standards, except for commerce and trade. A great deal of concern has been shown as to the situation which would result in case the bill now pending before Congress becomes a law. I cannot conceive any other condition than that stated above."

In other words, the object of this bill is to create a special system of weights and measures used by the Government but not by others—a proposition which is exactly comparable with one for a special Government system of currency. According to Professor Stratton the bill can have no other effect than this because, "if the metric system becomes the system in common use in this country it will be through laws enacted on the part of the different States."

The reader will, however, have difficulty in reconciling Pro-

* These quotations are from the copy of the report published in the *Journal of the Western Society of Engineers* for August, 1902.

fessor Stratton's statement with the following, which he gave to the House Committee:

"The problem to be solved is how this change in weights and measures can be brought about with the least inconvenience to all concerned. It is evident that the inconvenience, expense and confusion which will necessarily attend such a change will not be lessened with time, but on the contrary will be the more difficult the longer it is postponed."

Mr. Southard says that the object of the bill is to "secure uniformity in Government transactions," which is precisely what we have to-day to a greater degree than any metric country on earth. So far as appears, the only Government purchases now made by the metric system are the medical supplies of the army, and Mr. Southard proposes that the transactions of the customs, internal revenue and postal departments, the equipments of the army and navy, the erection of public buildings and the improvement of rivers and harbors shall all be changed in order to "secure uniformity" with the medical supplies of the army!

Mr. Southard should have read the following from a letter by Mr. J. H. Ball, of Barcelona, Spain, to the *American Machinist:*

"In handling the numerous machines which I have to come across in my business I find only two nations whose measures are always uniform in all respects, and those two are England and the United States."

Which is the more important, uniformity between the Navy Department and the Medical Bureau of the War Department or uniformity between existing and future ships of the navy? The Anglo-Saxon nations have substantial uniformity to-day, which no metric country has or ever has had. In no country of the world has the metric system secured uniformity; but, ignoring the experience of the world, Mr. Southard proposes to abandon the uniformity which we have, in order that after a transition period of confusion and indefinite length we may again reach uniformity. Mr. Southard should heed the words of John Quincy Adams (italics mine):

"Is your object uniformity? Then before you change any part of your system, such as it is, compare the uniformity that you *must* lose with the uniformity that you *may* gain."

After this "uniformity" is brought about according to Professor Stratton we shall continue to have the present system in common use until the State legislatures have ordered otherwise.

That is, the Government will use one system and the public will use another, and this is to be called uniformity.

This real purpose of the bill was, however, stated by Mr. Jas. Christie at the discussion of the Mechanical Engineers:

> "When it becomes evident that the time is ripe for it, the national Government can inaugurate the system in its own departments, whence it will soon spread through the manufactures and commerce of the nation."

The sort of uniformity which this bill will bring about is well illustrated by the statistics of the Census Reports. Shall the system be used in those reports? Then in the name of uniformity we shall have an abrupt break in these reports and no comparison between old and new can be made except after translation. Shall it not be used? Then in the name of uniformity we shall have the business of the country done under one system and Government reports of it under another.

Nowhere in the pamphlet of testimony before the House Committee, nor in the report of the Committee by which the passage of the bill was recommended does the idea appear that the adoption of the system is to be confined to the Government, nor that the purpose of the measure is to bring about uniformity in the departments. The whole discussion relates to the adoption of the system by the business and manufacturing interests of the country, the Government merely taking the lead.

The bill, however, has another object which the metric advocates do not mention. Regardless of all present disclaimers it will enable them to shout from the house tops, "The United States has adopted the metric system."

Along with these remarkable statements went others. Thus Professor Stratton said:

> "If at a later date the metric system is made the sole legal standard, it can mean no more than that all business of the departments with the public must be carried on in the metric system; but who for a moment would suppose, even in this case, that if the Government should buy a machine tool the parts of that machine would necessarily have to be constructed in the metric system?"

Again Mr. F. J. Miller said:

> "My belief is that a full compliance with the pending law will be secured when a machine builder simply goes on manufactureing his machines as he does now, and with precisely the same taps, dies, jigs, reamers, and all other tools and fixtures; but when a department of the

Government wants a machine he will probably be required to state all the dimensions given in the specifications in millimetres."

The object of the bill then appears to be to gratify the metric advocates by compelling the Government departments to write their specifications in the metric system while they buy the same goods that they have always had. Is it for this petty outcome that the House Committee is holding hearings and technical societies are having discussions and taking votes? What will be the gain from such a course? Where will there be any saving of time in calculations? With such commercial measurements in the metric system, and constructive measurements in the English system, where does the uniformity come in? More to the point, however, it must be remembered that these gentlemen are not charged with making Government purchases, nor with the interpretation of the law for the Government departments. When this law, reading "all the departments . . . in the transaction of all business . . . shall employ and use *only* the weights and measures of the metric system," reaches the Navy Department through an executive order, what right will Admirals Bowles and Melville have to interpret the word *only* in this easy-going way? Mr. Southard thinks "the officers of the Government are inclined to be reasonably accommodating." It will not be a matter of inclination, but of obeying the law.

Finally, I would like these gentlemen to explain how they reconcile their easy-going interpretation with the italicized words of the following extract from the opinion of the Attorney-General:

"Indeed, as each bill * *prohibits to the departments the use of any other system*, by a familiar rule of construction, this will be taken as the only prohibition intended, and it will end there."

The sort of uniformity which the metric advocates will bring about is thus described by John Quincy Adams (italics mine):

"The legislator * * * finishes by increasing the diversities which it was his intention to abolish and by loading his statute books only with the impotence of authority and the *uniformity of confusion*."

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* Two bills appear to have been submitted to the Attorney-General.

CONCLUSION.

The changing of established standards is impossible. Their measurement in millimetres is equally impossible. Established standards will, therefore, preserve the inch. The millimetre may be forced into use, destroying our present uniformity and introducing the diversity which everywhere accompanies the use of the metric system, but this is all that can be done. These people may legislate until doomsday; they may make infinite confusion, endless turmoil, limitless sacrifice, but move the English inch?—the Archimedean lever is still unknown.

THE METRIC FAILURE IN THE TEXTILE INDUSTRY.

Thus in this one pregnant subject of *Clothes*, rightly understood, is included all that men have thought, dreamed, done, and been: the whole External Universe and what it holds is but Clothing; and the essence of all Science lies in the *Philosophy of Clothes*.

DIOGENES TEUFELSDRÖCKH.

THE METRIC FALLACY AS TO TEXTILES.

There is no darkness but ignorance.—*Twelfth Night.*

The Committee on Coinage, Weights and Measures of the last Congress had charge of the bill to introduce the metric system into the United States, to substitute an "entire new system of weights and measures for one long established and in general use," a task that, in the words of John Quincy Adams, "is one of the most arduous exercises of legislative authority." We had, therefore, every reason to expect that legislators resting under such great responsibility would consider the question cautiously, calmly and judiciously; that they would summon expert witnesses from all trades, professions and occupations; that they would be eager to receive information on both sides of the question, wholly irrespective of their own personal opinions; that if any bias was shown it would be in favor of the Anglo-American and not the French system. We had a right to expect that before the proposed revolution in our weights and measures received the sanction of the committee the wisdom of the step would be proved beyond a doubt. As far as the textile industry was concerned these expectations were wholly disappointed.

The only two witnesses who appeared as textile representatives at the hearing before that committee were both in favor of the metric system. One was the president of a cotton and worsted yarn and dress goods mill; the other a mechanical engineer and principal of a textile school. The committee were content to accept the testimony of these two witnesses as conclusive regarding the effect of changing the standards of textile manufacturing, which, rated by the number of employés, is the chief industry in the United States. They summoned no textile operative nor overseer, no one with a practical knowledge of manufacturing to tell them what this change of standards would mean in the actual work of converting fibres and filaments into fabrics. They did not consider it worth while to summon any representative of the great American silk industry. No one was there to represent the extensive carded woollen industry. No manufacturer of men's wear woollen or worsted goods appeared. No one was there to speak for the cotton raising and wool growing interests. No representative of the linen, hemp or jute industry appeared to tell the committee what he thought of the plan to drive the world's linen, hemp and jute standard from this country. No one came from the cotton cloth industry to explain that the cotton standard which they sought to destroy was the standard of the world. No knitter of underwear or hosiery, no manufacturing clothier or tailor appeared. Above all, no one who opposed the metric system in the textile industry was called upon to express his views. Such men were not invited. The committee accepted without question statements that carried the stamp of absurdity, as if anxious only to record reasons, no matter how flimsy, to support a conclusion they had reached in advance.

Both the committee and the two witnesses discussed the question with the calm confidence of men framing the textile schedule of a tariff bill, as if they need but say the word to shorten the inch and lengthen the yard, as easily as they had once lowered the tariff on wool and raised it on worsted top.

Of the 213 lines of testimony of the first witness only 26 related to textile weights and measures. Liberal extracts were given from an address by an astronomer who, after soaring into the clouds of speculation and prophecy, came down to earth and gave the result of a count he had made of all kinds of pounds, feet, inches, pints, etc., including not only American standards of these denominations, but also the German fuss and zoll, the French pied and pouce, and a medley of units in other countries, reaching the imposing total of 53 kinds of miles, 235 different pounds and 29 sorts of pints. All this was presented to convince the committee, as the witness admitted it had convinced him, that the Anglo-American textile industry should have the incommensurable kilogramme-metre added to its present single world-wide, yard-pound standard.

The witness told the committee he did not know how many, but "probably" 600,000,000 people "use" the metric system. This statement brought forward no protest although no country on earth has made the metric system its textile standard, and the only countries having a single textile standard and where direct textile calculations are possible are Great Britain and the United States, with a population of more than 475,000,000.

He advocated the metric system because of its "simplicity," yet it is certain that its nomenclature is cumbersome, the size of its units badly suited for mill work, and textile calculations by it are as laborious if not more so than by the English system.

He told the committee how "economical" it would be to introduce the system into this free country in 1902; that then the Frenchman will not be thinking of the metre while the American is thinking of the English yard, and while the witness was speaking the French textile worker was thinking, working and figuring in a maze of yards, metres, aunes, kilogrammes, pouces, sous, moques, deniers and Paris pounds.

He thought that "at least two years' notice" of the change ought to be given to the American people, "say the first of July, 1904," although more than a century of the most arbitrary, ruthless and persistent exercise of autocratic power to force the people to use the metric system had resulted only in involving France and the rest of Continental Europe in a hopeless chaos of textile standards.

This textile witness did not believe that the "try-it-on-the-Government-dog" policy would be enough. After two years he would have both Government and people use it, and as it has been permissive for thirty-four years without result, his plan leads inevitably to a compulsory law with penalties attached, like the following from the French decree of 1810:

> Violations of the foregoing provisions shall be considered breaches of the police regulations and punished by a fine of not less than five nor more than fifteen francs for the first offence; the fine may be increased for a repetition of the offence.

Imagine the cry of "Police!" on Leonard Street, New York, because some one had been "caught with the goods on," a skein of yarn measuring 840 yards. It might help to reconcile us to such a law if the culprit was one who had petitioned Congress for the metric bill.

The witness did not apprehend any difficulty in changing, although the autocrats of Europe, from Robespierre to Abdul Hamid, the present Sultan of Turkey, have found it impossible.

The committee next learned the reason for this confidence. A German in his employ had been "in Germany" when the system was made compulsory there in 1871, and had told him "there is no real difficulty in making the change." That employé was certainly 31 years younger in 1871 than in 1902, in all probability then a young man in the early twenties. Of course he knew all about Germany in 1871. Twenty weeks after this testimony was given before a committee of the American Congress, another cotton and woollen manufacturer, Kommerzienrat Münch-Ferber of Hof, Bavaria, arose before a committee of the German Reichstag and denounced the attempt to introduce the metric system into the German textile industry, declaring that it would throw that industry into "ungodly disorder" (heillose Verwirrung).

The Washington witness told the committee how "gladly he would welcome the metric system in his own work." Strange to say, no one asked him why he did not use it then, seeing that the system he was yearning for had been legally permissive in this country for thirty-four years. Apparently the committee had no use for such horse sense. Their statesmanship consisted in "trying it on the Government dog."

The witness then gave the metric system a sweeping and unqualified personal recommendation for the mills of others as well as for his own. He told how the New England Cotton Manufacturers' Association favored the report of the Paris Metric Congress of 1900, although the fact, stated by the secretary of that organization and as easily ascertained on February 6, 1902, as on January 7, 1903, is that "the Association never committed itself to the metric system of measuring yarn."

The witness then stated he manufactured neither woollen nor cotton goods for export, and did not know what was used in China, but with genuine metric logic assured the committee that the introduction of the metric system "would certainly" be of advantage to those people who do export.

At this point the chairman thanked the witness, probably for having given the kind of an opinion the committee wanted, and the next textile witness took the stand. His testimony occupies about 668 lines of reading matter, of which 107, or about 15 per cent., relate more or less remotely to the metric system in the textile industry. He started out by promising

"to present some of the technical details in which the use of units is involved, and to show that there is much time lost in the various computations, owing to our lack of system in denoting the constants that have to be used. The textile industry can undoubtedly furnish one of the strongest possible statements in this line, as strong as, and possibly stronger than any other of our great manufacturing industries, for where once goods were composed entirely of one kind of fibres without being mixed with others, to-day it is very common to have several kinds in one fabric, and the several branches of manufacturing are therefore interdependent, so that we find many different fibres used in the goods that are produced within the limits of one corporation."

This is a stock metric argument, and a good one too. The only difficulty is that it can be used with equal force for any system of weights and measures or yarn numbering. Substitute Saxon, French, Austrian, Spanish, English or what not for the word metric, and not only is the theoretic logic unimpaired, but its practical force is generally increased.

The United States now has four systems of numbering spun yarn. The desirability of having but one is unquestioned. The disagreement is on the question of which shall be the one. The French plan is to make the metric system the one by adding it to the four we now have. The common-sense plan is to select the best one of the four we have and discard the other three. One theory is based on the assumption that four and one are equal to one; the other, that four less three are equal to one. If we must idly dream of uniformity let it be the uniformity within sight, based on the English yard-pound and the 840-yard cotton skein. With apologies to Lady Macbeth we may say to the metric theorists:

Yet do I fear thy nature;
It is too full of the milk of human theory
To catch the nearest way.

Once the witness and questioner reached a thin place in the ice and by a quick turn saved themselves from a plunge into the icy waters of fact:

A Member of the Committee: Your statement is that 70 per cent. of the (cotton) spindles in the world are not using the metric system.

Witness: Very true, but—

Member of the Committee: Of course our woollen industry is of large moment in this country; do you believe, etc.

The witness stated that the metric system had been made the "standard" for his school and emphasized its advantages for textile work. He promised to put on record English and metric calculations, the former covering "several sheets of paper," the latter requiring "but very few figures." These had been evolved over night after the invitation to testify before the committee had been received. Those calculations were not put on record. Eight months later the witness submitted to the American Society of Mechanical Engineers some formulas for English and metric textile calculations to prove the greater simplicity of the latter. Evidently the fabric to which they referred was spun from such stuff as dreams are made of, woven on the loom of imagination and designed to cover the nakedness of the metric and not of the human system. The width in the loom was given in units of 4 inches (decigrammes) although the centigramme (1-10

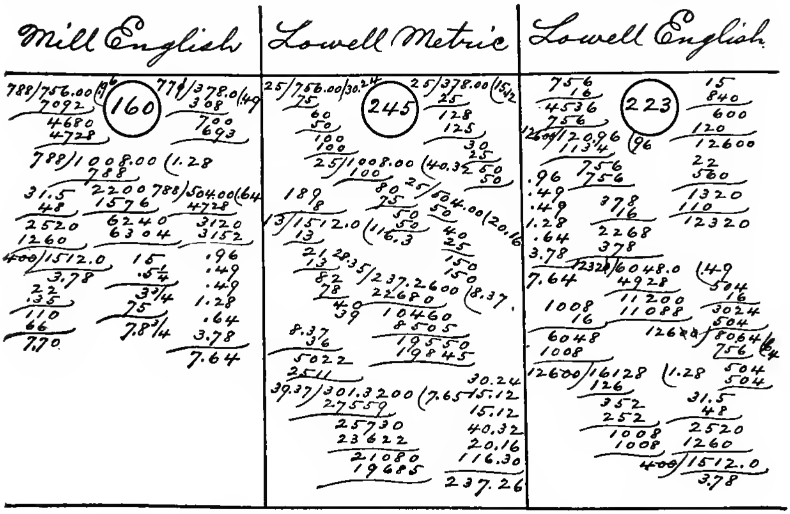


FIG. 1.—LOWELL TEXTILE SCHOOL AND MILL CALCULATIONS.

of an inch) is too long for expressing woven widths. The weight per yard was extended to the ten-thousandth of an ounce, requiring over ninety miles of cloth for this fraction to equal one pound, although the tenth is small enough for practical purposes. Nevertheless these formulas worked out actually show to the advantage of the English system. At Fig. 1 are the calculations by the two methods of the formulas and by the method of the mill:

Lowell metric 245 figures.
Lowell English 223 figures.
Mill English 160 figures.

Besides muddling the student's ideas regarding mill standards, the "introduction" of the metric system into that school has made it possible with 245 figures to arrive at the same result that is reached with 223 figures by the elementary English formulas or with 160 figures by mill methods.

This witness told how easy it would be to "disseminate information" about the metric system among the "rank and file of the people":

"As to the question of how the rank and file of the people adopt the system it may be said, so far as the textile interests are concerned, that many of our large manufacturing centres are provided with textile schools, and these schools can easily disseminate such information and teach the matter in such a way that there will not be any difficulty arising. * * * Nor are the night textile schools the only agencies to teach our operatives the use of the system directly, for there are night schools with relation to almost any form of study and in nearly every community in the country, so that we shall not have to trust to our operatives to pick up the system, but they will have an actual opportunity to study it. Our country was never so well supplied with schools as it is now."

Here then is the solution of the difficulty during the "transition" period. Our 1,000,000 textile operatives are to attend night schools—under compulsion, of course.

Another new theory as to the almighty dollar in metrology was announced as follows:

"Our board of trustees represents the control of about sixty-five millions of capital, and having placed themselves on record in this matter, and with the resolutions adopted by our associations of manufacturers, you must see that there is some weight behind all this."

The metric question is to be decided by capital. This theory eliminates the people from the discussion and transfers the decision to millionaires.

At one point the witness allayed the wide-spread alarm as to the effect of the metric system on the weather and on the weight of our summer and winter clothes:

"After the adoption of the metric system does it mean that we are going to have cooler weather in winter or warmer weather in summer, so that we must wear clothes of a different weight? Is it not altogether ridiculous to suppose any such change, and if our clothes are to be of the same weight after as before making the change of our unit, will not, of course, the yarn be spun to the same counts, and will not there then accordingly be only the change of the name of the size of the yarn? And is not a rose as sweet by any name?"

In the 748 lines of testimony whose connection with the metric system it is difficult to trace, these two witnesses gave opinions and information on a variety of subjects, including the number of their employés, the daily consumption of wool at their mills, the relation of science to commerce, the importance of the ocean cable, the radius covered by the telephone, the Lowell Textile School, their intention "not to propagate the general cause of science," the composition of the school board of trustees, their consultation with the Division of Botany at Washington, the ramie fibre, the necessity for training the brains as well as the hands of workmen, the greater chance for inventors in early times than at present, the effect of labor-saving machinery on the labor supply of the country, the courses of study on which a man may "build a superstructure to enable him to meet the world as a textile man," the endowment fund and equipment of the school, testing the strength of materials, the amount of knots, wanes, shakes, etc., in a 12 x 6 stick of timber, the comparative value of raw cotton and cotton cloth, the process of mercerizing cotton, the value of a pound of Brussels lace, the American invasion of Europe, log-rolling in behalf of the metric bill, the shrinkage of iron castings in cooling, the distribution of textile schools, the system of jigs and templates in modern machine-shop practice, what England will do if the United States "falls into" (the metric) line, the weight of our summer and winter clothing "after the adoption of the metric system," the calibre of a 2-inch shafting in the Lowell district, and the distillation of coal. One of the witnesses gave an objective demonstration that a straight line measures the shortest distance from one point to another, and told the committee how many sheep his grandfather kept when the witness was a boy.

This is the kind of evidence that was followed by a report bearing all the earmarks of having been dictated from that metric hothouse, the National Bureau of Standards, and in which the committee "earnestly recommended" the passage of the bill.

Attention has been called to the testimony of these two witnesses to show what rubbish was solemnly accepted at Washington by the representatives of the people on February 6, 1902, when considering the question of changing the established standards which are the priceless inheritance of 80,000,000 of people, who at the present rate of increase will number 200,000,000 before the end of the century. Attention is called to it now that the farce may not be repeated when another metric hearing is given by a Congressional committee.

In the free discussion following the report of the coinage committee the hollowness of the metric pretensions was thoroughly exposed. This led the American Chamber of Commerce at Paris to present to the French Society of Civil Engineers a series of questions as to the actual state of weights and measures in France. With touching consideration all reference to the textile industry was omitted. The French engineers, however, annexed this "observation" on French textile standards to their replies:

"With the exception of linen and jute, which, by reason of the preponderance of England in the world's markets, are still put up in bundles of 360,000 yards and variable weights, all systems of reeling yarn used in France are based on the metre and gramme or their multiples (kilogramme or demi-kilogramme)."

The man who wrote those words with no intention to mislead never designed a textile fabric, never wove a yard of cloth, never spun a pound of yarn. In manufacturing textiles the ratio between weight and length or area takes the plaee of cubic measurements. The only metric or decimal ratio is that obtained from the kilogramme and kilometre skein. All other systems of yarn numbering are metric only in name and by a simple calculation can be made English, Austrian, Saxon or Dutch. Look at the ten indigenous French systems of numbering spun yarn. Reducing No. 1 yarn by each system to its metric equivalent we have:

No. 1 Metric system	= No.	1	metric.
No. 1 French	= No.	2	"
No. 1 Roubaix	= No.	1.43	"
No. 1 Fourmies	= No.	.71	"
No. 1 Reims	= No.	.70	"
No. 1 Eastern France	= No.	1.44	"
No. 1 Sedan	= No.	1.50	"
No. 1 Elboeuf (*a*)	= No.	7.20	"
No. 1 Elboeuf (*b*)	= No.	3.05	"
No. 1 Elboeuf (*c*)	= No.	2.99	"

All based by conversion on the metre and gramme or their multiples, if you will, but what a mess. Apply the same process to the four Anglo-American systems of yarn numbering and what do we have?

No. 1 Run 1,600 yards per pound = No. 3.22 metric.
No. 1 Cotton 840 yards per pound = No. 1.69 metric.
No. 1 Worsted 560 yards per pound = No. 1.13 metric.
No. 1 Linen 300 yards per pound = No. .60 metric.

These metric equivalents are "based on the metre and gramme or their equivalents," but does any sane textile manufacturer want them? Americans will not be fooled by this humbug about basing yarn counts on the "metre and gramme or their equivalents." It is too transparent. Above all, it is unworthy of a society bearing the high-sounding title, *Société des Ingénieurs Civils de France, fondée le* 4 *Mars*, 1848, *reconnue d'utilité publique par décret du* 22 *Decembre*, 1860.

The greatest of metric fallacies is the idea that weights and measures can be changed by law. The metric system was founded on this mistaken idea, and the chaos on the Continent to-day is proof that the thing cannot be done. A recent pamphlet by M. Edouard Simon, secretary of the Paris Metric Congress of 1900, in reply to Mr. Halsey's paper, explains why the struggle for a century to make the French standards metric has failed:

"In our country (France) two principal causes have prevented up to this time the wished-for unification (of yarn numbering), one arising from domestic, the other from foreign commerce. As regards wool, which is particularly referred to by Mr. Halsey, it is sufficient to remark that the business of spinning mills is, in many cases, still localized. Woollen yarn intended for mills of Sedan is spun in Ardennes. The weavers of Reims obtain their supplies of yarn from the surrounding districts; the weaving mills of Elbeuf and Louviers have their spinning done in local mills. These conditions have contributed to the maintenance of certain peculiar usages. It is worthy of remark, however, that the skeins are always measured in metres and the weight expressed in kilogrammes or demi-kilogrammes. This habit or routine, if you prefer, in the absence of an economic or industrial evolution, has been perpetuated.

The importation of English fabrics into our market following the commercial treaties of 1860, the trend of fashion that has been followed, the low-priced goods, the development of the trade in ready-made clothing, have brought about a complete transformation in the structure of fabrics. To satisfy a rapidly increasing number of customers, the manufacturers have endeavored, by combining various textile fibres, to produce attractive fabrics at the lowest possible cost. Accordingly a weaver formerly doing business in a very small district has been compelled to use a varied assortment of yarns from different districts. The inconvenience connected with the different methods of numbering in the various manufacturing centres has thus been increased."

The influences that have proved more powerful than legislation in France, have come both from within and without the country. Compulsory laws in France and everywhere else can be enforced only so far as violations can be brought under the eye of the police. That is why they failed in the French textile industry in spite of the most systematic and long-continued effort ever made by any country to change its standards of weights and measures. To compel a change of textile standards it is necessary to control the thoughts of the textile workers, and that is impossible. Law may force cloth to be measured and ticketed by the metre in public markets, but it cannot make the manufacturers think in metres. The fallacy that it can is still strong in France, but a century of failure has had its effects, as shown by the following extracts from the discussion at the Paris Metric Congress of 1900, of the proposal to enforce the penal law of 1810 (p. 87 and 90):

A Member: Coercion has had no more effect than has persuasion.

Discussing the following resolution:

Resolved: That the law of 1810 be enforced throughout France:

M. Isaac: I ask the suppression of that resolution.

M. Cousin: It seems to me useless to stir up the Government to take up arms.

M. Isaac: Granted. It is necessary to maintain silence as to this article.

And silence was maintained.

Yet in the face of such evidence as this, men can be found to advocate coercion in America.

Never was a more complete exposure of the metric fallacy made than by M. Paul Lamoitier, a French textile manufacturer. Exasperated by having quotations from his technical works published in America to show how little the French use the metric system in the textile industry, he began last October (1902) in *l'Industrie Textile*, Paris, a series of articles calling for more coercion and heaping reproaches upon his countrymen for their neglect of *le système universel*, a neglect which he mercilessly exposed. While these articles were appearing in France he wrote several letters for publication in America to persuade Americans to adopt the metric system. The following extracts are from these various articles, some written for French, others for American consumption:

LAMOITIER

To Americans.

Mon Dieu! that you (Americans) should remain stubborn and not adopt it (the metric system), is for the above named nations and for France but a secondary consideration. The metric system wins its own way because it is the most simple, the most logical, practical, uniform and universal.

Then why do you use the decimal system for your calculations? You are not logical in your reasoning.

To Frenchmen.

Ah! these Americans are not considerate of our feelings, and they are right. *We are as much in the anarchy of weights and measures for the textile industry as at the time of the Revolution*, for we have the denier of Montpellier and of Milan for silk, with the aune as a unit of length.

This article, however, is not written for Americans. Nevertheless, they are perfectly right in speaking of our "European chaos" of yarn numbering and I will attach their argument to my remarks, not for the purpose of going backward like them, who would return to the ancient aune and the greater chaos of ancient and absurd measures.

"It (a new law) would put a stop to the chaos which the Americans ridicule. * * * In short (this for the Chauvinists, and consequently for all of us), they would not ridicule us any more. It is not pleasant to be thus continually ridiculed by foreigners, especially when they have reason for doing so."

After having established the metric system, is it not truly ridiculous that more than 110 years later we should be still using the English yard, the old or French pound, the denier of Montpellier or of Milan, the ancient aune, the many different skeins, etc.?

My idea, Monsieur, regarding a Congress of Yarn Numbering at St. Louis, far from being a farce, can be of no interest to us because it (unification of yarn numbering) is an accomplished fact.

In conclusion, here is the advice of a friend of your great country (America):

The calculations based on the metric system are the most simple, the most practical, the most exact, the most uniform for all textile materials. It will be a boon to your great nation when that system shall be used exclusively in your country.

And this is the reason why they are right in mocking us when they say we do not use the metric system for numbering yarn and for weaving calculations. Nothing is more arbitrary than to reckon the yarn by the thousand metres and the width of the cloth and the picks of the filling by the inch. It is nonsense and a derision. Note also that while I speak here only of France, I could say as much of all Europe.

In the face of foreign sarcasm it (the metric system) should be established at the earliest possible moment.

We have here a pristine confusion, which will spread throughout the world, and increase in proportion to the establishment of the metric system.

Ah! the famous aune, do you know its equivalent? Exactly 3 ft., 7 in., 10 lines and 10 points, or in other words, 1.188447 metres; the foot being equal to .324839 metres, and divided into 12 inches, the inch into 12 lines and the lines into 12 points.

You would not imagine this as you are in the habit of calling it 1.19 metres.

You laugh!

It is, however, no laughing matter unless you consider it, as I do, profoundly ridiculous.

In England the opposition arises principally from an opinion that their commerce in textiles would suffer by the change. This is an error. In the first place, to allow competition in the markets nothing would prevent the competing nations from using occasionally the English standards.

As for the recalcitrants (English, Americans and others) a very simple procedure will be to oblige them in all countries where the metric system is legal, to mark their yarns by the metric system.

Let us say to them: "Do you want to trade with us? Then confine yourselves to that which is the most simple and the most practical. * * * There is no better way than this to make them repentant."

I have the honor to inform you that what I have insisted on is an accomplished fact. The permanent committee of the Congress of 1900 has declared that the count of silk will indicate the number of kilometres per kilogramme (fixed weight).

Glory, monsieur, to the permanent committee of the Congress of 1900, who have attained so quickly this marvellous result! (1903.)

Numbering by the kilogramme (fixed weight) can be used but little in practice for silk because of its fineness and the method of spinning. The Brussels Congress decided to retain the old method of numbering silk, based on a fixed length. Thus we obtain a very simple and practical system, suited for all calculations. (1900.)

The metric fallacy exposes itself.

The mass of error, half truths and deception might be extended indefinitely, but the mind revolts from such an outrage on common sense and longs for, demands, the truth. What is the truth about the metric system in the textile industry? I will try to answer that question in the following chapters.

TEXTILE WEIGHTS AND MEASURES.

How use doth breed a habit in a man.—*Two Gentlemen of Verona.*

As food, clothing and shelter are the three primary necessities for the existence of man throughout the greater portion of the earth's surface, so the textile industry, which supplies clothing, takes its place among the most important and extensive of human occupations. Wherever man exists the manufacture of fabrics is found in some form. The oldest records of human history contain references to spinning and weaving. The higher the development of civilization the more complicated, varied, accurate and extensive do textile processes and products become. This industry, which is found in its highest development in Europe and the United States, gives employment to millions of men, women and children and the value of its annual products reaches fabulous amounts.

Three years ago the textile industry in the United States with its 1,000,000 operatives led all others in the number of employes. This vast army of workers was employed in many different mills, widely scattered throughout the country, every State claiming a share.

Anything affecting the standard of weights and measures affects the whole textile industry, root and branch. The ideas of every textile worker concerning every operation of manufacturing are associated intimately with the standards of and ratios between weight, length and area, upon the proper adjustment of which the success of every process depends. When, therefore, the proposition is made to change the standards of weights and measures it becomes necessary to consider the interests of the vast textile organization, upon which all other industries, in fact, the very existence of man depend. If it is possible to demonstrate the advantage and possibility of making a change in weights and measures in the textile industry, the final decision should, nevertheless, depend upon how far such change was possible and profitable to all other occupations. It is a question of possibility and advantage to the greatest number. If the metric system offers many disadvantages and no compensating advantages for textile manufacturing and the change to it in this great industry is likely to prove impossible, the proposition to make the change general is manifestly untenable. With the possible exception of a few minor and distinct trades all the industries of the country must stand or fall together on the question of weights and measures. Leaving the problem in its broad aspects to be considered by others, I will confine my attention to its bearings on the manufacture of textile products.

In textile manufacturing measurements are employed for weight, distance and area only, and those for distance are in turn limited by reason of the elimination of all measurements of thickness. The volume and thickness of textile materials, finished and in process of manufacturing, are indicated by the ratio between weight and length. The bulk of cloth, for example, is expressed, not in cubic inches, but in either the weight per yard of a given width or in the number of yards per pound.

Likewise the size of yarn is expressed, not by the diameter or volume of the thread, but either by the length of a given weight or the weight of a given length. If cotton or other loose fibre is spun to such a size that one pound of yarn measures 840 yards (about one-half mile) the *count* or ratio between weight and length is No. 1. If the yarn is spun so that one pound measures twice that length, or 1,680 yards (about one mile), the count is No. 2. This 840 yards per pound is the English standard for numbering cotton yarn, by which the count indicates the number of 840-yard lengths in one pound. The fixed weight system of numbering yarn is used almost exclusively throughout the world for yarn spun from loose fibres like wool or cotton. These materials are received by the spinner in the form of a tangled mass that is first converted into a coarse sliver or rope, which each successive process, up to and including spinning, makes finer. The process may be likened to the stretching of rubber; the farther a pound is stretched the smaller or finer becomes the strand, and the higher is the count or number that indicates the length of a pound.

By the second method of numbering yarn the count or ratio indicates the weight of a fixed length. Thus if 16,000 yards of silk weigh one ounce, the count or ratio between weight and length is No. 1. If two of these strands, each 16,000 yards long are placed side by side, the 2-ply thread will measure 16,000 yards and weigh two ounces, and the count or ratio between weight and length will be No. 2. This is the English standard for numbering thrown silk, by which the count indicates the weight in ounces of 16,000 yards.

The silkworm spins the silk filament to an extreme fineness, a single filament sometimes measuring 1,100 miles per pound. In this form it is too fine and delicate to be woven. The first process, therefore, is to double and twist a number of the cocoon filaments together by a process called reeling, which is carried on where the silk is raised. This reeled silk is the "raw silk" of commerce and the raw material of our silk mills. It is still too fine for weaving and passes through several processes of doubling and twisting, which convert it into what is called "thrown silk," each operation increasing the size and weight of the yarn and, consequently, the number or count.

The length of the silk filament as spun by the worm remains unchanged throughout all the subsequent processes of manufacturing. A coarser thread is obtained by twisting two or more threads together. In this way the weight is increased and the count indicating the weight of a fixed length increases in the same proportion. On the other hand, the length of the sliver made from loose fibres for spun yarn increases with each process and the count indicating the length of a fixed weight increases in the same proportion. Thus by using the fixed weight system of numbering in the manufacture of yarn from fibres, and the fixed length system in the manufacture of yarn reeled from filaments, the *count* in each case becomes higher as the process of manufacture advances. From this it is easily seen why "spun silk" yarn which is made from the tangled mass of waste silk is numbered by the fixed weight and not by the fixed length system.

In manufacturing yarn from loose fibres the raw material is first put into the form of a coarse sliver about as large as a man's wrist. Succeeding processes double and draw this sliver finer until it is about the size of a lead pencil, in which form it is called roving. The final process of spinning draws it still finer and twists it into yarn. During these successive stages it is frequently necessary for the workmen to test the size of roving, slubbing or yarn. In making these tests it is plainly impossible to weigh a given quantity and then measure it. To obtain an ounce, or other weight, it would be necessary to estimate roughly that amount and then take away or add piece by piece until the scales were balanced, leaving the yarn in such a broken and tangled mass that it could not be measured. These mill tests, therefore, are invariably made by first measuring a given length and then weighing it to determine the ratio between length and weight. By this method the length is fixed, the weight variable. The number by the regular fixed weight system, if wanted, is found by calculation or by reference to a conversion table. Automatic scales indicating the fixed weight number are often used. For many processes of manufacturing no conversion is required as the weight can be regulated as well by the fixed length as by the fixed weight system. For heavy sliver the fixed length system is practically a necessity. Any convenient length is chosen, from one yard upward. Thus the *Revue Technologique*, Paris, January 10, 1903, states French practice in the cotton industry:

The numbers for all spinning machines (mules) are based on this length of 1,000 metres, but as it would be too expensive and consume too much time to use so great a length of sliver or roving, the following lengths have been adopted nearly everywhere for the preparatory machines (in France):

Lappers	1 or 2 metres
Cards	5 metres
Draw-frames	5 metres
Slubbing frames	25 metres
Intermediate	50 metres
Finishers	100 metres
Mules and ring frames	1000 metres

It is necessary to calculate the number of the yarn from the weight of these lengths.

Again, in French worsted processes the tests are made by comparing the weight of an arbitrary length of sliver or roving with the standard. Following are the standards for the various processes as given by a French writer in a treatise on French spinning:

Weight of one metre of sliver or roving:

Cards	7 to 10 grammes
Draw-frames	9 to 1 gramme
Roving frames	1 to $\frac{4}{10}$ gramme

The same method is employed with the English system. A length of 12, 20, 50, 80 or 120 yards is frequently used as being a convenient fraction of the hank of 840, 560 or 1,600 yards, facilitating conversion to the fixed weight standard when desired. In the manufacture of knit goods, the calculation of the weight of the knitted fabric cannot be made from the yarn counts as is possible and necessary in the manufacture of woven fabrics. The weight of the knitted fabric is regulated by experiment and observing what weight of goods is obtained with a certain weight of yarn, gauge of frame, tension, and other adjustments. No calculations based on the yarn count being necessary, the size of yarn spun and knitted in the same mill is often regulated by fixed length tests, as in the case of sliver and roving. Instead of measuring so many yards, the practice in our leading knitting centres is to save time by weighing a certain number of ends from one "draw" of the mule, a "draw" being slightly more than 2 yards. The number of draws varies in different places. In Cohoes, 3 draws or $6\frac{1}{4}$ yards are used; in Amsterdam, 6 draws or $12\frac{1}{2}$ yards; and in Little Falls, 12 draws or 25 yards.

In Spain the weight in quarter ounces (Spanish) per 400 *canes* is used and an indefinite number of variations may be found throughout the textile world irrespective of the system of weights and measures employed. They are necessary operations for testing the size of the yarn by reeling and weighing, and are not classed as systems of numbering spun yarn. Following is a list of these methods compiled from recent authorities:

Country.	*Unit of Weight.*	*Length.*
Spain	quarter unça	400 canes
France	gramme	1, 2, 5, 25, 50, 100, 250 metres
Scotland	pound	14,400 yards
England	dram	80 yards
Germany	gramme	420 or 840 yards (English)
Germany	gramme	10, 20, 50, 100, 200, 300, 400, 500, or 1,000 metres
America	grain	1, 5, 10, 12, 20, 50, 80, or 120 yards.

When the yarn is woven into cloth the bulk of the fabric is indicated by the weight of an area of fixed dimensions, usually a length of one yard and a width expressed in inches. Silk is an exception to this rule. Owing to the practice of loading silk with foreign substances the weight of the finished silk fabric is a matter of indifference to the buyer, who relies upon the "handle" and appearance alone in judging the value of the goods.

The English yard-pound is at present the single standard of numbering spun yarn throughout all English-speaking countries, including the British colonies, China and Japan. All English fixed weight systems of yarn numbering are based on the number of skeins or hanks in one pound. Hanks of different lengths are used for the different materials:

Woollen,	1,600	yards.
Cotton,	840	yards.
Worsted,	560	yards.
Linen,	300	yards.

The hank used for carded woollen yarn varies in England, but in the United States a hank or run of 1,600 yards is the principal system, the only important exception being found in Philadelphia and vicinity where the 300 yard hank or linen cut is used. These systems are by no means confined to English-speaking countries. The 300 yard system is, with the exception of a local and unimportant Austrian standard, the world's single standard for linen, jute, hemp and allied fibres, so that if a spinner in any of these materials in the United States should mention, say, No. 20 linen yarn to a spinner in Great Britain, France, Germany, Austria, Russia, India, China or Japan, in fact, in any country in the world, both would understand without further explanation that the yarn measured 6,000 yards per pound.

These four systems were brought to America from England where they originated and are still in use. All are based on the English yard-pound so that the only variation in the English system of yarn numbering consists in the lengths of the hanks.

Of all the leading branches of textile manufacturing the linen, hemp and jute industries are the most distinct. These materials are seldom mixed or combined in the same fabric with either cotton, woollen, worsted or silk yarn. Its world-wide standard of 300 yards seldom comes in contact with the remaining systems. The 840 yard skein is the standard for cotton yarn throughout the world. The only exception is found in France where a French system *that is not metric* is used for cotton yarn. The 560 yard skein is the single standard for worsted yarn throughout the British Empire and the United States. It is also one of the leading standards for worsted yarn in Continental Europe.

The modern silk industry was first established in France and Italy, and their various systems of numbering silk yarn were adopted and became so firmly rooted long before the birth of the metric system that they have resisted all attempts to change them and are to-day the world's standards for what is known as raw silk. These systems of numbering were based upon the weight in deniers of 9,600 aunes of silk, the denier being a coin weighing 24 Paris grains. In testing the weight of silk 1-24th of 9,600, or 400 aunes, was used, and the weight of this shorter length in grains also indicated the weight of the longer length in deniers. Slight variations in the weight of the grain have caused variations which are practically negligible. Thus, in Continental Europe the length of 400 aunes is reduced to its equivalent, 476 metres, and the denier to .0531 gramme. To improve these awkward expressions a fixed length of 450 metres and a weight of .05 gramme have been substituted. As very little raw silk is produced in Great Britain or the United States the English and American silk manufacturers receive their supplies of raw material from abroad numbered by the denier-aune standard. Instead of converting the denier-aune count into an exact but awkward equivalent as has been done in Continental Europe, a distinct system, based on a fixed length of 1,000 yards and its weight in drams, has been adopted in Great Britain and the United States as the exclusive standard for numbering thrown silk. It is called the Manchester system, probably from its having originated in Manchester, England. Not only is it the only standard in use in English-speaking countries, but it is used to a considerable extent in the machine lace industry of Calais, France.

Paris Metric Congress, page 33:
M. Persoz. The English dram system is also used in the Calais district in the machine lace industry.

In addition to yarn numbering there are in the textile industry measurements of the width, length and weight of the woven cloth. The width is expressed in inches; the length in yards; and the weight either in ounces per yard or yards per pound.

Such is the present condition of our textile weights and measures. The metric proposition means that our fundamental standards, the yard, inch, pound, ounce, grain and dram shall be abolished and their places taken by the metre, decimetre, centimetre, millimetre, gramme, decigramme, centigramme and milligramme. It also means that for all materials, with the possible exception of silk, a skein of 1,000 metres and a weight of 1 kilogramme shall be the bases of numbering yarn. In other words, if

1 kilogramme of yarn measures 1,000 metres, the number is 1; if 2,000 metres, it is No. 2; if 3,000 metres, it is No. 3, etc., the number indicating the number of thousand metres per kilogramme. I say with the possible exception of silk, because the advocates of the metric system have not been able to agree among themselves as to how silk yarn shall be numbered by the metric system.

This, in brief, is what we are asked to abandon and what to accept. Let us first consider what sort of a task it is to change established weights and measures. From the growing of the fibre until it appears in the form of cloth ready for clothing, the ideas of every one of our textile workers, in every process of this complicated industry, are bound inseparably to the standards of weights and measures, the pound, ounce, dram, grain, yard and inch. It is of vital importance in the consideration of the metric question that a correct idea be formed of the nature and extent of this connection between textile standards and the technical knowledge and experience of textile workers.

The thickness and volume of the material in process are expressed by the ratio between the weight and the length of the sliver, roving or yarn. To the textile operative this count indicates not only the length, diameter, volume and weight of the material, but also the proportion between them. The yarn count is thus the keystone of the arch of textile weights and measures. It is the guide for all operations and the expression not only of length, diameter, volume, weight and their complex relations, but also a means of expressing the quality and length of fibres.

The count of worsted yarn, for example, indicating the number of 560-yard skeins per pound, has become a means of indicating the quality of worsted wool. Worsted wool is called 40's if it can be spun to 40 x 560 or 22,400 yards per pound; 60's, if it can be spun to 60 x 560 or 33,600 yards per pound; 80's if it can be spun to 80 x 560 or 44,800 yards per pound. This method of designating the quality of worsted wool is an established custom throughout the commercial and manufacturing world, and when the wool dealer of Hamburg, Germany, or the worsted spinner of Bradford, England, or the worsted manufacturers of Lawrence, Mass., designate worsted top by a number it is based upon the English yard-pound. The sign "60's" does not mean a number or yarn of a certain size to the wool grower, dealer, buyer or sorter; to them it means wool of a certain fineness, length of staple, curl and strength. To the carder, spinner and practical manufacturer it means all this and something more. It means a yarn of a certain size, uniformity and strength, measuring 33,600 yards per pound, and cloth of a certain texture and quality. In conversation the term 60's means the quality of wool to one man, the size of yarn to another, yet both ideas are in harmony. To change this system of numbering changes the language of textile workers as well as the mere expression of the ratio between the length and the weight of one pound of yarn.

As the process of manufacture advances, measurements become a still more frequent and important factor in the mill. The wool carder's ideas of the innumerable qualities and mixtures of stock, the adjustment and operation of the delicate carding machinery all centre on the yarn number, indicating a certain number of yards per pound. To change the size of the yard and pound would also throw his ideas of size and spinning qualities into hopeless disorder.

The spinner and weaver likewise gauge their work by the yard, inch and pound. The yarn count to them means a certain length per pound; the twist is measured by the turns per inch, and the expressions 6, 8, 10, 18, 24, or 40 turns expresses not only so many turns per inch, but certain degrees of hardness in yarn, ideas that are inseparably connected with certain effects in woven and finished fabrics. The yarn count, or length per pound, means a certain appearance of the yarn, a certain strength and elasticity; it tells what production should come from each machine, and how much should be paid for spinning 100 pounds or hanks. It is the standard of the experience in the past, the work of the present and the possibilities for the future.

The weaver works in a maze of measurements that include yarn numbers or yards per pound, threads of warp per inch, dents of the reed per inch, width in inches, length in yards, picks of filling per inch.

These measurements are vital factors in the structure of the fabric. They are constantly changing to meet the demands of fashion in the multifarious fabrics from gauze dress goods to frieze overcoating cloth, including an endless variety of fabrics too numerous to be mentioned here. Each of these fabrics is subject to innumerable variations in which correct measurements are essential.

The vast army of hard-working men, women and children engaged in our textile mills, most of them with but an elementary education, highly organized to work together with the precision of machinery in the conversion of fibres and filaments into fabrics, have become familiar with the established weights and measures in the hard school of experience. Their ideas of the yard, inch, pound, ounce, dram and grain as textile standards have been acquired while toiling long hours, day in and day out, for years in noisy, nerve-racking mills. In such a matter as changing of standards of weights and measures, each and every one is naturally a confirmed conservative. Their personal resistance to changes of acquired habits and ideas defies all efforts and arguments. Added to this is the fact that these textile operatives, scattered widely throughout the country, most of them unable to communicate with each other even when working in the same mill, are, nevertheless, essential parts of one great organization for the production of fabrics, of which all are sold by the English yard or pound. To obtain a merchantable product it is essential that each operator should do his work carefully and accurately. An error in the weight or length in the work of any of these processes may easily spoil the finished goods.

A proof of how intimately the system of weights and measures is connected with the everyday life of the people was furnished in January, 1902, by an attempt to substitute a new yarn scale for an old and inaccurate scale that had been used for years in the spinning-room of the Assabet Mills, Maynard, Mass. There was, doubtless, no desire on the part of the management to alter the wages of the help, the sole object of the change being to correct the inaccuracy of the old standard and to bring it into harmony with the system in the many other mills operated by the same company. Nevertheless, a change of the scale changed the count of the yarn and, in the absence of a corresponding change of the price list, caused a reduction of wages as effectually as a straight cut in wages would have done. A strike of the spinners followed and for a time threw over a thousand hands out of employment. This incident illustrates the widespread disturbance which is bound to accompany any attempt to change from one system of weights and measures to another.

The inch is the accepted standard for both woven and finished widths. Aside from the difficulty in changing from the inch to the centimetre in expressing widths in the mill, there would be the persistence of the inch for this purpose outside the mill, in the wholesale and retail trades, which would compel the textile worker to retain the present standard.

The introduction of the metric system into this country would upset the standard of values. The metre is $3\frac{3}{8}$ inches longer than the yard and the difficulty in adjusting prices to correspond with this difference of $3\frac{3}{8}$ inches would extend to every branch of the textile trade.

A change of textile standards would seriously impair, if not destroy, the value of the vast collection of textile records, consisting of printed literature and written records of individual mills.

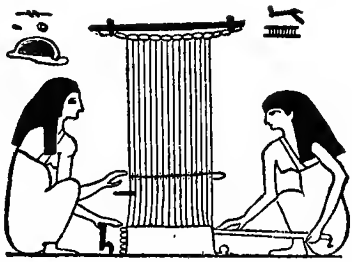
To these considerations must be added the size of the American textile industry, the vast extent of territory affected, the enormous population of 80,000,000, increasing at the rate of 4,000 per day, and all trained to the use of the English standards.

I ask the reader to consider calmly for a while the facts to which I have but hurriedly called attention; the complex nature of textile processes and products; the character of the employes; their hard struggle for existence; their meagre educational advantages; their inbred conservatism; the necessity of perfect harmony of action by all these operatives. Consider the importance of accurate measurement in textile manufacturing, and that these millions of textile operatives are constantly engaged in making such measurements. Look these conditions fairly in the face. Do not belittle nor exaggerate them. Talk with the operatives. Go into the mill and view them from the standpoints of the sorting, scouring, picking, carding, combing, drawing, spinning, spooling, reeling, warping, slashing, weaving, dyeing, bleaching, fulling, gigging, drying, shearing and final finishing processes, from any and every reasonable and practical standpoint, and then answer to the satisfaction of your own judgment and common-sense this question:

Is it possible to change radically our textile weights and measures?

The only conclusions that can be reached from such an examination of the facts are that the proposition to drive the present standards out and the metric standards into this industry is so absurd as to deserve no consideration whatever; that our textile weights and measures can be eradicated only by exterminating all who use them and by destroying all our textile records.

In forming an opinion on this question we are fortunately not obliged to rely on personal observations which, of course, are conclusive to the observer only. Since 1790 Continental Europe has been the scene of a determined struggle to change all standards of weights and measures to the metric system, and before comparing the system we have with the one we are asked to accept, it will be profitable to study the condition in which that struggle has left European textile standards.



THE CONTINENTAL CHAOS.

Confusion's cure lies not in these confusions.—*Romeo and Juliet.*

The metric system was a product of the French Revolution. At the height of the Reign of Terror, on August 1, 1793, the following decree by Danton and his associates marked the beginning of that policy of force in introducing the metric system into the French textile industry that has continued to the present time:

Decree of Aug. 1, 1793.

Art. 1. The new system of weights and measures founded on the measurement of the earth's meridian and the decimal division will be used throughout the Republic.

On September 23, 1795, the following decree provided that the metre should take the place of the aune:

Art. 1. On 1 nivose approaching, the use of the metre is substituted for that of the aune in the commune of Paris, and ten days after that date in the department of the Seine.

Art. 2. In consequence all merchants, both retail and wholesale, stationary and travelling, who use the aune, are ordered to procure metres.

Art. 11. The police will make in their respective arrondissements and several times during the year, visits to the shops and stores, public places, fairs and markets, to test the weights and measures.

All violators of this ordinance will be punished by the confiscation of the illegal measures, and will be brought before the police tribunal where a fine will be imposed to suit the case.

This decree was carried out with relentless energy by the Revolutionary government, and with the police patrolling the market places the metre was gradually forced into the stores. The French manufacturers, however, continued to reel, spin and weave by the old standards, and to remove the anomaly of one standard for trade and another for manufacturing the following decree was issued by Bonaparte in 1810:

Art. 1. On and after March 1, 1811, all proprietors of spinning mills shall make the hanks of cotton, linen, hemp or wool, each 100 metres long, so that a skein shall measure 1,000 metres in length.

Art. 2. These yarns shall be ticketed with the number of such skeins in one kilogramme.

Art. 3. Violations of the foregoing provisions shall be considered breaches of the police regulations and punished by a fine of not less than 5 nor more than 15 francs for the first offence; the fine may be increased for a repetition of the offence.

In France the cotton industry was then next to silk manufacturing in importance, and this decree threatened to throw the business of manufacturing and selling cotton goods into confusion. The protests of the cotton trade forced the government to a compromise, giving the manufacturer a standard based on the new French pound of 500 grammes (which was 11 grammes heavier than the old pound), in accordance with the following royal decree of June 7, 1819:

Art. 2. On and after Oct. 1, 1819, all cotton spinners of the kingdom shall reel their cotton yarn in 100 metre hanks, of which 10 shall make 1 skein of 1,000 metres.

Art. 3. To accomplish this object all the said spinners shall adopt new reels or alter those they now use so that in future all mills shall be equipped with hexagonal reels of 1,428 metres, provided with a wheel or counter of 70 teeth.

Art. 4. On and after the same date all cotton from French mills shall be ticketed with a number indicating the number of hanks forming a pound or demi-decigramme.

Art. 8. Cotton yarn which may be found after Oct. 1, 1819, without the mark indicating the factory or country of origin will be seized. If after a trial by jury the yarn shall be found to be of French origin, the owner or person in whose possession it was found will be fined 6 per cent. of the value of the yarn.

This law of 1819 was a formal surrender of arbitrary power to the power of established usage in the cotton trade. The worsted industry was practically non-existent at that period. The carded woollen branch continued to use their old standards in the mill, and the law could not reach them because carded yarn was mostly woven and spun in the same mill and did not appear in the market places under the eyes of the police. Linen continued to be reeled and numbered by the English system regardless of the imperial decree.

The manufacture of silk had reached too high a state of development to be disturbed, and so the denier and the aune continued to be the standards for silk yarn. Fifty-six years later, on June 13, 1866, the following law was placed on the French statute books:

The test for the fineness of silk shall be made by the weight of 500 metres in demi-decigramme.

The following preamble of a resolution by the Paris Metric Congress of 1900 shows that this law of 1866 was a dead letter from its birth:

Whereas: The official French numbering for silk, defined by the law of 1866 has never been used in the silk trade.

These old French statutes are given here to show to what an extent arbitrary law has been carried into the mills and the market places to make French textile standards metric. Conditions then were extremely favorable for such an attempt to change textile standards. At that time textile materials were carded, spun and woven almost wholly by hand power. The development of power machinery in the textile industry began in 1767 with the invention of the Hargreaves jenny, followed by the Arkwright spinning frame in 1769, by the Crompton mule in 1780, and the Cartwright loom in 1785. The last of these four great textile inventions appeared but four years before Louis XVI., on the eve of his flight to Varennes, gave his perfunctory approval to the decree establishing the metric system in France. Yarn was then spun by hand, and the size of the thread regulated by touch and not by measurement and weight. The great textile inventions we have mentioned but dimly foreshadowed the development of the complicated and finely adjusted machinery of the present. Standards of length, area and weight played an insignificant part in the rude textile industry of that time.

While textile machinery and processes have been slowly and laboriously brought to their present high state of development, the metric system was finished at the first heat. The metre, then supposed to be the 10,000,000th part of the distance from the equator to the pole, gave the metric standards of length and weight, just as we find them to-day, to the primitive French textile industry eager for improved methods of production. A more propitious time could not have been chosen for the introduction of the system. The most drastic of laws were enacted, and since that time it has been the settled policy of every French régime to make French textile manufacturers use the metric standards only. This policy, now over a century old, has been worse than a total failure; it has been a partial success. The manufacturing standards of weight and measure are not metric in a single branch of the French textile industry of to-day. The habits and the necessities of the rude industry of a century ago have proved superior to the power of autocratic governments. The partial success attained by thus forcing the metric system into the industry has resulted only in increasing the confusion that it was intended to remove. The evidence on this point in French textile literature of the present time is overwhelming, and admits of no denial. It is taken from the latest French textile books and journals; it is from men who ardently favor the French system.

France is an extensive producer of linen yarn, the best flax in the world being produced along the border line between France and Belgium on the River Lys. Practically all of this yarn is spun to the English standard.

Lamoitier, "Traité de Tissage," p. 63: *The English system of numbering is used* for linen, hemp and jute. The lea is 300 yards or 274.2 metres; 12 leas make a skein of 3,600 yards; 100 skeins a bundle of 360,000 yards. A linen thread is called No. 1 when 1 skein of 274.20 metres (300 yards) weighs 453 grammes (1 English pound). If we wish to transform this into the French system (not metric), the base being the pound of 500 grammes, we will have corresponding to French No. 1

$$\frac{274.2 \times 500}{453} = 302.60 \text{ m.}$$

By the official (metric system) based on 1,000 metres per 1,000 grammes the English No. 1 corresponds to metric No. .605 or 605 metres per kilogramme. By the French (not metric) system No. 1 corresponds to English No. 3.30.

That is the result of the struggle for 100 years to make the French linen industry metric.

The revolt in the French cotton industry against the metric standard based on the metre and gramme was so strong that the government was forced to let the cotton spinners use the French pound of 500 grammes. That explains why the metric standard of yarn numbering is not used at all in the cotton mills of France.

Lamoitier, "Traité de Tissage," p. 58: The official French system is based on a length of 1,000 metres and a constant weight of 500 grammes (French pound.) * * * In England the cotton number indicates the number of 840 yard hanks per English pound or 453 grammes. The yard is about .91 metres. 840 yards is equal to 840 x .91 = 764.40 metres. A No.

20 cotton thread (English) has a length of 764.40 metres x 20 = 15.288 metres per pound or 453 grammes, and per kilogramme

$$\frac{15288 \times 1000}{453} = 33.748 \text{ metres per kilogramme.}$$

or 16,874 metres per demi-kilogramme (French pound).

Our calculations are approximate. The exact length of 840 yards is 768.0792 metres.

This shows how far the French cotton spinner is removed from a decimal uniformity, and gives a hint as to the tremendous difficulties he meets in converting one system into another. The illustrations so far show that the French linen yarn standards are English and not metric; this is because the trade could not rid itself of the English yard-pound. They also show that the French cotton yarn standards are not metric. This is because the French cotton spinners would not base their yarn standard on the kilogramme.

When we turn to the French woolen and worsted standards, we find that, owing to the partial success in forcing the adoption of the metric yarn standard, the woollen and worsted industry presents a perfect babel of tongues.

Lamoitier, *l'Industrie Textile*, Paris, Oct. 15, 1902:

We still have the diverse standards of Roubaix, Fourmies and Reims for worsted, the moque of Sedan, the livre, the quart and the sous of Elbœuf, the yard for linen, etc.

Lamoitier *l'Industrie Textile*, Paris, Oct. 15, 1903:

And what do we find here? The yarn count in the North of France is a length and in the Centre a weight. What is more it is a weight for organzine and a length for organzine waste! I will take my oath that the manufacturer of Rouen, if he has not studied each section separately has no idea what is the standard of Reims or the denier of Lyons or Milan. And on the other hand the manufacturers of Reims and Lyons are likewise puzzled in making comparisons of the diverse numberings of the diverse materials.

M. Desire Chedville, textile manufacturer, Saint-Pierre-les-Elbœuf. "Paris Metric Yarn Congress, 1900," p. 87: We hope no new burdens will be imposed on the industry, but if we look the facts in the face, we will find that notwithstanding the decree of 1810, and in spite of the serious efforts put forth by industrial societies of many districts, we still have the ancient units of weights and measures and we scarcely comprehend each other when we talk of spinning at Reims, Roubaix, Elbœuf, Sedan or Vienna, where the skeins still measure 1,420, 710, 3,600 or 1,500 metres.

Remember that 1,000 metres is the only metric standard for yarn numbering, and that the lengths mentioned by M. Chedville are simply the metric equivalents of pre-Revolutionary standards which have withstood the metric assaults of the past 110 years.

Following is Lamoitier's statement of the conditions of the worsted industry, showing five separate and distinct systems of numbering yarn:

Lamoitier, "Traité de Tissage," p. 63:

In certain districts of France and Germany the old units are still retained, as well as in conservative England.

Roubaix, hank	714 m.,	unit of weight	.500 kg.
Fourmies "	710 "	" " "	1. "
Reims "	700 "	" " "	1. "
Germany "	1,577 " or 1,000 "	" " "	1. "
England "	560 yds. "	" "	1 pound

Referring to carded woollens, this writer adds, p. 24:

For carded yarn there are likewise the old standards in use although the official metric standard (1,000 metres per kilogramme), has been adopted at Reims and in the north of France, at Verviers and in Germany. At Sedan they still use the old standard (1,500 metres), and the kilogramme for unit of weight. At Elbœuf the skein measures 3,600 metres (equivalent of an old standard), and the pound is taken for unit of weight. The pound is divided into 4 *quarts*, each *quart* into 10 *sous*. A yarn of 10 quarts, 2 *sous*, is equivalent to 2 22-40 for a length of

$$3{,}600 \times 2 + \frac{3600 \times 22}{40} = 9{,}120 \text{ metres!}$$

We shall further on study the counts of silk, cotton, linen, etc. We regret extremely these anomalies which obstruct business, lead to regrettable errors and wantonly complicate all calculations.

Ibid., p. 87: We here give a table for wool based on the standard of 710 metres (equivalent of an old standard), leaving it to the reader to compile others for silk and the vegetable fibres according to his requirements. *These tables are used only for facilitating calculations.* For estimating the cost of an article we believe *it will be useful to all engaged in the woollen industry*, the 710 standard being the most extensively used of all the arbitrary systems.

Where textile standards are uniform, as in the United States, the length of the filling yarn in yards per pound of cloth is calculated by simply multiplying the width in inches by the number of picks (filling threads per inch). The following extract shows how complicated this simple operation has been made in France by a century of metric laws:

Lamoitier, "Traité de Tissage," p. 90: The picks of filling being ordinarily and arbitrarily counted by the quarter-inch, it is necessary before making the calculation to convert them into the number per centimetre. Following is the table for these calculations:

Picks per ¼ inch	Picks per cm.	Picks per ¼ inch	Picks per cm.

(The metric equivalents are then given from 5 to 30 picks per quarter inch.)

Remarks: For higher sets use multiples of the given numbers. There are 148 quarter-inches per metre. 1 centimetre is equal to 1.48 quarter-inches.

The present practice in measuring the width of ribbon, tape and other narrow fabrics illustrates perfectly how firmly weights and measures are established and maintained by the course of trade and industry. France is the home of the ribbon industry. The French *line*, which is 1-12 of a French inch became the standard for measuring the width of narrow fabrics long before the French Revolution. Apparently the *line* was selected by the French weaver because it was well adapted for such measurements, and its use has for the same reason been extended with the extension of the ribbon trade until to-day it is the world standard for ribbon widths.

Frowein, "Kalkulator für Artikel der Textilbranche," p. 90:

The loom widths of ribbon and tape are given in French lines. The fineness of the reed is indicated by the number of dents per French line.

For additional evidence on this point reference is made to the estimate of cost of a tape fabric by the same writer in another part of this chapter. If the reader will take the trouble to inquire at the ribbon counter of any American dry goods store he will find that ribbon widths are expressed in *lines*, and that the clerk at the counter usually has a special rule marked off in *lines* for measuring such widths.

The widths of many wide fabrics are expressed in quarter yards or ells. This is the custom throughout the world, and in Continental Europe results in an exasperating confusion owing to the different values of the metre, yard, ell, aune and other units used there. The introduction of the metre into the United States would cause a similar confusion with us. The Continental standards for widths of looms and cloth are thus described:

Lamoitier, in *l'Industrie Textile*, Paris, Nov. 1902.

I wish to call attention to another anomaly which is rather exasperating.

The widths of English looms are expressed in quarters of a yard. We (the French), thus have $\frac{4}{4}$, $\frac{5}{4}$, $\frac{6}{4}$, $\frac{7}{4}$, $\frac{8}{4}$, $\frac{9}{4}$, $\frac{10}{4}$, $\frac{11}{4}$, $\frac{12}{4}$, looms, and upwards. These looms allow goods to be woven of the following widths: .95 m., 1.20 m., 1.45 m., 1.70 m., 2 m., 2.20 m., 2.240 m., 2.65 m., 2.90 m., 3 m. It is probable that a French loom builder to be logical will adopt the metre as the base. We have here, consequently, a pristine confusion which will spread throughout the world and increase in proportion to the establishment of the metric system.

But this is not all. A resident of Mülhouse expresses the widths of his cottonades likewise in quarters of a yard. But there it is probably the aune that is taken for the standard, and we have as equivalents of $\frac{3}{4}$, $\frac{4}{4}$, $\frac{5}{4}$, $\frac{6}{4}$, $\frac{7}{4}$, $\frac{8}{4}$, $\frac{9}{4}$, $\frac{10}{4}$, etc., the metric measurements .90 m., 1.20 m., 1.50 m., 1.80 m., 2.1 m., 2.40 m., 2.70 m., 3 m., etc.

I demand the abrogation of these anomalies, as M. le deputé would say, and that only the metre be allowed for the measurement of all widths, whether of looms or of woven goods! Is this not logic itself?

Because of its peculiar fitness for textile work the French weaver still uses the French inch (1.08 English inches) for gauging the density or set of woven fabrics. The following extract from a work by the professor of weaving at the Société Industrielle d'Amiens shows that the French instruments for determining the set of a fabric are made by the inch or by both the inch and the centimetre. Apparently none are wholly metric:

Dantzer, "Traité de Tissage," p. 137:

The density of a fabric is expressed by the number of threads in a unit of length. The centimetre, $\frac{1}{4}$ inch and inch are used for this purpose. By the following table inches can be reduced immediately to centimetres:

$\frac{1}{4}$ inch	= .0069 m.
1 inch	= .0276 m.
45 inches	= 1.242 m.
78 inches	= 2.153 m., etc.

The density or set is determined by the aid of a small instrument called a thread counter. It consists of a plate in which is cut a rectangular opening of which one side measures 1 centimetre and the other side $\frac{1}{4}$ inch. There are thread counters in which the openings are respectively $\frac{1}{2}$ centimetre, $\frac{1}{8}$ inch, 1 centimetre, $\frac{1}{4}$ inch, 2 centimetres and $\frac{1}{2}$ inch.

Among the most important of textile calculations are those for estimating the cost of manufactured goods. An error in such an estimate might easily cause serious loss to a mill. On page 91 of Lamoitier, "Traité de Tissage," is given an estimate of the cost of a worsted serge, which shows how the survival of the ancient units of weights and measures complicates such calculations in France at the present time. The yarn, instead of being numbered by the decimal or metric system of 1,000 metres per kilogramme, is numbered by the Fourmies system, whose metric equivalent is 710 metres per kilogramme. The weight of the yarn numbered by this inconvenient system is calculated from the length. The picks are stated arbitrarily as 37 per centimetre, evidently to make the operation as simple as possible. As we have already seen, the French use an inch equal to 1-37th of a metre for counting picks, and 100 picks per French inch is equal to 37 per centimetre. This, as Lamoitier's table shows, is about the only set for which the old and the metric expressions are in whole numbers, and for practically all others, such numbers as 17.76, 23.68, or 39.96 picks must be used. The great liability to error made under such conditions needs no further demonstration.

In *l'Industrie Textile*, Paris, issue of August 15, 1902, appears a description of a new French ring spinning frame built by Dufassez-Allard et Simon and installed in the mill of M. Leclercq-Dupire at Wattrelos, from which we make the following extract:

> The production of warp yarn No. 22, Roubaix system of 1,420 metres per kilogramme (metric equivalent of the old Roubaix standard), is as follows:
>
> Mules 19.83 hanks per 65½ hours.
> Ordinary Ring Frames 24.06 hanks per 63 hours.
> New Ring Frames 30.86 hanks per 63 hours.
>
> * * * The numbers in the following table are based on the Roubaix standard of 1,420 metres per kilogramme, and the 1,000 metre equivalents are based on the kilogramme. (Here follows a table giving the Roubaix numbers by which the yarn was spun, together with the metric equivalents.)

This statement of the test of a new machine is the strongest kind of proof that the Roubaix and not the metric standard is used by the spinners in the Roubaix district. I want to call attention to the discrepancy between Lamoitier and this article as to the definition of the metric equivalent of the Roubaix standard. One gives it as 714 metres per French pound, equal to 1,428 metres per kilogramme; the other states it as 1,420 metres per kilogramme. This shows the confusion in the French mills. Here is a French opinion on this point:

> Lamoitier in *l'Industrie Textile*, October 15, 1902:
>
> To say that all this leads to insignificant variations is an error. I know, for example, what serious disputes have arisen from the difference of the standards of Roubaix and Fourmies. Do you want an example?
>
> I know a shipper of Cambrai who sent from 5,000 to 10,000 kilogrammes

of worsted to be spun to No. 100's on cops, to Messrs. F., at Fourmies. The shipper lived in the Fourmies district, but (in a way absolutely abusive in my opinion), reckoned the yarn by skeins of 714 metres, thus gaining 4 metres per kilo as compared with the Fourmies standard. The work was paid for by the number of skeins and the shipper thus gained 400 metres per kilo. As the shipper delivered only enough material to make the number of skeins required, there arose a violent dispute which lasted several months.

Turning to the French silk industry we find still more striking illustrations of the survival of old standards. When the metric system was established over a century ago, cotton, linen, wool and other loose fibres were converted into yarn by rude processes that were little if any better than those employed at the dawn of history. The present development of the spun yarn industry is due to comparatively recent improvements in carding, combing and spinning machinery. We have seen how, in spite of these favoring conditions, the mediæval standards of these industries still survive in France. In the silk industry the conditions were different. Silk is spun by the worm to such a degree of fineness and uniformity as to defy all attempts of man to equal it by artificial means. This was as true a century ago as it is to-day, and explains why the manufacture of silk at the birth of the metric system had reached a much higher development than the cotton, woollen or linen industries. Silk manufacturing then resembled the highly developed textile industry of the present day, and we may, therefore, learn by a study of the progress of the metric system in the silk industry the probable result of an attempt to change our textile standards. We can begin such an examination in no better way than by presenting statements of the friends of the metric system as to the condition of silk weights and measures in France and the rest of Continental Europe at the present time:

Lamoitier, *l'Industrie Textile*, October 15, 1902:

It is absolutely unworthy of us French, who were the first to find and apply the metric system, to retain the aune and the denier for measuring silk.

M. Jules Persoz, Silk Conditioning House, Paris, France, "Paris Metric Congress," 1900, p. 33:

The size of silk is expressed in different ways in the different countries. In France a law of June 13, 1866, provides that the number of silk shall indicate the weight in grammes of a skein 500 metres long. Although legal *this standard has not been adopted by the trade*, accustomed to a system based on the weight in grammes or deniers (about .053 gramme), and a length of 400 aunes (476 metres). Nearly the entire European trade employs similar variations.

M. Chamonard, 29 Rue Puits-Caillot, Lyon, France, at "Paris Metric Congress," 1900, p. 35:

There is, to be sure, considerable apparent confusion in the measures used in the various silk markets. In France, in spite of the law of 1866, the denier (.0531 gramme)—476 metre is used; in Germany, the Turin system denier (.05336 gramme)—476 metres; in Italy, the denier (.05 gramme)—450 metres. But these local measures which seem very diverse are nearly equivalent. Thus, 20 denier Italian corresponds to 19.80 denier French and to 19.90 denier Turin. Now the new numbers proposed will be 11 per cent. higher, a 20 denier Italian would be 22.20 by the new method. That would cause complete confusion in our ideas of to-day as to the relation existing between the number and the size of silk. And thus under the pretence of unification we create disorder.

Ibid., p. 79:

I will add in two words that the length of the 500 metre is so contrary to established usage that it has never been used. The law providing it has rested a dead letter since its passage twenty-five years ago.

M. J. Testenoire, Silk Conditioning House, Lyons, France. "Paris Metric Congress," 1900, p. 79:

Because of the difficulties in adopting the standard called international (demi-decigrammes per 500 metres), the conditioning houses of Lyon, Elberfeld and Crefeld, which have experimented in this direction, have been forced to return to the ancient measures to satisfy their customers. Besides the Lyon and Italian standards there are two others, those of Turin and Milan, which are nearly abandoned. The official French system is not used. There remain, therefore, the Lyon and Italian systems.

Lamoitier, "Traité de Tissage," p. 49:

The count of silk indicates the number of deniers in the weight of 400 aunes. Besides, other standards are used, the aune and denier of Montpellier and of Lyon. The Lyon aune measures 1.19 metres; and the denier weighs .0531 gramme. There is also the Italian system. In Italy and Switzerland the demi-decigramme is taken for the denier and 450 metres for the length.

The daily market reports afford the most convincing proof of the survival of the old system of yarn numbering, and the total neglect of the metric system of numbering in the French silk industry. In *Le Moniteur de Tissage des Soieries*, published at Lyon, under date of June 12, 1903, appears a long list of silk quotations furnished by Bayer, Mozet, Guilliee & Cie. of Lyon. The list includes silk from France, Spain, Italy, Hungary, Syria, Bengal, China and Japan. The size of every quality of organsin, trame and grège is given by the denier system, based on the denier and aune. The metric sizes are not mentioned at all. This would be uniformity were it not for the fact that the silk is sold in bulk by the kilo, the cloth by the metre, thus confusing textile calculations and ideas with the incommensurable aune and metre, denier and kilogramme.

The denier-aune remains to this day the French standard for numbering silk. The essential factor, the ratio between length and weight, indicating the length, weight, diameter and cubic capacity of the silk thread, is the same as before the origin of the metric system. The introduction of the metric system has compelled French manufacturers to employ in calculations the awkward metric equivalents, the number of times .0531 gramme is contained in the weight of 476 metres, instead of the old and convenient standard, deniers per 400 aunes.

The French silk manufacturer of to-day would be far better off as regards silk standards, if the metric system had never been devised, for he would have the aune for all textile measurements, cloth as well as yarn, instead of the mixture of units and their exasperating equivalents. Napoleon recognized this when he said:

> The geometers, the algebraists, were consulted in a question which was, in fact, purely one of an administrative character. They thought that the unity of weights and measures should be deduced from some natural order, so that it might be adopted by all the nations.
>
> The law needed for this matter was so simple that it could have been written out in twenty-four hours, and could have been adopted and put into practice throughout the whole of France in less than a year. All that was required was to make the units of weights and measures of Paris the only legal units throughout France.
>
> The Government and the artisans had for generations past used these weights and measures.
>
> By sending standards to every commune, and by ordering the administration and the tribunals not to recognize any others, this reform would have been carried out without trouble, inconvenience, or coercive measures.

It is amusing as well as instructive to study the erratic and futile attempts to change the silk standards of France. The problem was so difficult that no interference with established standards was attempted until 1866, when a law was passed providing that the silk count shall indicate the demi-decigrammes per 500 metres, or the equivalent, grammes per myriametre. This was proclaimed as the "universal silk standard," was endorsed by Metric Congresses, extolled in newspapers, at banquets and other public places, and "adopted" by public conditioning houses, which had the new count marked on their tickets.

During this period the new system styled "official" was included in all the books on silk manufacturing, with pages of tables giving the equivalents of the old and new counts. Lamoitier thus describes it:

"Traité de Tissage," p. 50:

Because of the fineness of silk and the method of reeling it, the method of numbering by the kilogramme (1,000 metre hanks per kilogramme), can seldom be used. The last (Metric) Congress of Brussels settled the question of the unification of the metric system of numbering by retaining the fixed length base, and substituting the myriametre for the aune, and the gramme for the denier. And thus we obtain a system (fixed length) very simple, practical, suited for all calculations, and universal because all of its units are metric.

Note that this, like all other metric systems, was born "universal."

Then came a period of uncertainty during which the kilometre, myriametre, and 450-metre systems found their advocates. The 450-metre-demi-decigramme system was practically the metric equivalent of the old denier-aune standard, but could not be juggled into anything decimal. If the denier-aune standard was based on the gramme the length was 9 kilometres; if on the decigramme it was 900 metres, and if on the demi-decigramme it was 450 metres. None of these was decimal. Something had to be done, however, and the Metric Congress at the Paris Exposition of 1900, mindful of former failures to make the silk workers use "universal" standards, formally admitted defeat and adopted the equivalent of the denier-400 aune in the following resolutions:

Whereas, The official French numbering for silk, defined by the law of 1866, has never been used in the silk trade, and,

Whereas, The only systems in use are the Lyons, used in the United States, France, and Japan; the Italian, used in most of the other silk countries, notably in Germany, Austria, Italy and Switzerland, and,

Whereas, It is important while seeking unification on metric and decimal bases to take into account the customs of the different silk markets, and,

Whereas, The difference between the two above-named systems is negligible, therefore,

Resolved, That the Italian system, which is metric and decimal, be adopted by all nations as the international standard.

Adopted unanimously.

In other words:

Whereas, Water will not run up hill at our command, therefore,
Resolved, That water shall in future run down hill.

It is encouraging to have a Metric Congress "adopt" a standard for anything because it is in general use. Some time they may learn at Paris that there are 36 inches in a yard, 16 ounces in a pound and 840 yards in a skein of spun yarn. This glimmer of common sense was short-lived. The Congress adjourned, leaving the control of "universal" weights and measures to a permanent committee, who, after the new demi-decigramme-450-metre standard began to appear in technical literature, announced on April 22, 1903, that this "universal" silk system had been replaced by one based on the 1,000 metre hanks per kilogramme. And the Frenchman who in 1900 had declared that a fixed weight system could not be used for numbering silk yarn, thus hailed a fixed weight system as the silk standard for the universe.

Lamoitier, *l'Industrie Textile*, July, 1903:

This is the standard established for the universe. Glory to the permanent committee of the Congress of 1900 who have reached so soon such a marvellous result!

And the silk workers of Lyons are still reeling and weaving by the denier-aune. Metric systems may come and metric systems may go, but the denier-aune goes on forever.

In mathematics certain truths are considered self-evident. No line of reasoning can demonstrate them more clearly than they demonstrate themselves. This is the case with the evidence of the confusion existing in the textile weights and measures of France to-day. Although France is the birthplace and has been the home of the metric system for more than 113 years, textile weights and measures are no nearer uniformity than in other parts of Continental Europe. The evidence as to this confusion outside of France is likewise overwhelming. Every technical work on textile manufacturing, every textile journal published in Europe is filled with the proof of it. I will present a small portion of such testimony, enough, however, to convince the most sceptical. During the revision of the German tariff last year, 1902, an agitation was started to dispense with the English and use the metric system for assessing duties on imports of yarn. The committee of the Reichstag gave a hearing on the question, and the following item from the *Leipziger Monatschrift* tells how fiercely the proposition was resisted by German textile manufacturers:

At the sitting of the tariff commission on June 24 (1902), the proposal to introduce the metric system for cotton yarn came up. According to Münch-Ferber, delegate to the Reichstag, and a textile manufacturer, the adoption of the amendment providing for the use of the metric system for yarn would lead to "ungodly disorder" (heillose Verwirrung), in the domestic weaving industry because all the machines are built to suit the English system of numbering.

"Kalkulator für Artikel der Textilbranche," by Friedrich Frowein, published in 1901 at Barmen, Germany, is a practical treatise written for the purpose of simplifying textile calculations for everyday use. It, therefore, represents not only German practice but also the *simplest* form to which such calculations can be reduced for German manufacturers.

Frowein, "Kalkulator," 1901, p. 3:

Cotton yarn is reckoned by the English hank and reel; this has been adopted by all spinners of nearly every country. The price is likewise always given per English pound.

On page 5 he begins an attempt to simplify the confusion of standards. Ten different units of length are mentioned as follows:

Prussian ell	25½	inches	or	67	cm.
Wurtemburg ell	34¼	"	"	62	cm.
Vienna ell	29½	"	"	78	cm.
Baden ell	20	"	"	60	cm.
Swedish ell	24	"	"	60	cm.
Russian archin	28	"	"	72	cm.
English yard	36	"	"	91	cm.
Danish ell	24	"	"	63	cm.
Bavarian ell	34¼	"	"	84	cm.
Saxon ell	24	"	"	56½	cm.

The author explains the relation of each standard to the metric system. This requires ten paragraphs, each accompanied by a comparative table. One will give an idea of all:

Frowein, p. 9:

A Bavarian ell has 34¼ inches or 84 cm. A metre is equal to $41\frac{1}{10}$ Bavarian inches. One thread of single yarn per centimetre in a fabric one Bavarian ell wide and 54 Bavarian ells or 45 metres long, gives a length of 3,780 metres and, at 60 grammes per 100 metres for No. 1 yarn (English), a weight of 2,268 grammes.

6 Faden No. 1 (English)	=	504	Faden	=	22,680	Metres	=	13,608	Grammes.
12 " " "	=	1,008	"	=	45,360	"	=	27,216	"
18 " " "	=	1,512	"	=	68,040	"	=	40,824	"
22 " " "	=	1,848	"	=	83,160	"	=	49,896	"
28 " " "	=	2,352	"	=	105,840	"	=	63,504	"

The weight for any size is found by dividing the gramme number by the yarn number (English).

A similar formula is given for each of the other nine units, and in every one the English standard of yarn numbering (840 yds. per lb.) is the only one mentioned, because it is the only system used for cotton in Germany. These explanations still leave the reader entirely in the dark as to the relations between each ell and the other nine standards. Such a confusion of standards beggars description. It shows how the German textile industry is handicapped to-day.

Next comes another series of ten explanations of how to calculate the weight of yarn when the density of threads (set) is given in threads per inch. One will illustrate all:

Frowein, p. 11:

Cloth 1 Prussian ell wide and 100 ells long.

1 thread per inch (1 ell = 25½ inches), 25½ threads per 100 ells long = 2,550 ells = 1,020 grammes (75 ells = 50 metres = 1,700 metres No. 1 per 100 metres 60 grammes).

The following extract shows the use of the English inch for gauging twist in yarn:

Ibid., p. 16:

The usual twist is from 25 to 30 turns per English inch. The expression, so-and-so many turns, always means per English inch and this is the universal practice in the trade. In order to determine the turns accurately, the number in a metre as indicated by a twist-counter is divided by 40, as there are 40 English inches in one metre.

Note the tendency in practice to lengthen the metre to even inches.

The same work contains a series of estimates of cost, covering a wide range of textile fabrics which include cotton, linen, worsted and silk cloths, ribbons, tapes, elastic fabrics, wool lace, rick-rack, bobbin lace, etc. In every one except silk goods the English system is predominant, and for silk the old aune and denier are the standards. One of them, the estimate of cost of cotton tape fabric, is shown at Fig. 2, and in each of the others a similar tangle of English, metric and local standards exists. In this estimate a separate column is inserted for prices per English pound, showing the prominent place occupied by this Anglo-American standard in the textile industry of Continental Europe. The reed is gauged by the number of dents per *French line.* The yarn counts in both warp and filling are *English,* based on the 840 *yard* standard. The picks of filling are given as so many per *French inch.* The weight of the warp yarn is calculated in *metric grammes* from the *English counts,* and extended at a price in marks per *English pound.* The length of the filling yarn is calculated per 100 *metres* of cloth from the picks per *French inch* and the width in *French lines.* The weight of the filling in *grammes* is then calculated from the *English* yarn count and the length in *metres.* This weight in grammes is then extended at a price in marks per English pound.

All of this blind staggering among a lot of incommensurable units, consisting of the *French inch, English yard, metric metre, French line, English pound* and *metric gramme* is necessary to arrive at the cost of cotton tape measured lengthways in *metres* and widthways in *French lines.* This is a simplified method of "using the metric system in Germany." It shows what the United States must come to if the system is ever introduced here.

On page 82 Frowein says:

All plans to dispense with the English hank (840 yards) have heretofore involved the changing of our reels and skeins. From a practical standpoint we do not view this as possible and we consider that the work of a calculator should be confined rather to the conversion of the various lengths and hanks now in use into metric standards. While theorists and some others in trade circles favor the adoption of the French system with 1,000 metres, the author does not believe that its introduction is possible. On one side the cost of changing our machinery, and on the other the alteration in yarn numbers, offer insurmountable obstacles to the project. Furthermore we do not believe that the introduction of the metric system would be of any advantage to the spinner. The English spinner undoubtedly sets the standard with his system, that has been used for more than a century and is known throughout the world, and he will not consent to the introduction of the metric system. The German and French spinners who use the English hank will likewise refuse to give their consent.

That is the opinion of a practical German in close touch with the textile trade.

We have taken from this little book by Frowein but a few ex-

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Zwirn-Band.	Preis à engl. Pfd.	Preis à 100 Mtr.
5 1/2''' 5 stichs Rieth zu I. 64 Schuss per Zoll Kette 33 Faden 80. Zwirn. Einschlag 40. Water Eisengarn.		
Kette:		
33 Faden × 1½ gr. = 50 gr.		
Einwirken 10% = 5 „		
55 gr.		
Stoff	1.80	
Farbe schwarz . .	—.25	
Winden	—.20	
	2.25	
Ein engl. Pfd. Mk. 2.25, folglich 55 gr. . .		—.28
Einschlag:		
5½''' × 64 = 352'''		
Einwirken 5% = 18'''		
durch 12''' : 370''' = 31 Faden à 100 Mtr.		
31 × 1½ gr. = 47 gr.		
Stoff	1.10	
Farbe und lüstriren	—.45	
Winden	—.35	
	1.90	
Ein engl. Pfd. Mk. 1.90, folglich 47 gr. . .		—.20
		—.48
Verlust 6%		—.03
Kettenscheeren à 100 Faden à 100 Mtr. 6 Pfg.		—.02
Arbeitslohn		—.50
Fracht und Aufmachung		—.17
		1.20
Spesen und Zinsen 8%		—.10
Herstellungskosten		1.30

FIG. 2.—A GERMAN ESTIMATE OF COST OF COTTON TAPE.

Dotted lines = Old French Standards.
Broken lines = English Standards.
Double lines = Metric Standards.

tracts showing the chaos of European textile standards. To take them all would mean to translate the entire book, for from beginning to end there is an uninterrupted mixture of English, local and metric standards.

A sample card published in Bayreuth, Germany, by Otto Holtzhausen, shows 14 lengths of white cotton yarn, ranging from No. 6 to No. 45, mounted on a black ground with the number above each. In the few explanatory words attached appears this sentence: "Die Nummernbezeichnung ist die englische." (The counts are English.) This collection is issued for sale to German merchants and manufacturers. There is not one American cotton manufacturer whose ideas of yarn sizes are not expressed exactly by this German card. Every one of the 46,000,000 cotton spindles in England is spinning yarn by its standard. The French spinners with their minds muddled by the use of both the English system and a French system which is not metric, are all acquainted with the English numbers on the Bayreuth card. The spinner in Germany, where it was published, in Switzerland, Holland, Belgium, Austria, Italy, Spain and Russia, are using and are perfectly familiar with its standard. If we journey still further around the globe we will find the 5,000,000 spindles of India spinning cotton yarn by the same standard and at less cost than in any other place on earth. Let us go still further until China is reached; open the German card and the almond eyes of the celestial cotton spinner will brighten in recognition of its numbers and sizes. Passing northward to Japan we will find that the card likewise indicates the sizes of Japanese yarn. Crossing the Pacific to the United States we shall still hear the same monotonous story. Every American cotton mill is spinning cotton yarn by the 840-yard standard of this German card.

The table at Fig. 3, taken from the *Leipziger Monatschrift* of October 31, 1902, illustrates the confusion of German standards and how deeply the English yard-pound is embedded in German textile literature and practice. It has been compiled for daily use by weavers in reckoning the amount of yarn required for orders. It is called: Theoretical requirements of yarn for 100 *metres* of cotton cloth 100 *centimetres* wide, in *English pounds*. This is bad enough, but worse is to come. The yarn counts at the head of the columns are *English* based on 840 *yards per pound*. At the left the set is given in threads per *Vienna inch*. The

Austrian weaver runs his eye down the columns headed *English yarn No.* until he reaches the line at the left of which is the set in threads per *Vienna inch,* and there he finds the weight in *English pounds* of the yarn he needs for 100 *metres* of cloth 100 *centimetres wide.* And this is also called "using the metric system."

The German spinners and merchants do not find it plain sailing

Theoretischer Garnverbrauch für baumwollene Gewebe pro 100 m Länge und 100 cm Breite in Pfund engl.

Engl. No.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Kette-Abfall Schuss-Abfall	5,—% 6,½%	5,—% 6,—%	5,—% 5,½%	4,½% 5,½%	4,½% 5,—%	4,½% 5,—%	3,½% 5,—%	3,½% 5,—%	3,½% 5,—%	3,—% 5,—%	3,—% 4,½%	3,—% 4,½%	3,—% 4,½%	3,—% 4,—%	3,—% 4,—%
Fäden p. ¼" 8	15,83	14,39	13,19	12,18	11,31	10,56	9,90	9,31	8,80	8,33	7,92	7,54	7,20	6,88	6,60
Einweben %	3,41	3,10	2,84	2,62	2,43	2,27	2,13	2,01	1,89	1,79	1,70	1,62	1,55	1,48	1,42
9	17,81	16,19	14,84	13,70	12,72	11,87	11,13	10,48	9,90	9,38	8,91	8,48	8,10	7,74	7,42
„ %	4,31	3,92	3,59	3,32	3,08	2,89	2,70	2,54	2,40	2,27	2,16	2,05	1,96	1,87	1,80
10	19,79	17,99	16,49	15,22	14,14	13,19	12,37	11,64	11,—	10,42	9,90	9,43	9,—	8,61	8,25
„ %	5,32	4,84	4,43	4,09	3,80	3,55	3,33	3,13	2,96	2,80	2,66	2,53	2,42	2,31	2,22
11	21,77	19,79	18,14	16,75	15,55	14,51	13,61	12,81	12,09	11,46	10,89	10,37	9,90	9,47	9,07
„ %	6,44	5,85	5,37	4,95	4,60	4,29	4,03	3,79	3,58	3,39	3,22	3,07	2,93	2,80	2,68
12	23,75	21,59	19,79	18,27	16,96	15,83	14,84	13,97	13,19	12,50	11,88	11,31	10,80	10,33	9,90
„ %	7,66	6,96	6,38	5,89	5,47	5,11	4,79	4,51	4,26	4,03	3,83	3,65	3,48	3,33	3,19
13	25,73	23,39	21,44	19,79	18,38	17,15	16,08	15,13	14,29	13,54	12,86	12,25	11,69	11,19	10,72
„ %	9,—	8,18	7,50	6,93	6,43	6,—	5,63	5,29	5,—	4,74	4,50	4,29	4,09	3,91	3,75
14	27,71	25,19	23,09	21,31	19,79	18,47	17,32	16,30	15,39	14,58	13,85	13,20	12,59	12,05	11,55
„ %	10,32	9,38	8,60	7,94	7,37	6,88	6,45	6,07	5,73	5,43	5,16	4,92	4,69	4,49	4,30
15	29,69	26,99	24,74	22,84	21,21	19,79	18,56	17,46	16,49	15,63	14,84	14,14	13,49	12,91	12,37
„ %	11,97	10,88	9,98	9,21	8,55	7,98	7,48	7,04	6,65	6,31	5,99	5,70	5,44	5,20	4,99
16	31,67	28,79	26,39	24,36	22,62	21,11	19,79	18,63	17,59	16,67	15,83	15,08	14,39	13,77	13,20
„ %	13,61	12,38	11,34	10,48	9,72	9,08	8,49	8,—	7,56	7,16	6,81	6,47	6,19	5,92	5,67
17	33,65	30,59	28,04	25,88	24,03	22,43	21,03	19,79	18,69	17,71	16,82	16,02	15,29	14,63	14,02
„ %	14,78	13,44	12,32	11,38	10,56	9,86	9,24	8,69	8,20	7,78	7,39	7,03	6,73	6,44	6,15
18	35,63	32,39	29,69	27,40	25,45	23,75	22,27	20,96	19,79	18,75	17,81	16,97	16,19	15,49	14,84
„ %	17,24	15,66	14,36	13,26	12,32	11,49	10,78	10,14	9,58	9,08	8,62	8,20	7,84	7,50	7,18
19	37,60	34,19	31,34	28,93	26,86	25,07	23,50	22,12	20,89	19,79	18,80	17,91	17,09	16,35	15,67
„ %	19,21	17,46	16,—	14,78	13,72	12,80	12,—	11,30	10,67	10,11	9,61	9,15	8,73	8,35	8,—
20	39,58	35,99	32,99	30,45	28,27	26,39	24,74	23,28	21,99	20,83	19,79	18,85	17,99	17,21	16,49
„ %	21,28	19,34	17,74	16,38	15,20	14,18	13,30	12,52	11,82	11,20	10,64	10,14	9,68	9,25	8,86

FIG. 3.—A GERMAN YARN TABLE.

in following the dictum of the Paris Metric Yarn Congress of 1900, that spun yarn shall be numbered by the skein of 1,000 metres per kilogramme. Otto Holtzhausen, of Bayreuth, Germany, rises to remark in the *Leipziger Monatschrift* that the Congress, while telling what the trade should do, omitted to explain how to do it:

The Paris Congress in its second resolution provides that "all kinds of reeled yarn shall be put up in skeins of 1,000 metres each, divided decimally."

This is not specific enough as to the method of reeling. It is assumed that 10 bindings of 100 metres each will be used in place of 7 bindings of 840 yards wound on an English reel 1½ yards in circumference. Then follows resolution 3:

"All kinds of reels are permissive providing they give the length of 1,000 metres."

The provision in the second resolution for dividing the skein decimally has remained nugatory because in reeling polished yarn only two divisions, and in cross reeling no divisions whatever are possible. Furthermore, the use of 10 bindings will increase the cost of reeling, because it is without doubt more expensive to tie the skein in 10 parts than in 7 as at present.

Fully as convincing proof of the European confusion is found in a series of articles now (July, 1903) running in the *Leipziger Monatschrift für Textil-Industrie* and entitled, "Calculationen in der Weberei mit besonderer Beruecksichtigung der Greiz-Geraer Kleiderstoffbranche," by B. Ziegenhorn. In the introduction he says:

Surprising as it may seem, the number of ends is reckoned by so many "gangs" of 40 threads each, although this does not correspond with the decimal system. Likewise the picks are counted by the Saxon inch.

Ibid.:

The filling is calculated by multiplying the metric filling set by the metric width. For example:

59 gang 7½ gang reed.
104 metres wide in loom.
120 metres wide finished.
120 picks per Saxon inch.

Here we have neither metric width nor metric filling set, as both factors are given in Saxon inches. The width is equal to as many units of 6 Saxon inches as 7½ is contained in 59.

Next comes a table covering 60 square inches of fine type to assist in the conversion of Saxon sets into metric and Saxon widths. The German writer then gives a long list of examples to illustrate the method of estimating the cost of various fabrics. In every one of them the width and the warp set in the loom and the picks are given in Saxon inches.

In the April, 1903, issue, a layout and explanation for a Jacquard crêpe cloth is expressed as follows:

B. Ziegenhorn:

Jacquard crêpe.

Finished width 100 centimetres.

55½ threads per inch (Saxon).

Warp, 59 gang = 2,360 ends, 2-40, Cheviot, English (840 yards per pound).

Reed, 8 gang per 6 Saxon inches = 755 dents per metre.

Loom width, 44.3 Saxon inches = 104½ centimetres.

Filling, No. 24 English (840 yards per pound), .54 threads per Saxon inch 229 per 10 centimetres.

It should be noted that the English worsted reel is 1 yard in diameter:

7 skeins of 80 turns each = 560 yards. The count indicates the number of 560 yard skeins per English pound. In the example given $\frac{2}{40}$ English = No. 20. As one English pound = 453.59 grammes, and one English yard = .91438 metre, the metre length is:

20 x 560 x .91438 = 10241 metres per English pound.

The length per metre is then found as follows:

$$\frac{10241 \times 1000}{453.59} = 22577.6 \text{ metres per kilogramme.}$$

The metric number is rounded to 22½ or to 22 if the calculator desires to facilitate the calculation still further.

The tendency toward round numbers in changing from one standard of yarn numbering to another is thus referred to in the *Leipziger Monatschrift* by Otto Holtzhausen, Bayreuth, Germany:

The Alsatian yarn market in Mülhouse, where the French system is used, furnishes an instructive example in rounding yarn counts. The proportion of three systems, English, French and metric, are thus expressed:

French : English :: .846 : 1
French : metric :: 1 : 2
English: metric :: 1 : 1.6932

In the Mülhouse market the following round equivalents are used:

French No. 14 = English No. 14,
French No. 18 = English No. 21,
French No. 24 = English No. 28,
French No. 30 = English No. 36, etc.

Thus the ratio is changed to .8333 : 1 = 5 : 6 in order to facilitate calculations, resulting in an increase of about 1½ per cent. in the French sizes. The same thing would occur in expressing the metric equivalents of the English counts the ratio 1.6932 being changed to 1⅝.

The difficulty in changing textile standards is thus stated by the same writer in the *Leipziger Monatschrift:*

The change to the metric system of numbering means a complete revolution of our notions of the thickness and length of yarns, because of the variations in the divisions of the English and the metric scales. Thus English No. : metric No. :: 1 : 1.6932. Consequently if we are to retain the English sizes now used in our mills it will be necessary to indicate them by compound numbers. This difficulty is still further aggravated when we consider the method of packing skein yarn. At present we have 10 English pounds in one bundle and a bundle of No. 10, 16, 20 or 24 yarn contains respectively 100, 160, 200 or 240 hanks (of 840 yards each). This makes it possible to divide the bundle into ½-pound skeins, as is necessary for the process of dyeing, bleaching or fancy weaving. This will be impossible with the metric system if the sizes of the yarn are not changed because the metric skeins in a 5-kilogramme bundle of yarn of our present sizes would be as follows:

English No. 10 = metric No. 16.6932 = 83.5 metric skeins.
English No. 16 = metric No. 27.0912 = 135.5 metric skeins.
English No. 20 = metric No. 33.8640 = 169.3 metric skeins.
English No. 24 = metric No. 40.6368 = 200.3 metric skeins.

From this it is clear that it will be impossible to divide a bundle into equal parts of say 250 grammes, each containing skeins of uniform size, allowing the yarn to be put again into bundles of the original size after bleaching, dyeing, or other process. It is also evident that the metric numbers cannot be rounded up or down to make such division possible because such rounding cannot be carried so far as to cause a material difference in the size of the yarn.

In the May, 1903, instalment of his article, Ziegenhorn gives further examples of crêpe cloths, showing the same confusion of standards. At Fig. 4 is his explanation of how to convert the English cotton yarn numbers to the metric standard. The English standards are underlined with broken lines - - - -, the Saxon with dotted lines..... Attention is called to the frequent appearance of such awkward expressions as .914, 768, and 453.59, which are the metric equivalents for the English yard, 840 English yards and the English pound respectively. It is useless to try to emphasize the exasperating confusion thus exhibited.

Technical and trade literature of Continental Europe is replete with evidence of this confusion. Take for example the textile market reports in the *Wochenberichte der Leipziger Monatschrift für Textil-Industrie* of July 8, 1903:

Bremen, July 4th.—All quotations for cotton given in marks per English pound.

Zurich, Switzerland, July 4th.—All sizes of cotton yarn given in the English system (840 yards per pound, while quotations are mixed, some given per kilogramme, others per English pound.

Mülhouse, July 4th.—Cotton yarn sizes given by both the metric and the English system.

Stuttgart, July 6th.—Cotton yarn quoted by English sizes, per kilogramme and per English pound.

Milan, July 4th, Lyon, July 3d, Turin, July 4th, Canton, China, July 6th, Shanghai, China, July 6th, Yokohama, Japan, July 6th.—Silk. All sizes based on the old denier-aune standard. No mention of metric sizes.

These conditions are unquestioned. They may be seen by any one who will take the trouble to read the current market reports and textile journals of Continental Europe.

German textile books present a confused jumble of English, local and metric standards.

Ausführung IV. $72^{1}/_{2}$ Faden im Zoll.
$3^{3}/_{4}$ Proc. Einarbeitung.
(Zeichnung u. Karte 18^{1}.)

Kette: 77 Gang = 3080 Faden 48 aa.
Blatt: $10^{1}/_{2}$ gängig, 4 fadig = 742 Rohre auf 1 m.
Arbeitsbreite: 44 Zoll = 104 cm.
Schuss: 2/70 gebleichten mercerisirten Baumwollzwirn.
Farbe u. Appretur: Entweder nur Waschappretur für crême, weiss oder zarte Ballfarben in uni oder nur auf Wolle.

106 m Kette angelegt, 103 m Rohwaare.
Kette: 327 Zahlen 48 aa.
Schuss: 245 Zahlen 2/70 gebleicht merceris. Baumw.

Die Nummer des Baumwollzwirnes ist bei der Ausführung der Calculation in metrische umzurechnen. 2/70 = 35 englische Baumwoll-Zahlen (hanks) à 7 Gebind (leas) à 80 Faden à $1^{1}/_{2}$ Yard à 0,914 m. 1 hank ist demnach **7 · 80 · 1,5 · 0,914 = 768 Meter lang.** Die englische Nummer wird nach der Anzahl solcher hanks, die zusammen ein englisches Pfund wiegen, bestimmt. Nummer 35 ist sonach **35 · 768 m = 26880 m lang** und wiegt 453,59, rund 454 Gramm: mithin enthält **1 kg** davon:

454 : 1000 = 26880 : 59207 Meter.

2/70 Baumwollzwirn wäre also c. 59 Nummer metrisch.

Dotted lines = Saxon Standards.
Broken lines = English Standards.

FIG. 4.—A TYPICAL GERMAN TEXTILE CALCULATION.

Kutzer, "Garn-Nummerirungen," 1901. Systems of yarn numbering:

Linen, hemp and jute: English and Austrian (the latter is local and unimportant).

Ramie: English and metric.

Cotton: English, French and metric.

Worsted: English, French and metric.

Carded woollen: metric, English, French, Austrian, Berlin or Belgian, Prussian, Old Austrian, Vienna, Saxon.

Waste silk: English and metric.

Reeled Silk: Old Lyons, New Lyons, Turin, Milan, Piedmont, metric (demi-decigrammes per 500 metres, official but not used).

In addition to these Kutzer gives a long list of local systems used for the different textile materials. Thirteen pages are filled with elaborate tables for the conversion of these standards into each other. The work closes with a list of 21 ells and 10 different pounds used in Continental Europe, giving the metric equivalent for each.

"Die Eigenschaften der Gespinste," by Heinrich Brüggemann, Stuttgart, 1897, is a mass of complicated formulas, tables and explanations to simplify the use of European textile weights and measures. Of the forty-three pages devoted to the subject of yarn numbering and sizes, forty are occupied with the English and local European systems.

Donat, "Methodik der Bindungslehre," Wien, Pest, Leipzig, 1901, contains a repetition of the confusion of which the following statement of yarn numbering is a fair sample:

> Cotton: English, French, metric.
> Linen and jute: English, Austrian.
> Worsted: English, metric.
> Carded woollen: English, Austrian, Prussian, Saxon, metric.
> Silk: Milan, Turin, Lyon, metric (not used).

On page 110 is the following list of 7 ells, 5 pounds and 4 inches with their metric equivalents:

UMRECHNUNGS-TABELLE.

Ellen.	Meter.	Pfund.	Kilogramm.
Leipziger	.566	Englisch	.4536
Böhmisch	.6	Leipziger	.467
Berliner	.667	Französisch	.4895
Brabanter	.694	Zoll	.5
Wiener	.777	Wiener	.56
Englisch	.9144		
Französisch	1.188		

1 Leipziger inch	= 2.336 cm.	1 cm. = .428	Leipziger inch.
1 Englischer inch	= 2.54 cm.	1 cm. = 2.54	Englischer inch.
1 Wiener inch	= 2.635 cm.	1 cm. = .379	Wiener inch.
1 Französischer inch	= 2.707 cm.	1 cm. = .369	Französischer inch.

On page 111 is a section treating of twist in yarn. The turns are given by the English inch, no mention of the metric system being made.

"Mechanische Technologie der Weberei," by Hermann Oelsner, Altona, 1902, is a standard German treatise on weaving, now in its eighth edition. Like the other books referred to, it shows plainly the present confusion of weights and measures in Europe as well as the general use of the English standards. Following are a few extracts:

Oelsner, p. 20:

The English system of reeling is the one most used. The spinners of nearly all countries have adopted it. The hank is 840 yards long. The count indicates the number of hanks of 840 English yards (768 metres), in 1 English pound. 1 pound = 454 grammes. In France and a portion of Belgium cotton yarn is numbered by the French system, the count indicating the number of 1,000-metre hanks in 1 French pound (½ kilo).

Ibid., p. 74:

Carded woollen yarn is reeled and numbered in a great many different ways, which appear to have been the result of chance rather than of any practical requirements. Following are the most important:

Prussian, 2,200 Berlin ells and 1 Berlin pound.
Cockerill, 2,240 Berlin ells and 1 French pound.
Saxon, 800 Leipzig ells and 1 French pound.
Saxon, 1,200 Leipzig ells and 1 French pound.
Vienna, 1,760 Vienna ells and 1 Vienna pound.
Bohemia, 800 Leipzig ells and 1 English pound.
English, 560 English yards and 1 English pound.
Elbœuf, 3,600 metres and 1 French pound.
Sedan, 1,256 Paris ells and 1 Paris pound.

Ibid., p. 83:

In Germany and Austria worsted yarn is reeled and numbered to correspond with the English system. In France, Belgium, Switzerland and Italy the hank is 600 aunes in length, the count indicating the hanks per ½ kilo.

Ibid., p. 93:

The size counts of silk indicate the weight in deniers of 9,600 aunes.

On page 107 of Oelsner's work is a table showing the following comparisons of yarn numbering: English, 840 yards per pound; French, 1,000 metres per 1 French pound (½ kilo); English, 560 yards per pound; Old French, 600 aunes (720 metres) per French pound; Prussian, 2,200 Berlin ells per French pound; Saxon, 800 Leipzig ells per French pound.

Following this table is a long section on general calculations which are involved in an indescribable mixture of local, English and metric standards of length and weight. Chaos prevails throughout the entire section. There is a long series of comparative tables introduced to simplify the conversion of one standard to another. Following are a few samples of the confusion exhibited in this part of what is probably the best and most practical work on weaving in the German language:

Page 108: The standards of length for *nineteen* different systems, stated in the following units: Leipzig ell, Berlin ell, Vienna ell, English yard, metre.

Page 110: The circumference of eleven different reels. *Six* are given in English yards, *two* in metres, the other *three* in *local ells.*

Page 119: In Prussian mills the set of fabrics is based on the number of *gangs* of 40 threads each in a quarter, Berlin ell ($6\frac{3}{8}$ Prussian inches).

Page 121: The following table gives the threads per centimetre and per French inch for the Crefeld system of indicating the set. The system is based on $38\frac{2}{3}$ French inches = 104.8 cubic metres = $41\frac{1}{4}$ English inches. (This table is too long to be inserted here. Following are a few sample fractions taken from it: $11\frac{59}{131}$; $31\frac{1}{19}$; $12\frac{53}{131}$; $33\frac{18}{29}$.)

In Switzerland and France the system is based on the number of threads and dents per French inch or per cm.

Page 124: An elaborate table *based on the Leipzig inch* and showing the effect of contraction on the set.

Page 130: The metric equivalents of the following standards of length:

Prussian ell,	Vienna ell,
Saxon ell,	English yard,
Brabant ell,	Danish ell,
Bavarian ell,	Swedish ell,
Würtemberg ell,	Russian archin.
Baden ell,	

The same equivalents *in round numbers.*

Pages 132, 133, 134, 135: These four pages and part of page 136 are filled with tables reducing the metre to Berlin, Leipzig and English ells (yards), Berlin, Leipzig and English ells to metres, centimetres to Leipzig, Rhenish and English inches.

Page 137: Tables for reduction of sets by Leipzig standard (6 Leipzig inches) to threads per Leipzig inch, per 140 centimetres, per centimetre, per Rhenish inch and per English inch. All this is German practice in the textile industry to-day. The Saxon inch, English yard, French metre, English pound and French kilogramme are involved in hopeless confusion. This exhibit, bad as it is, shows only the bare formulas. The real difficulty begins when an attempt is made to apply them, to make the calculations that are constantly arising in daily mill work. It should not be forgotten that the introduction of metric standards into American textile industry, where the English yard, inch, pound and ounce now reign, means a condition but little better than this Saxon-English-metric mix-up.

A hand-book of cotton spinning, Guia Practic pera la Filatura del Cotó, by Emili Riera, Barcelona, 1901, shows that a similar confusion exists in Spain. As the machinery used is English the illustrations for the book have been taken from English drawings, the English words not having been changed. The Catalonian system of numbering yarn is thus described:

Riera, p. 70: The Catalonian system is based on a weight of $1\frac{1}{10}$ lliures and a hank of 500 canes. The count indicates the number of hanks in this weight.

Evidently this system of counts was derived from the English, for there is a difference of only $4\frac{1}{2}$ per cent. between them. Then follows an explanation of a Spanish method based on a fixed length and the weight in quarter ounces. Then comes the English followed by the French system, but the metric standard is not mentioned. There are several tables showing the equivalents by the Catalonian, English and French systems of numbering yarn, with the weight of 1,000 metres, but no mention of the metric count. The book exhibits a deplorable confusion of Spanish, English and metric weights and measures, to which lack of space prevents extended reference.

The evidence which is here presented proves beyond a shadow of doubt that as far as textile weights and measures on the Continent are concerned the attempt begun 110 years ago to make them metric has been a failure, the small measure of success attained having served only to increase the disorder. It demonstrates that changing established size numbers for yarn is practically impossible, that the attempt to change them in Europe has simply caused a conversion of the standards on which they are based from old to metric units, causing a condition worse than the first. The same result would surely follow a similar attempt to change the American system of numbering yarn.

Assuming that American weights and measures are changed to the metric system, let us trace the resulting changes in yarn numbering as indicated by the experience of Europe. During the first stage of the "transition" period the yard and pound, kilogramme and metre would be in use, and it would be necessary to preserve the metric equivalents of the yard and the pound; the cotton, woolen, worsted and linen standards being expressed as follows:

Cotton, now 840 yards per pound; then 768.09 metres per 453.59 grammes.

Worsted, now 560 yards per pound; then 512.05 metres per ~~kilogramme~~. 453.59 grammes

Woollen, now 1,600 yards per pound; then 1,463.04 metres per ~~kilogramme.~~ 453.59 grammes

Linen, now 300 yards per pound; then 274.31 metres per ~~kilo-gramme~~s 453.

The next period would come after the yard and pound had disappeared; the cotton, woollen, worsted and linen standards could then be based on the kilogramme as follows:

Cotton skeins of 1,693.63 metres per kilogramme.

Worsted skeins of 1,129.09 metres per kilogramme.

Woollen skeins of 3,226 metres per kilogramme.

Linen skeins of 604.85 metres per kilogramme.

A comparison of the awkward expressions of either the first or the second stages with our present standards of 840, 560, 1,600 and 300 yards per ounce, shows how much better off we are now than we would be then.

The first two stages of this process of evolution can now be found in France. In Elbœuf the numbering of carded yarn is based on a fixed weight of 40 sous (an old unit of weight) or its equivalent, 500 grammes, and a variable length expressed in a skein of 3,600 metres. This is the first stage. Passing to Roubaix, for example, we find the evolution in the second stage, the fixed weight being the kilogramme and the variable length expressed in skeins of 714 metres.

The third stage in France is the use of the system based on the 1,000-metre skein and the kilogramme. The last named is the only one that is metric, and has been introduced to some extent in the woollen industry, but in the other branches it is used so little as to hardly warrant the statement that the last stage has begun.

Thus the experience of Europe teaches us that the metric system will first give us a 768.09-metre, 453.59-gramme cotton yarn system for centuries, with equally absurd bases for each of the other systems. If we escape from them we shall have another era with the absurdities reduced one-half; in the meantime, endless confusion.

The process of conversion by which yarn counts remain unchanged has left Continental Europe with practically all the systems of numbering yarn that have ever been used there to any considerable extent. This chaotic state of yarn numbering is shown in tabular and graphic form in another chapter where the two systems, English and metric, are compared.

The evidence presented by Europe proves that a change of textile standards is a task of such difficulty as to be practically impossible, even when backed by all the might of arbitrary and despotic power, and confirms beyond a doubt the belief that an attempt to change textile standards in a free country like our own is simply impossible, and that partial success will create confusion instead of contributing to uniformity.

In this matter of weights and measures the preferences and opinions of employers do not control. There is probably not one textile manufacturer in France, Germany, Austria, Italy and Spain, who does not ardently favor the use of the metric system. No one should deceive himself by thinking that this unanimity is due to the merits of the metric system. They favor it because it offers the only way of escape from the chaos of local standards in which Europe is involved. They are, however, powerless to bring this about, owing among many other things, to the familiarity of their employes with the old units. Textile weights and measures are regulated by the millions who create wealth in the mill, not by the hundreds who count that wealth in the counting-house.

Let us now compare the system we have with the metric system which we are asked to accept in its place. The evidence shows that such a change is impossible and therefore a comparison of the two systems is not of any practical value, except as it may furnish cumulative proof of the folly of attempting to change American textile standards.

THE ENGLISH AND THE METRIC SYSTEM COMPARED.

Look here upon this picture, and on this.—*Hamlet.*

The English textile standards are six in number:

yard,
inch,
pound,
ounce,
dram,
grain.

The metric textile standards are eight in number:

metre,
decimetre,
centimetre,
millimetre,
kilogramme,
gramme,
decigramme,
centigramme.

The first thing to attract attention is the individuality of the English names. The words yard, inch, pound, ounce, dram and grain are short, crisp expressions, and each conveys a distinct impression to both the eye and the ear. Each stands forth as the unique representative of a particular measure of weight or length.

The metric words, metre, decimetre, centimetre, millimetre, kilogramme, gramme, decigramme and centigramme are long, cumbersome and very much alike. The name of each metric unit of weight sounds like the name of every other metrie unit of weight; the name of each metric unit of length sounds very like that of every other metric unit of length. The English units have English names which are a part of the English language. The metric units with their Greek and Latin prefixes and wearisome suffixes have a strange, monotonous sound and appearance. It is difficult to connect the idea with the metric word. As some one has well said: The metric units resemble a party of foreigners in uniform; they all look alike and jabber alike.

As far as nomenclature is concerned the English system is decidedly superior.

It is the dimensions of the units, however, that are most important. The yard is 36 inches long, the metre $39\frac{3}{8}$ inches. This difference is less than 10 per cent. of the yard, and not enough to affect the value of either as a textile standard.

The exclusively decimal divisions of the metre are, however, decidedly objectionable. The mind naturally divides the yard by successive halving. The first division is into halves; then come $\frac{1}{4}$ and $\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$. This is the general practice in handling textiles.

One-quarter is the smallest fraction of a yard used in measuring cloth from the loom. One-eighth is the smallest used for finished goods. By the metric system $\frac{1}{4}$ becomes .25, while $\frac{1}{8}$ is .125. These long, cumbersome decimals will not answer for expressing fractions of the yard. The purchaser of cloth by retail could never be induced to call for $\frac{5}{10}$ of a yard when she wanted $\frac{1}{2}$, or for $\frac{875}{1000}$ when she wanted $\frac{7}{8}$.

The other English textile standard of length is the inch. For the various uses to which the inch is put the metric decimetre, centimetre and millimetre are used.

The English inch is unquestionably the best standard for determining the set (density of threads) of textile fabrics in cloth analysis. It is not so long as to make the counting of the threads too laborious. It is not so short as to cause serious error by discarding a fraction of a thread. For example, 27 warp threads per inch are equivalent to $6\frac{3}{4}$ per quarter inch. The omission of the fraction, $\frac{3}{4}$, from the number of threads per quarter inch means a difference of 168 threads in the warp for goods 56 inches wide, while the omission of a like fraction from the number of threads per inch means a difference of but 42 threads in the same width. Every practical textile manufacturer will recognize how important the difference, 126 ends, is in a 1,512 end warp.

For like reasons a distance approximating an inch is the best for gauging the set of the filling (picks). The superiority of the English inch for this purpose is attested by the fact that the French weavers, over one hundred years after the birth of the metric system, are still using the inch for counting picks.

Turning to the metric system we have the centimetre ($\frac{4}{10}$ inch) and the decimetre (4 inches) for gauging the set of cloths. The centimetre is too short, because the omission of one thread or even a part of a thread from the calculations makes a difference which might seriously affect the structure of the fabric. Take, for example, a 32-ounce Irish frieze cloth made 140 centimetres wide; 10 threads per centimetre would be equal to 1,400 threads in the warp. An omission of one thread in the count is easily made in cloth analysis and would mean a difference of 10 per cent. of 140 threads, which with the ordinary size of frieze yarn would make a difference of $1\frac{6}{10}$ ounces per yard in the warp alone. The same error might easily creep into the filling, impairing both the appearance and the weight of the goods.

That this is a practical difficulty with the metric system is shown by the following extract from "Methodik der Bindungslehre und Decomposition für Schaftweberei," a standard German work on weaving by Franz Donat, Professor at the Royal Weaving School at Reichenberg:

"The threads in warp and filling are gauged by the number per decimetre. The use of the decimetre is unsafe (unsicher), because from one-half to one thread (even more in silk goods), may easily be overlooked."

Weavers at the loom must frequently count the picks in the cloth to make sure that the fabric is being woven with the right number of filling threads per inch. This must be done in the midst of the confusion and din of the weave room while the loom is running, and while counting the picks the weaver must watch the work and machines to see that nothing goes wrong. In ordinary woollen fabrics the picks often run as high as sixty per inch. To count these sixty threads in one inch correctly under such conditions requires the closest attention, and errors are then very likely to occur owing to interruptions incident to the operation of weaving. To count correctly four times that number, or 240 per decimetre (4 inches) under the same conditions would be a physical and mental impossibility.

For expressing the woven and finished widths of textile fabrics the English system offers the inch and its subdivisions; the metric system, the centimetre or the millimetre. Wide cloths are woven and sold in the United States as so many even inches wide. For example, we have 36, 40, 44, 48, 50 or 56 inch goods. These expressions of width (consisting of but two figures) are easily written or spoken and are constantly used, not only by the manufacturers but also by the commission merchants, jobbers, retailers, tailors, and that large part of our population who buy dress goods, and all other kinds of textile fabrics at the retail counters of our stores.

The centimetre is too short for the finished widths of wide fabrics. Inches express such widths as closely as is necessary.

By the metric system the finished goods are expressed in centimetres. This necessitates the use of three figures for all goods 40 inches or more in width. A comparison of the following expressions both when written and spoken shows how much more concise and expressive are the English terms:

English.	*Metric.*
36 inches.	90 centimetres.
40 inches.	100 centimetres.
44 inches.	110 centimetres.
56 inches.	140 centimetres.

Frequently these widths are given in quarter-yards, thus, $\frac{8}{4}$, $\frac{7}{4}$, $\frac{6}{4}$, $\frac{5}{4}$, $\frac{4}{4}$, $\frac{3}{4}$, etc. Turning to ribbons and tape, European practice proves that the metric units are unsuited even for very narrow widths. The French inch divided into 12 lines, the line being again divided into quarters, is still used there for the width of narrow fabrics. Frowein, "Kalkulator für Textile Branche," p. 91, thus states the difficulty with the metric units:

The different widths of tape and ribbon often vary by $\frac{1}{4}$ line. It is greatly to be regretted that, the millimetre being too long for the measurement, we find here an obstacle to using the millimetre for expressing widths and thus bringing it into use in commerce.

None of the successive decimal divisions of the metre are suited for either the commercial or manufacturing widths of textile fabrics. For the finished widths of the wide goods the decimetre is too long, the centimetre too short. For narrow fabrics the millimetre in turn is too long and its decimal divisions too short. For all of these widths the inch, divided to suit the particular case, answers every purpose perfectly. Could there be any stronger confirmation of the following extract from John Quincy Adams' report?

Thus, then, it has been proved, by the test of experience, that the principle of decimal divisions can be applied only with many qualifications to any general system of metrology; that its natural application is only to

numbers; and that time, space gravity and extension inflexibly reject its sway.

Next compare the English and metric systems for expressing the width of wide goods in process of manufacture. Cloth is made wider in the loom than when finished, to allow for the shrinkage in finishing, the difference varying widely in different fabrics. This loom width must be adjusted with extreme care that not only the final width, but also the weight, "handle" and finish of the goods may be right.

An occurrence at the Hecla Mills, Uxbridge, Mass., in 1887, will illustrate this point. The mill was started on fabrics for which the samples had been made in another mill. In sending the drafts to the Hecla, the designer at the other mill marked the loom width $3\frac{4}{10}$ inches wider than it should have been. Before the error was discovered the Hecla mill was filled with tender and unmerchantable goods, a large part of which was sold as "seconds," most of the remainder at a heavy loss. This is an extreme case but shows the necessity of a correct adjustment of the loom or manufacturing width. A difference of $\frac{3}{4}$ of an inch in the width at the loom or fulling mill may mean the success or failure of a fulled worsted or woollen fabric.

The American practice is to express the loom width in inches and tenths of an inch; thus 68.1 inches. This adjustment to $\frac{1}{10}$ of an inch is as fine as is required, the expression requiring but three figures. The metric practice is to express the loom width in centimetres or millimetres. The centimetre ($\frac{4}{10}$ inch) is four times as long as one-tenth of an inch, and thus the loom width can be adjusted to the tenth of an inch with four times the degree of accuracy that is possible with the use of the centimetre.

The objection to the use of the millimetre is that it necessitates the use of four figures to express the width of wide cloths.

From these considerations the conclusion is obvious that as a practical standard for the manufacturing width of wide cloths, the English inch divided into tenths is superior to the metric centimetre or millimetre.

The square yard and square metre are used to some extent in trade and commerce; as a standard by which to assess customs duties, for example. For such purposes there is nothing to choose between the yard and the metre. The difference in the size of these two units does not affect the utility of either. Measures of area in textile manufacturing are employed chiefly in the analysis of fabrics, the square inch being the English, the square centimetre or decimetre the metric standard.

Cloth analysis is an important operation of the textile manufacturer. Much depends upon the degree of accuracy with which the structure of a fabric is determined, and a slight error may cause much loss to a mill by reason of the goods coming out different from the sample they were intended to duplicate. The two important factors to be determined from measures of area are the weight per yard or metre, and the size of the yarn. Both are calculated from the weight of a sample of small area, and upon the size of this area depends the accuracy of the analysis. The effect of an error on the resulting fabric diminishes as the area of the sample enlarges and increases as the size of the sample grows smaller. The analysis of cloth involves much tedious labor in ravelling and counting threads, which increases with the size of the sample. Experience has shown that for analyzing most cloths, particularly union fabrics composed of two or more kinds of yarn, the best size is that approximating four square inches. It is not so large as to make the ravelling and counting of the threads unnecessarily laborious, nor so small as to make a serious defect in the cloth result from a slight error. The size of the yarn in a sample can be determined by a simple division of the threads per inch by the weight, *if the sample is of a certain area.* This area must be such that each thread in the set of the fabric will be equal to the length of the skein on which the size number is based. Now let us see what such an area is by the English and also by the metric system.

The set of fabrics is expressed in threads per English inch. The English system of yarn numbering based on 840 yards per pound, or 4.32 inches per grain, is used as the basis for cloth analysis. It is plain that for each thread per inch there will be 4.32 inches of yarn in an area of 4.32 square inches. The yarn count can then be calculated by a simple division of the threads per inch by the grains in the weight of the area which has been found to be the best for the analysis.

The metric system of yarn numbering is based on 1,000 metres per kilogramme, 1 decimetre per decigramme, or 1 centimetre per centigramme. We can thus adjust the size of our sample to suit either the decigramme or centigramme basis. By the former the area is one square decimetre (15½ inches); by the latter one square centimetre ($\frac{1}{7}$ square inch). To meet the requirements of the simplest calculation there is no unit of area between the square centimetre ($\frac{1}{7}$ square inch), which is one-sixth the size of a two-cent postage stamp, and the square decimetre ($15\frac{1}{2}$ inches), which is equal in area to an ordinary business envelope. The square centimetre is out of the question because it is so small; the square decimetre is equally unavailable because it is so large. We cannot get around the difficulty by making the area 10 square decimetres, for this is but $1\frac{1}{2}$ square inches, or less than one-half the area required (4 square inches).

The only course open with the metric system is to make the area approximately 4 square inches, say 5 centimetres square, complicating the calculation and involving the correct position of

FIG. 5.—THE SAMPLE ANALYZED.

the decimal point in doubt. Much the greater part of the calculations for cloth analysis are those to determine the size of the yarn, and for these we find the English units of area much superior. The weight of cloths is expressed by the English system by ounces per yard or by yards per pound, by the metric system by grammes per metre.

By the metric system the weight per metre of cloth is calculated from the area (25 square centimetres) by multiplying the weight of the sample by the width of the cloth in centimetres and dividing by the area of the sample. By the English system each grain of the weight of the sample is equivalent to one ounce per yard $52\frac{1}{2}$ inches wide, and thus by multiplying the weight of the sample in grammes by the width of the cloth in centimetres and dividing by $52\frac{1}{2}$, the ounces per running yard are found. The process in each case is one of simple proportion. The yards per pound or metres per kilogramme are calculated by a similar process.

We will illustrate these calculations by the analysis of two samples of the union fabric shown at Fig. 5, one by the English, the other by the metric system. This cloth is an English cotton and worsted fabric known in the market as the "Varsity" vesting. A sample $1\frac{8}{10}$ inches by $2\frac{4}{10}$ inches and another 5 centimetres by 5 centimetres are cut for the English and metric analyses respectively. Each piece is weighed, and enough warp and filling is then ravelled to enable the projecting threads to be counted in one inch of the English and in 5 centimetres of the metric sample. After the warp and filling threads are thus counted, the remainder of the sample is ravelled and each kind of yarn separated and weighed. The results of these operations are as follows:

English sample:

Warp.—Worsted, 4.2 grains, 62 threads per inch.
Cotton, 1.8 grains, 31 threads per inch.
Filling.—Cotton, 7 grains, 130 threads per inch.
Total, 13 grains.

Metric sample:

Warp.—Worsted, 25 centigrammes, 124 threads per 5 centimetres.
Cotton, 11 centigrammes, 62 threads per 5 centimetres.
Filling.—Cotton, 41 centigrammes, 255 threads per 5 centimetres.
Total, 77 centigrammes.

Upon weighing a sample, then extracting the wool with caustic alkali and weighing the residue when dry, we find the cotton to be 66 per cent. of the original weight. This result is obtained by the same calculation with either the English or the metric system so that no comparison need be made here.

The sizes and sets of the yarn and the weight of the goods are then calculated, as shown at Figs. 6 to 13 with the following result:

Worsted Warp.—English, Fig. 6, 15 figures.
—Metric, Fig. 7, 27 figures.
Cotton Warp.—English, Fig. 8, 15 figures.
Metric, Fig. 9, 23 figures.

Cotton Filling.—English, Fig. 10, 16 figures.
Metric, Fig. 11, 25 figures.
Weight of cloth.—English, Fig. 12, 38 figures.
Metric, Fig. 13, 22 figures.

A summary shows that 84 figures have been used in the English and 97 in the metric calculations.

There remain to be determined the nature and quality of the

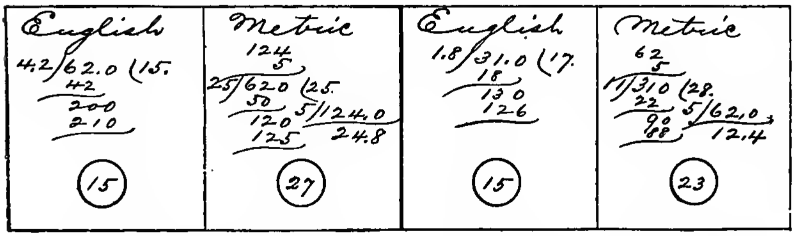


FIG. 6. FIG. 7. FIG. 8. FIG. 9.

WORSTED WARP. COTTON WARP.

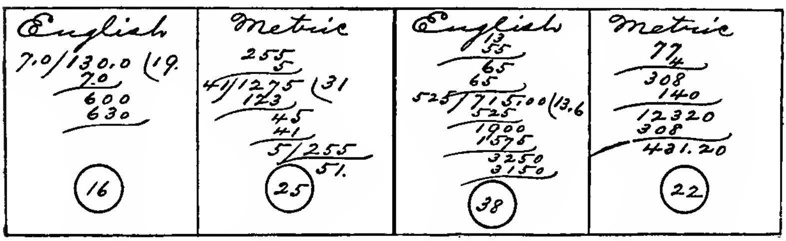


FIG. 10. FIG. 11. FIG. 12. FIG. 13.

COTTON FILLING. WEIGHT.

ENGLISH AND METRIC CALCULATIONS FOR CLOTH ANALYSIS.

raw material, probable processes of manufacture, twist in the yarn, weave and finish of the goods. For this work it is essential that the analyzer should have good judgment and practical experience, which, although not affected by either the English or the metric system, can easily become impaired when the mind is clouded by the joint use of two standards of weight and measure.

We thus find that for cloth analysis the English units of area are superior to the metric units, because the former fulfil the requirements of exactitude in the work and simplicity in the calculations.

Let us now turn our attention to the units of weight. We have the metric kilogramme to answer the purposes of the English pound. I can find no reason for preferring one to the other in textile work. It remains a fact, however, that the French textile industry has for 110 years successfully resisted all attempts to displace the French pound, which approximates the English pound, being only 5 per cent. heavier, and to-day the whole French cotton industry use this pound as a basis for yarn sizes.

The weight of cloth is expressed by ounces per yard and yards per pound, or by grammes per metre and metres per kilogramme. In America the weight of cloth sold by the ounces per yard is generally expressed in even units, rarely in fractions of an ounce; thus woollen cloths are sold as 12, 15, 20 or 30 ounces per yard. These are short, concise, businesslike expressions whose superiority over the metric expressions will be recognized at once when the two are placed side by side:

English.	*Metric.*
12 ounces per yard.	370 grammes per metre.
15 ounces per yard.	450 grammes per metre.
20 ounces per yard.	600 grammes per metre.
30 ounces per yard.	900 grammes per metre.

Three figures are required for the metric as compared with two for the English weight.

The dekagramme might be used for the weight per metre to reduce the number of figures at the cost of adding two syllables to the word gramme, but judging by French and German textile books and periodicals it is not so used, the gramme being the only unit employed.

In manufacturing cloths it is necessary to watch the variations of weight per yard which should, as a rule, be kept within one-half ounce. This gives five units for the usual half-ounce range of variation, and answers admirably for expressing the manufacturing weight per yard.

The grain divided into tenths is used for analyzing cloth by the English system, and as far as size is concerned there is little to choose between it and the decigramme and centigramme, which serve the same purpose with the metric system.

We now come to a comparison of the English and metric systems of yarn numbering. There are many systems of yarn numbering based on the metric as well as on the English system. In another part of this work will be found a comparison of the English with the metric systems of yarn numbering as they are used to-day. Here, however, we will compare the pure metric with the English system. The former is based on 1,000 metres per kilogramme. It is used but very little in Europe, chiefly for woollen yarn, practically not at all for cotton, linen, and silk. Obviously it would be unfair to the English system to compare this 1,000 metres per kilogramme standard with the mixture of all the English standards, just as it would be unfair to the metric system to compare one of the English standards with a mixture of all the metric standards. For this reason the comparison will first be made between the 1,000 metres per kilogramme and the English 840 yards per pound, the latter being the standard for cotton yarn throughout the world, outside of France, where a system that is not metric or decimal is used.

The claim that the metric system offers the world a single standard for numbering all kinds of yarn is repeated so often and with so much emphasis, that it has led many to believe that the 1,000 metre per kilogramme standard possesses some peculiar property that makes it superior as a universal system. The advocates of the metric system tell us that by adopting that system of numbering yarn all kinds of material, cotton, silk, wool, linen, etc., when combined in one fabric, as they often are, will be numbered by one standard, facilitating calculations and giving textile operatives a clearer idea of the construction of textile fabrics.

But what are the facts? The metric 1,000 metre per kilogramme standard being a fixed weight system is not suited for numbering silk, and it is no better suited for numbering spun yarn than is the English 840 yard per pound system, now used for cotton throughout the world. This English system is as well adapted for woollen, worsted, linen or other material as it is for cotton. Our comparison shows us that the English system for other textile purposes is preferable to the metric. Then if any system of yarn numbering is to be selected as the world's single standard it should be the English cotton which is the best of the English standards and is the one used most throughout the world. No one thinks of using our 840 yards per pound system for anything but cotton yarn, and few use any other system for cotton yarn. This has caused people to lose sight of the fact that it can be used as well for any other kind of spun yarn. On the other hand, the metric 1,000 metres per kilogramme system is put forward with a great flourish as a universal system and, not being used for anything in particular, is often accepted as a standard for everything in general. The contrast between the two systems in this respect illustrates the difference between English practice and metric theory.

1,000 metres per kilogramme is equivalent to 496 yards per pound; the metric is, consequently, about 41 per cent. shorter than the English standard. The sizes can thus be indicated more closely by even units with the metric system, but this is of no advantage, as for all practical purposes it is found that with the longer English hank, gradations of two numbers or counts are near enough for all medium and fine sizes, while for the coarser yarns variations in the size can be indicated by the whole or fraction of a count.

Textile manufacturing involves frequent calculations in which the yarn count is a factor, and which must be made quickly and accurately, often when surrounded by the din and confusion of the mill. As it is claimed that the metric system facilitates such operations, we will next compare the English and metric counts in this respect.

Most of the calculations involving the yarn count are made as easily with one fixed weight system as with another, whether it be the English cotton, pure metric, worsted, run, linen, French cotton, Saxon woollen, Austrian linen, or any one of the thirty-three systems used in Europe. The following list of calculations will illustrate the large number that are not affected by the particular system of numbering employed:

The resulting count of two or more ply yarn from counts of single strands; also the count of the single strand to be placed with two or more strands of known size to make the resulting size equal to a given count. The same for all systems of yarn numbering regardless of the standards on which they are based.

The proportionate weights of the single strands in a two or more ply thread.

Take-up in length of single strands of fancy yarns. By percentage or vulgar fractions.

Average size of a lot of yarn composed of known quantities of given sizes.

Proportionate weights of different counts to make a given average count.

The proportionate lengths of known counts to make a given average.

Count of one single thread when the other count, average count and length of each are known.

Count required for given weight when one count, total weight and length of each count are known.

Effect of change in length or weight on the count of yarn.

The cost of twist yarn composed of single strands of different values.

Length of filling yarn per yard or metre from width and filling set.

The decided inferiority of the metric system of numbering yarn for making the calculations for cloth analysis was shown when comparing the sizes of metric and English units.

We now come to the calculations of the weight of the yarn from the length and count. If the length for which the weight is to be calculated is expressed in hanks a simple division with any fixed weight system of numbering, whether English or metric, is sufficient to give the weight. Another frequent calculation is that of finding the weight of the cloth. This by the metric system consists in calculating the grammes per running yard of cloth from the length (in metres) and metric count of the yarn; by the English system, in calculating the ounces per running yard of cloth from the length (in yards) and English count of the yarn.

The metric count indicates the number of 1,000 metre hanks per kilogramme or metres per gramme. If, then, we know the length of the yarn in metres, a division by the count or number of metres per gramme will give the weight in grammes. For example, the weight of 2,800 metres of metric No. 56 yarn is:

$$2{,}800 \div 56 = 50 \text{ grammes.}$$

The English count indicates the number of 840 yard hanks per pound or the number of $52\frac{1}{2}$ yard hanks per ounce. If we know the length of the yarn in yards, a division by the number of yards per ounce will give the weight in ounces. The English count, however, indicates not the number of 100 yard hanks per ounce, but the number of $52\frac{1}{2}$ yard hanks, so that it is necessary to reduce the English count to a 100 yard per ounce basis before a simple division will give the ounces per yard. This reduction involves the multiplication of the English count by $.52\frac{1}{2}$, an extra calculation not necessary with the metric system, and so far and only so far as that reduction is concerned, is the English inferior to the metric in calculating the weight of cloth. Fortunately for the users of the English system this reduction can be made mentally in nearly every case. For years I have so reduced yarn counts to the "run" or 100 yards per ounce standard and this is the best practice in American mills to-day. The "run" count, as will be easily seen, is one-half of the English count plus one-twentieth of that one-half. Then to obtain the "run" from the English count one-twentieth or 5 per cent. is added to one-half of the latter count. The following illustrations make the operation clear:

No.	60	English	= 30	+ 1½	or	31½	Runs.
"	40	"	= 20	+ 1	"	21	"
"	36	"	= 18	+ .9	"	18.9	"
"	34	"	= 17	+ .85	"	17.85	"
"	24	"	= 12	+ .6	"	12.6	"
"	18	"	= 9	+ .45	"	9.45	"
"	17	"	= 8½	+ .42½	"	~~8.95~~ 8.92½	"
"	8	"	= 4	+ .2	"	4.2	"
"	5	"	= 2½	+ .12½	"	2.62½	"

Simplifying the reduction in this way reduces the advantage possessed by the metric over the English system in this class of calculations to nearly the vanishing point.

There remain to be considered the large number of important textile calculations in which the yarn count is not a factor. Many of these are for determining cost. The factors are units of length or weight, values expressed in dollars and cents, and percentage of loss or gain. Our currency is decimal, and it is mill practice to use decimal or vulgar fractions in expressing weight and length. The metric system, therefore, offers no advantage over the English system in these calculations which comprise by far the most important required in mill work. Following are a few such problems:

The calculations of shrinkage in length and loss of weight. These are made in every process of manufacturing from the time the raw material enters the mill until it emerges in the form of the finished product. They are made by percentage, and as easily with one set of units of weight or extension as with another.

Effect of shrinkage and value of waste products on the cost of materials in process.

Average cost of mixtures of raw materials such as wool, cotton, shoddy, etc. Here the quantity of each kind of stock is extended at a given price per pound and the total cost divided by the total weight. The same operations for both systems. Multiplying 25 by 48 is the same operation whether the 25 represents pounds or kilogrammes, whether the 48 represents cents, centimes or pfennige.

Determining the proportion of materials of different values to give a required average cost. A question in alligation.

The take-up of warp in weaving. Calculated by percentage.

Width, warp set and total threads. To calculate any one from the other two. Same for both systems.

Periodical statements of manufacturing operations showing production, total and average cost.

Summing up the comparison of the English 840 yard per pound with the metric 1,000 metre per kilogramme standard in calculations, we find that the English is superior to the metric in cloth analysis; that in a great many important textile calculations neither system offers any advantage over the other; that in calculating the weight from the length and count of yarn an advantage of the metric system consists in not having to make a reduction of the counts, which by the English system can in practically all cases be made mentally.

The chief value of a system of weights and measures lies in the extent to which it is used, particularly in the number of people whose ideas of measure and weight are based upon its standards alone. The English system of weights and measures is the only one which is the single standard for any country. The English yard, inch, pound, ounce, dram and grain are the only standards used in the British Empire and the only ones used in the United States. The other country coming nearest to having a uniform system is Russia, whose linear units are either equal to or are commensurable with the English standards. The Russian standards of weight are distinct. The textile weights of China and Japan are involved in more or less confusion with the local standards of these countries and, as we have seen, the textile standards of Continental Europe are in a state of chaos. The extent to which a system is used as a single standard may be estimated either by the amount of textile machinery operated, the raw material consumed, or by the population for which it is the only standard. Reliable statistics of machinery are lacking except for cotton manufacturing, which is the most important branch of the textile industry. The statistics of population offer, therefore, the only means by which we can form an idea of the extent to which English weights and measures form a single standard.

The population of the earth is estimated at 1,400,000,000, that of the British Empire and the United States at 475,000,000. On this basis the English textile system is the single standard for 32 per cent. of the world's population, while the textile in the countries representing the other 68 per cent. has a mixed lot of standards.

We can, perhaps, get a better idea of the relative employment of the English and metric textile systems from the extent to which their respective systems of yarn numbering are used as shown by the following table:

Material.	*Methods of Numbering.*
Raw Silk.	Denier-aune throughout the world. (Neither English nor metric.)
Thrown Silk.	Denier-aune on the Continent.
	English dram-1,000 yards in United States and Great Britain.
Cotton.	French 1,000 metre-½ kilo (not metric) in France.
	English 840 yard-pound throughout the rest of the world.
Linen, Hemp, Jute.	English 300 yard-pound is the standard throughout the world. (Austrian local standard varies but 3 per cent. from English.)
Worsted.	English 560 yards is the standard for America and Great Britain, also used extensively on the Continent.
	Metric system is used with many other standards on the Continent.
Carded Woollen.	Run system in America except Philadelphia.
	Local standards based on the yard-pound in England and Scotland.
	Metric system with many other standards on the Continent.

This survey shows that in the extent to which it is used the English is far ahead of the metric system.

It is often claimed that the adoption of the metric system in textile manufacturing would make it easier to find foreign markets for the finished product. Textile goods are sold by length or weight. After the goods are finished they can be weighed or measured by any standard desired by the customer and without complicating the processes of manufacturing. This is the practice in this and doubtless in all other exporting countries. Following is some evidence on this point from metric sources:

M. le Baron Cantoni, "Paris Metric Yarn Congress," 1900:

An importing country may oblige the foreign exporters to conform to its regulations. But with an exporting nation the affair is more difficult. Italy has no colonies. We export about 60 million (sic) of cotton yarn and cloth to foreign countries and we compete directly with England, and until England changes we cannot hope to introduce a new system in the Orient or in other markets.

M. Ferdinand Roy, same occasion:

In certain of our French colonies the metric system has not been introduced. It is necessary to proceed gradually and at first to mark the number of metres beside the yards and the metric beside the English numbers.

Baron Esnault-Pelterie, same occasion:

This difficulty (in foreign trade), has been solved in France, since we export to the far East our cloths folded by the yard, although the metric is the legal system in France.

One piece of cloth may be measured and invoiced by the English yard, the next by the Spanish vara, another by the French metre, thus satisfying the requirements of foreign customers regarding the weights and measures of the goods they buy without disturbing the manufacturing standards and without causing the slightest complication in the manufacturing processes.

Suppose, however, that an agreement between manufacturing and foreign weights and measures is a help in securing foreign business. What system would help us most? The following table will show the value of cotton goods exported by the principal manufacturing countries in 1901, classified according to the two systems, English and metric:

English.		*Metric.*	
Great Britain..	$358,000,000	Germany..	$59,000,000
India.........	35,000,000	France....	36,000,000
United States..	32,000,000		$95,000,000
	$425,000,000		

More than three-quarters of the world's exports of cotton goods is supplied by Great Britain and India, and both are countries in which the English system is the only textile standard in use. Less than one-fifth is supplied by France and Germany in which the metric system is used but partially. England is also far in the lead in the export of woollen and worsted goods. The following statements by foreign authorities show how the exporters of textiles on the Continent are forced to conform to the English system:

M. Boucher-Feyerick, "Paris Metric Yarn Congress," 1900:

We Belgians export enormous quantities of linen yarn to England, Asia and Egypt, and we cannot adopt the metric system without risking the loss of this trade. Our customers in the countries named are familiar with the English system of numbering, and if we do not give it to them our competitors will, and we will lose the market. I speak not alone for myself but for all Belgian spinners. We cannot change.

Baron Cantoni, "Paris Metric Yarn Congress," 1900:

It is necessary to remember that nearly all the exports of cotton yarn are from England, and we can do nothing if that country does not adopt the system we favor. * * * The difficulty will always be in exporting to uncivilized lands where the people have been accustomed for a hundred years to English measures and numbers and where articles of cotton are often used as currency.

M. de Pacher, "Paris Metric Yarn Congress," 1900:

To begin with, I must say it is my belief that uniform numbering can be obtained in all countries only by a law made compulsory after a certain date. The spinners who should begin to number their yarn according to the resolutions of Congress before the old numbers were prohibited by law, would be under the necessity of keeping their product until forced to sell it at the best price and at an incalculable loss.

M. Louis Guerin, Lille, "Paris Metric Yarn Congress," 1900:

It is practically impossible for us (the French), to sell linen by any other than the English standard. * * * If the law of 1810 providing for the metric standard is enforced we shall be the first to complain of that which we have asked for.

The principal foreign market for textiles is found in Asia. Last year a new Chinese tariff was framed. It covered fifty-three items. On three the rate was assessed by the Chinese catty ($1\frac{1}{3}$ pounds); on five, ad valorem, on the other forty-five by the English yard, inch or pound. The metric system was not mentioned. The tariff was published in this form in German papers for the benefit of German exporters. In July, 1903, United States Consul H. B. Miller at Niuchwang, China, sent to the State Department at Washington a collection of Russian and native Chinese cotton cloths, with particulars as to length and width. Eight of the measurements were Chinese, three English and nine

Russian, the last named being either equal to or commensurable with the English units. No reference was made to the metric system.

The Japanese tariff shows a similar condition. Of the sixty-five textile items the rate on three is expressed by the dozen; on eleven by the Chinese catty ($1\frac{1}{3}$ pounds), and on fifty-one by the English yard. No mention is made of the metric system.

It is evident that if our textile standards are to be in conformity with the leading standards in foreign markets they must remain unchanged. If foreign trade is helped by an agreement between manufacturing and selling standards, the metric countries would be benefited by adopting the English system.

At this point I will call attention to the widely circulated claim that the consumers of silk and woollen yarn in India have become so accustomed to the metric system of numbering that they will have no other. The following facts show how baseless such a claim is. The only standard used anywhere for numbering silk is the denier-aune. India has a very hot climate and a very poor population; very little wool, therefore, is used as is shown by the following extract from the Monthly Summary of Commerce and Finance of the United States for December, 1902:

> The woollen industry expands but slowly in India in comparison with the expansion of cotton and jute mills. There were only four woollen mills at work at the close of 1901,—one at Cawnpore, one at Dhariwal in the Punjab, one in the city of Bombay and one at Bangalore—containing 594 looms and 22,986 spindles. The capital employed in it is also relatively small. There is, however, not much demand in India for woollen goods, except for descriptions which can hardly be profitably made in India in competition with the European mills, and any large expansion of the industry can hardly be anticipated.
>
> The importations and manufactures of silk and wool are unimportant in comparison with the importations of cotton manufacture. In most parts of India the climate and the habits of the people discourage the use of woollens to any extent, and they are worn mainly by the better class in Northern India, and then only in the colder months of the year. Nor is the use of woollen bedclothes at all a habit among them, the quilted razai of cotton or cotton sheet taking the place of the blanket very commonly. The people of India are too poor, generally speaking, for the possession of even the one garment of silk which in so many other countries is brought forth for wear on high days and holidays.

Evidently India is just the place to use the metric system for silk and wool.

We will now compare the English and metric systems of numbering yarn as we find them used throughout the world.

ANGLO-AMERICAN AND CONTINENTAL SYSTEMS OF NUMBERING SPUN-YARN.

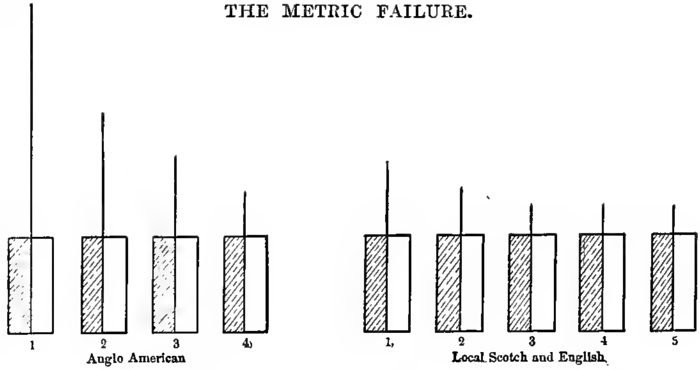
Country.	Material.	Weight: Unit.	Weight: Equivalent: English.	Weight: Equivalent: Metric.	Length: Unit.	Length: Equivalent: English.	Length: Equivalent: Metric.	Equivalents: English Cotton Count.	Equivalents: Run System Yards per Ounce.	Equivalents: Metres per Gram.
Anglo-American	Woollen	1 English lb.	1 lb.	453 grams.	1,600 English yds.	1,600 yds.	1,463 metres.	1.905	100	3.22
" "	Cotton	1 " "	1 "	453 "	840 " "	840 "	768 "	1	52.5	1.69
" "	Worsted	1 " "	1 "	453 "	560 " "	560 "	512 "	.66⅔	35	1.13
" "	Linen	1 " "	1 "	453 "	300 " "	300 "	274 "	.357	18¾	.60
England, local	Woollen	1 " "	1 "	453 "	256 " "	256 "	234 "	.305	16	.51
" "	"	1 " "	1 "	453 "	320 " "	320 "	293 "	.381	20	.64
Scotland, "	"	1 " "	1 "	453 "	200 " "	200 "	183 "	.238	12.5	.40
" "	"	1 " "	1 "	453 "	185 " "	185 "	169 "	.22	11.5	.37
" "	"	1 " "	1 "	453 "	480 " "	480 "	439 "	.571	30	.96
France	"	1 kilogram.	2.2 lbs.	1,000 "	1,000 metres	1,094 "	1,000 "	.59	31	1
"	Cotton	½ "	1.1 "	500 "	1,000 "	1,094 "	1,000 "	1.181	62	2
" Belgium and Switzerland	Worsted	½ "	1.1 "	500 "	600 aunes	788 "	720 "	.851	44.7	1.44
" —Roubaix	"	½ "	1.1 "	500 "	714 metres	781 "	714 "	.845	44.3	1.43
" —Fourmies	"	1 "	2.2 "	1,000 "	710 "	777 "	710 "	.419	22	.71
" —Elbœuf	Woollen	1 Paris lb.	1.08 "	489 "	1,254 aunes	1,634 "	1,494 "	1.80	94.5	3.05
" —Reims	Worsted	1 kilogram.	2.2 "	1,000 "	700 metres	766 "	700 "	.413	21.7	.70
" —Sedan	Woollen	1 "	2.2 "	1,000 "	1,500 "	1,641 "	1,500 "	.886	46.5	1.5
" —Elbœuf	"	½ "	1.1 "	500 "	1,254 aunes	1,634 "	1,494 "	1.764	92.6	2.99
" "	"	½ "	1.1 "	500 "	3,600 metres	3,938 "	3,600 "	4.253	223.3	7.2
Austria—Böhmen	"	1 English lb.	1. "	453 "	800 Leipzig ells.	496 "	453 "	.69	31	1
"	Cotton	1 Vienna "	1.23 "	560 "	1,487 Vienna "	1,268 "	1,169 "	1.227	64.4	2.07
"	Linen	1 English "	1. "	453 "	360 " "	306 "	280 "	.364	19.1	.62
"	Woollen	1 Vienna "	1.23 "	660 "	1,760 " "	1,500 "	1,371 "	1.45	76.2	2.45
Belgium and Lower Rhine	Woollen and Worsted	½ kilogram.	1.1 "	500 "	2,240 Berlin "	1,634 "	1,494 "	1.764	92.6	2.99
Germany—Prussia	Worsted	1 Berlin lb.	1.03 "	468 "	840 English yds.	840 "	768 "	.97	50.9	1.64
" "	Woollen	1 " "	1.03 "	468 "	2,200 Berlin ells	1,605 "	1,467 "	1.855	97.3	3.13
" "	"	½ kilogram.	1.1 "	500 "	2,200 " "	1,605 "	1,467 "	1.733	91	2.93
" "	"	1 Berlin lb.	1.03 "	468 "	2,150 " "	1,569 "	1,434 "	1.813	95.2	3.06
" "	"	½ kilogram.	1.1 "	500 "	2,150 " "	1,569 "	1,434 "	1.694	88.9	2.87
" "	"	1 Berlin lb.	1.03 "	468 "	2,000 Brabant ells.	1,520 "	1,390 "	1.756	92.2	2.96
" "	"	½ kilogram.	1.1 "	500 "	2,000 " "	1,520 "	1,390 "	1.641	86.2	2.78
" —Saxony	"	½ "	1.1 "	500 "	800 Leipzig "	496 "	453 "	.535	28.1	.91
" "	"	½ "	1.1 "	500 "	1,200 " "	744 "	680 "	.802	42.2	1.36
" "	"	½ "	1.1 "	500 "	2,200 " "	1,363 "	1,246 "	1.472	77.3	2.49
" "	"	½ "	1.1 "	500 "	2,400 " "	1,487 "	1,359 "	1.606	84.3	2.72
" —Alsace	"	½ "	1.1 "	500 "	700 metres	766 "	700 "	.827	43.4	1.40
" "	"	1 Berlin lb.	1.03 "	468 "	750 "	821 "	750 "	.948	49.8	1.60
"	"	1 kilogram.	2.2 "	1,000 "	1,577 "	1,725 "	1,577 "	.931	48.9	1.57
" —Saxony	"	½ "	1.1 "	500 "	440 "	481 "	440 "	.519	27.3	.88
"	"	½ "	1.1 "	500 "	320 "	350 "	320 "	.345	18.1	.64
Netherlands	Cotton	½ "	1.1 "	500 "	840 yards	840	768 "	.907	47	1.53
Spain	"	1.1 lliures.	.97 "	440 "	500 canes	851	778 "	1.044	54.8	1.77

The first nine lines of the table on the opposite page give the bases and equivalents for the four Anglo-American and five local English and Scotch systems of numbering spun yarn. These local standards are used for carded woollen yarn only. All are based on the English yard-pound. The only difference between them is in the length of the hanks. Even this variation of the Anglo-American hanks is less in practice than the table indicates, *because each hank is used almost exclusively for one kind of textile material.* Each of these standards is used in one branch of textile manufacturing whose processes are distinct and separate up to weaving. The workmen in each do not require, and usually do not have, any definite knowledge of the other two. This limits the contact of the four systems to the weaving and designing departments and to the general management of weaving mills. Fortunately, however, the 840, 560, 300 and 1,600 yard standards have certain relations to each other which remove the apparent difficulty of using them together.

The cotton is just one-half longer than the worsted skein, and the number by the worsted system is therefore larger by just one-half than by the cotton system; that is, No. 20 cotton is equal to No. 30 worsted. The cotton number can likewise be obtained from the worsted number by taking one-third from the latter; that is, No. 30 worsted equals No. 20 cotton. The English cotton count can be reduced to the linen basis by multiplying by 2.8. The reduction of the linen to the cotton count is effected by dividing by 2.8.

When we come to the 1,600 yard skein, the standard for the carded woollen yarn, we find that No. 1 woollen yarn, measuring 1,600 yards per pound, measures 100 yards per ounce; that No. 2 yarn measures 200 yards per ounce; No. $3\frac{1}{2}$ yarn 350 yards per ounce, the count indicating in each case the number of yards per ounce. This facilitates greatly the calculation of the weight per yard, which is expressed in ounces. If a yard of cloth contains, say, 4,000 yards of 3-run warp yarn, a simple division will show that the warp weighs $13\frac{1}{3}$ ounces per yard.

The advantage of the "run" system has led to its adoption for calculating the weight per yard, not only of carded woollen, but of cotton and worsted cloths, the "run" equivalents for the cotton and worsted counts being easily found by a mental calculation, as already explained. It is not claimed that this system involving the use of four methods of yarn numbering is the best



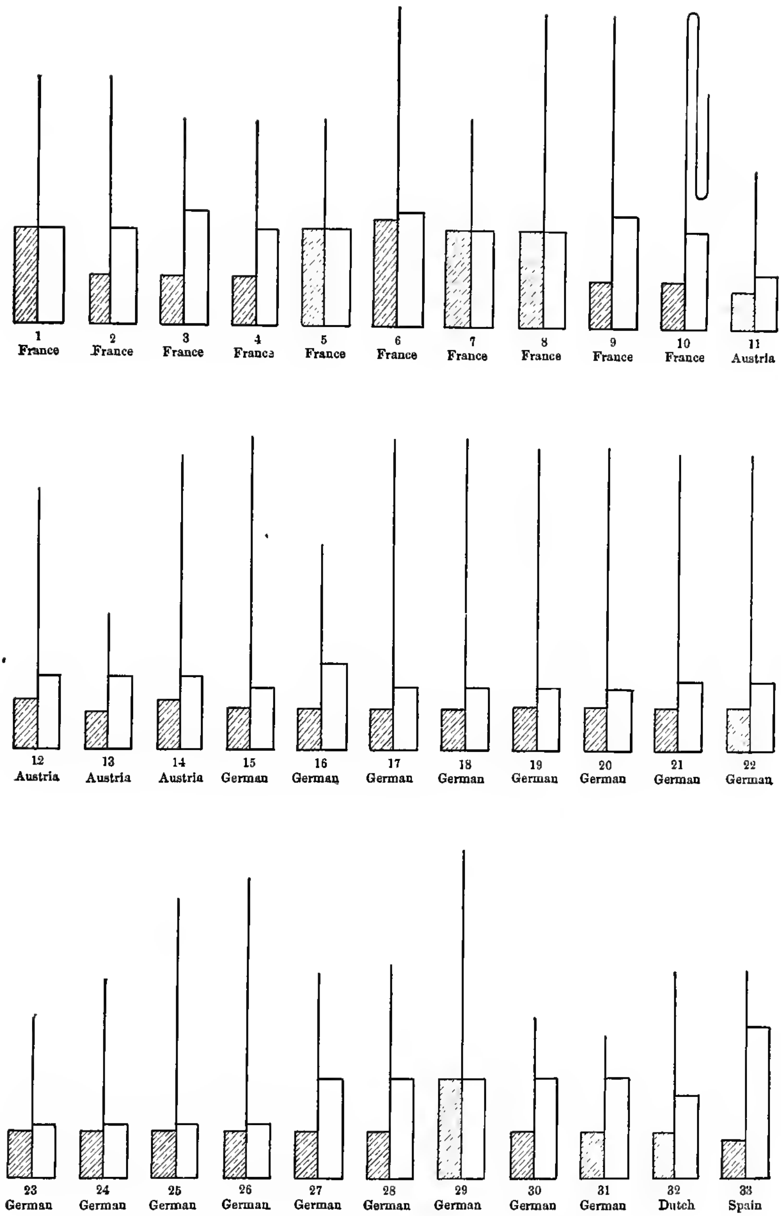
ANGLO-AMERICAN SYSTEMS OF NUMBERING SPUN YARN.

that can be devised. If we could start anew and establish a new standard, it is certain that mill experience with the present methods would dictate but one base for all textile materials except silk. But we are not starting at the beginning; we inherit from the past these four systems of numbering spun yarn. They are firmly established. They are all based on the yard-pound, and being readily commensurable offer decided facilities for their joint use.

Let us turn now to the metric yarn numbering of Continental Europe. The thirty-three indigenous systems of numbering spun yarn on the Continent at the present time are found on the same table. They are the remains of old European systems partially converted into metric equivalents—a heterogeneous lot of basic units of weight and length, including the kilogramme, half-kilogramme, Paris, Berlin, English and Vienna pounds, metre, aune, Leipzig, Vienna, Berlin and Brabant ells, Spanish cane and English yard. The last column in which are the metric equivalents of these thirty-three systems, shows what a chaos of yarn counts confronts Continental manufacturers. They must contend with this medley of ratios as well as the mixture of basic standards of weight and length. Added to these they have the English cotton, linen and worsted standards in common use to increase the disorder. It is indeed a chaos that beggars description.

The two charts * before us present in graphic form the world's systems of numbering spun yarn. The chart on page 218 shows

* The shaded rectangle at the left of each line represents the unit of weight; the blank rectangle at the right, the unit of length on which the system is based. These rectangles of length and weight are drawn to a scale. The perpendicular lines beginning one-half inch above the base line, represent the lengths of the hank.



CONTINENTAL SYSTEMS OF NUMBERING SPUN YARN.

the English, that on the opposite page the metric or Continental practice.

In its basic standards the English standards present absolute uniformity; the metric system, inconceivable diversity.

In the length of the hanks the English system shows its only diversity, and here the lengths are in round numbers. The metric hanks present an array of lengths expressed in numbers that stagger calculations.

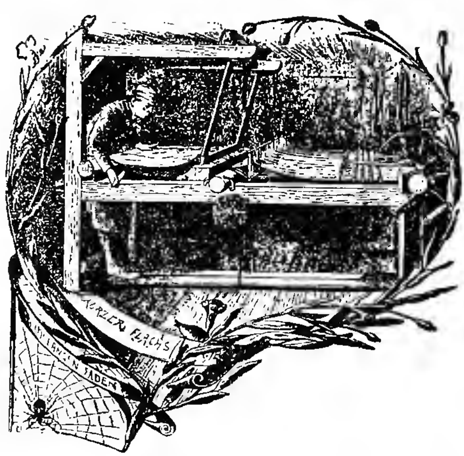
In the resulting proportions between weight and length the English system offers to Americans four ratios, readily commensurable. The metric are all incommensurable.

Each of the English standards is confined to one textile material and for all Americans outside of the Philadelphia district each textile material has its own single standard. The metric system employs four standards for cotton, one for linen, five for worsted and twenty-three for woollen.

The English systems are the only standards used in English-speaking countries. The metric systems are the exclusive standards for no country or manufacturing district. Wherever used they are in conflict with each other and with the English systems, which for cotton and linen are the standards of the world.

The choice lies between these two systems, English and metric. One has been adapted to mill work by a process of natural selection. The other is the result of the artificial scheme of French geometers and is unsuited for textile processes. It is inconceivable that America should abandon the first and accept the last.

English scale.			Metric scale.		
Base units	1 pound	= $\frac{1}{2}$-in. height.	Base units	1 kilogramme	= $\frac{1}{2}$-in. height.
Base units	1 yard	= $\frac{1}{2}$-in. height.	Base units	1 metre	= $\frac{1}{2}$-in. height.
Hank	80 yards	= $\frac{1}{16}$-in. height.	Hank	80 metres	= $\frac{1}{16}$-in. height.



CONCLUSION.

So evident that it will glimmer through a blind man's eye.—*Henry VI.*

Somewhat more than a century ago when the metric system was established in France, the French textile industry was carried on almost wholly by hand or foot power, and by processes as primitive as at the dawn of history. Wool, flax and cotton were slowly and laboriously carded by hand and then spun into yarn by the women of the household on hand spinning-wheels. The yarn was then knit or woven by hand.

The metric system appeared before the invention of the steam engine and the power spinning-machine, and before the inventions of Arkwright and Cartwright had begun that revolution in textile manufacturing which has resulted in the development of the present factory system for the production of complex and varied fabrics.

The weights and measures of this primitive industry were as simple as the machinery and processes. The size of the yarn was regulated by the judgment of the spinner and gauged by the sweep of her arm and the pressure of her finger. The texture of the cloth was regulated by the threads per inch, the one well-defined standard of measure employed in the textile industry one hundred years ago. No better time could have been selected for the introduction and adoption of a new system of textile weights and measures.

These favoring circumstances arising from the primitive state of textile processes were further supplemented in great degree by the political and social conditions under which the metric system was established. That system was conceived in the royal household of Louis XVI, and its introduction throughout the country became one of the settled purposes of the aristocracy and the established church. By a curious combination of circumstances the new system of weights and measures, proposed by the royal regime and advocated by the aristocracy and the church, was enthusiastically accepted by the revolutionary party. Robespierre and his followers welcomed it as something new at a time when all the institutions of the past were objects of their most intense hatred. The old weights and measures, the *boisseau*, *aune*, *pied* and *pouce* were inseparably connected with the oppression of the people by the nobles, who were accustomed to alter the dimensions of these units instead of raising the rate of taxation when they found it necessary to levy fresh contributions from their wretched subjects.

To the common people the old units of weights and measures were the objects of as much hatred as were the king and nobles. The nobles, the church, and the people, at war on nearly every other question, were united in favor of the adoption of a new system of weights and measures. The scientists commissioned to design this system included some of the greatest mathematicians the world has ever known. The scientific rank of these men was to guarantee the preëminence of any system of weights and measures they might devise, and by the weight of authority to lead people to accept it without protest, to make ridiculous any one who might dare object.

These men faithfully executed their commission. They designed a system like no other. Nothing less than the earth would answer as a basis for the system designed for the use of the whole world. The distance along the meridian of Paris from Dunkirk to Barcelona was measured and the distance from the equator to the North Pole along this meridian was calculated. One ten-millionth part of the distance thus estimated was successively multiplied or divided by 10 to obtain units for the use of the people.

The most drastic and sweeping French laws were enacted to compel the French people to abandon the old and accept the new system. During the one hundred years since that time every French regime has continued this policy of force.

No conditions can be imagined more favorable to the attempt to change a people's weights and measures. Notwithstanding these powerful influences, the textile weights and measures of France are at the present time in a state of indescribable confusion. As one Frenchman recently expressed it, "we are as much in the anarchy of weights and measures for the textile industry as at the time of the Revolution."

The reasons for the failure of this colossal effort of a century to change the textile weights and measures of France is not difficult to find. The ideas of length, area, volume and weight are as firmly grounded as any that find a lodging in the mind of man. They are bound to the records of the past, to the work of the present, and to the plans for the future. They are ineffaceably imprinted upon the mind of every child to regulate his ideas of extension and weight as long as life may last.

These natural conditions are alone sufficient to account for the failure of the metric system in France. Other influences, however, have served to make the failure more complete in the textile industry. The metric system needed something more than the transcendent mathematical faculties of its designers to make it suitable for textile measurements.

The eminent scientists who designed that system were able to solve the most difficult problems in higher mathematics, but they failed to comprehend what system of weights and measures was best suited for the carder, spinner, weaver and finisher of wool, cotton, linen and silk. The glamor of their fame failed to make the centimetre suitable for counting picks. Their system had to stand or fall on its merits, and falling has proved that the highest of mathematical abilities is not inconsistent with a dense ignorance of the practical affairs of every-day life. The most eminent of the mathematicians who designed the metric system exhibited an utter disregard of principle in both private and public life and the most complete incompetency when placed in an administrative office. The son of a farm laborer he owed his education to wealthy neighbors, and as soon as he became distinguished ignored both his relatives and benefactors. Although his discoveries in mathematics were sufficient to make his name immortal, he appropriated the work of others as his own. He changed his republican principles with the rapidity of the kaleidoscope to keep them in harmony with the successive republican regimes, and cut loose from them completely to become a follower of the First Consul to whom he proposed that the name "metric system" should be changed to "mesures Napoléones." In his greatest treatise on mathematics he inserted a note that "of all the truths therein contained the most precious to the author was the declaration he thus made of his devotion to the Peacemaker of Europe."

He omitted this note from later editions, and in 1814 when Napoleon's fall was inevitable tendered his services to the Bourbons and was rewarded with the title of marquis.

He begged and obtained the post of minister of the interior under Napoleon and was then charged with the practical work of an administrative office. Six weeks were sufficient to prove how little he knew about practical affairs, and at the end of that time he was transferred to the Senate. The visionary character of this designer of the metric system is thus stated by Napoleon on that occasion:

> Geometer of the first rank, he lost no time in proving himself to be an administrator far below mediocre. From his very first act we were convinced that we had made a mistake; he did not grasp any question from the true point of view; he searched everywhere for subtilities; he had a mind only for the problematical and carried the idea of the "infiniment petit" even into administrative affairs.

Such was the man who was the chief among the designers of the metric system and who advanced the following fantastic reason for its adoption:

> There is a certain pleasure for the head of a family to say: "The field from which my children derive their subsistence is such a part of the Globe. In that proportion I am co-proprietor of the World."

This man could demonstrate that the "lunar acceleration was independent of the secular changes in the eccentricity of the earth's orbit," but did not know that a weaver requires a unit of length approximating the inch. He could formulate the theory of probabilities with mathematical precision, but was ignorant of the certainty that exclusively decimal divisions of weights and measures are unsuited for manufacturing cloth. He was the first to introduce potential and spherical harmonics into analysis, but failed to recognize the advantage of the English cotton system for numbering yarn. He could prove the stability of the solar system, but failed to recognize the stability of a people's established weights and measures. He was familiar with theories of infinity, but ignorant of the wants, necessities and limitations of textile manufacturing. The co-workers of this man in constructing the metric system differed from him only in degree. They were a party of mathematical prodigies, ignorant of the essentials of textile weights and measures.

The artificial system they evolved has failed to meet the requirements of the textile trade. Nearly every one of its standards of length, area and weight is either too large or too small, and it has no units corresponding to the inch, foot, ounce and pound, approximations of which are found in every system of natural origin and for which the human mind appears to have some innate need. It is not to be wondered at, therefore, that the system thus conceived has failed, even in France where it was so greatly favored. A comparison of the conditions in France one hundred years ago with those in the United States at the present shows that the influences that so strongly favored the metric system there are lacking here; that the inherent natural difficulty of changing a people's weights and measures is as great now as then; and that the task has been rendered vastly more difficult by new conditions.

The textile industry has shifted from the household to the factory. Hand and foot power have been displaced by the water wheel, the steam engine and the electric motor. The spindle of the mule and the ring frame has taken the place of the old-fashioned spinning-wheel. The hand loom has disappeared. The high-speed power loom is in its place, and the cloth woven by one girl to-day is equal to that of two hundred weavers a century ago. The simple harness motion of the eighteenth century has been displaced by the dobby and the jacquard. A like development has been made in all the complicated processes of textile manufacturing. Instead of the plain, crude, hand-made fabrics worn by the people of the eighteenth century we now have intricate textures of wool, worsted, cotton and silk, manufactured by power in innumerable combinations of weave, color and design. In the rude textile processes a hundred years ago there was but little need for weighing and measuring. To-day there is not a single process of textile manufacturing in which accurate weights and measures and accurately adjusted ratios between weight and linear measure are not essential to the success of the mill.

Then the diversity of weights and measures throughout the country was an imperative reason for reform. Now the yard-pound is the single standard for the United States and all English-speaking countries, and is in general use wherever textile fibres are spun into yarn. The trend throughout the world is toward the supremacy of the English language and the English yard-pound.

The United States has an area nineteen times that of France in 1790, and a population three times as large. The increase of our population in a decade is equal to the total increase of the population of France for the past century.

The political conditions which so strongly favored the origin and establishment of the metric system in France have no counterpart here. We have no king to order a change of our standards of textile weights and measures, no established church or aristocracy to execute the royal decree. In the place of a people accustomed to being controlled by an arbitrary government, we have a people who govern themselves, and who are quick to resent the interference of the police power in their private affairs.

In the place of a people in revolt against all that reminds them of the past and looking upon their old weights and measures as the badges of a servitude from which they had just escaped, we find here a vast population satisfied with republican institutions which are the result of centuries of growth in self-government and to which their laws, language, and weights and measures are inseparably bound.

When the metric system was introduced in France the French people were in arms struggling fiercely to change all established institutions, and make the metric system their only standard of weights and measures. To-day no demand for such a change comes from the American people. Our English standards have become a part of our lives and are interwoven with all our occupations. Any attempt to change these standards would be resisted by an inertia far more effective than the power exerted by the French people over one hundred years ago in favor of the metric system.

Notwithstanding a century of failure to change the textile standards in France, and with the radically different conditions in this country under which all the advantages France possessed are lacking and all the difficulties enormously increased, it is now proposed to establish the French system in the United States.

The men who make that proposition apparently know as little of the needs of the textile industry as did the founders of the metric system in 1790. It would be a plunge into chaos to emerge no one knows when, how or where. The generation introducing the metric system into the United States would not see the beginning of that chaos. In all probability no other generation would ever see the end.

ACTION OF VARIOUS ASSOCIATIONS ON THE METRIC SYSTEM BILL WHICH WAS REPORTED FAVORABLY TO THE FIFTY-SEVENTH CONGRESS, ARRANGED IN THE CHRONOLOGICAL ORDER IN WHICH THE ACTIONS WERE TAKEN.

RESOLUTIONS OF THE NATIONAL ASSOCIATION OF MACHINE TOOL BUILDERS.

Whereas, The members of the National Machine Tool Builders' Association, in convention assembled, having carefully considered the provisions of house bill H. R. 2054, do hereby emphatically protest against the enactment of said bill, because:

First: The experience of Germany, in which the old measures are still in large use, has shown that the change cannot be completed even after a generation of confusion.

Second: The sale of many million dollars' worth of Machine Tools has been made abroad, by members of this Association, especially to France and Germany, without requirement or request by the purchasers for changes in general construction, to conform to metric measurements, the only changes being in adjusting and measuring screws, the great majority of machines needing no changes whatever.

Third: The adoption of the metric system would entail an enormous first cost of new equipment to conform to the new standards and a constant increased cost in the maintenance of a double standard for repairs and renewals, and a consequent increased cost of the product to the consumer.

ACTION OF THE ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES.

The action of this society was in the form of a detailed reply to the circular of questions sent out by the committee of the Franklin Institute. The direct reference to the congressional bill is as follows:

We are decidedly opposed to this bill and we believe, if the metric system had possessed any merit, it would have come into use long ago, not by force of law but by that of expedience. . . Even granting all the merits that have been claimed for it, a fair statement from a commercial and engineering standpoint is that it offers no marketable improvement.

RESULT OF A BALLOT BY MAIL TAKEN BY THE NATIONAL ASSOCIATION OF MANUFACTURERS.

Question: Should Congress enact any law to enforce the use of the metric system in any of the departments of the government?

Answers: Yes, 51; no, 156; non-committal, 6.

RESULT OF A BALLOT BY MAIL TAKEN BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

In favor of the adoption of the Metric System of Weights and Measures as the only legal standard in the United States	103
Against adoption of the Metric System of Weights and Measures as the only legal standard in the United States	363
In favor of adoption of H. R. Bill No. 2054	95
Against adoption of H. R. Bill No. 2054	342
In favor of legislation which would promote adoption of the Metric System	153
Against legislation which would promote adoption of the Metric System	311
The substitution of the Metric for the English system would be detrimental to my business	243
The substitution of the Metric for the English system would not be detrimental to my business	**145**
The substitution of the Metric for the English system would be of advantage to my business	89

RESOLUTIONS BY THE ASSOCIATION OF RAILWAY MASTER MECHANICS.

Whereas, A bill for the adoption of the metric system in the departments of the Federal Government has been reported favorably to the House of Representatives;

Whereas, We consider that the only effect of such a law will be the creation of a government metric system and the continuation of the existing system in ordinary commerce and industry;

Whereas, It is evident that the confusion resulting from such a condition of things would be intolerable;

Whereas, We believe a change in the system of weights and measures used by the people at large to be impossible; therefore be it

Resolved, By the American Railway Master Mechanics' Association, in convention assembled, that we condemn all legislation intended to promote the adoption of the metric system in this country;

Resolved, That we especially condemn the bill which was reported to the last House of Representatives as one which can do nothing but introduce confusion where we now have uniformity.

RESOLUTIONS OF THE MASTER CAR BUILDERS' ASSOCIATION.

Whereas, A bill for the adoption of the metric system in the departments of the Federal Government has been reported favorably to the House of Representatives;

Whereas, We consider that the only effect of such a law will be the creation of a government metric system and the continuation of the existing system in ordinary commerce and industry;

Whereas, It is evident that the confusion resulting from such a condition of things would be intolerable;

Whereas, We believe a change in the system of weights and measures used by the people at large to be impossible; therefore be it

Resolved, By the Master Car Builders' Association, in convention assembled, that we condemn all legislation intended to promote the adoption of the metric system in this country;

Resolved, That we especially condemn the bill which was reported to the last House of Representatives as one which can do nothing but introduce confusion where we now have uniformity.

RESOLUTIONS OF THE FURNITURE ASSOCIATION OF AMERICA.

Whereas, A bill for the adoption of the metric system in the departments of the Federal Government has been reported to Congress with recommendation to passage;

Whereas, Such a bill can have but one of two results—the creation of a special system of government weights and measures on the one hand, or a change in the system used in the commerce and industries of the country on the other;

Whereas, A special government system of weights and measures would be as absurd as a special government system of currency, and,

Whereas, A change in the weights and measures used by the people at large, can only be accomplished at great cost, after generations of confusion and with no adequate compensating advantages, therefore be it

Resolved, By the Furniture Association of America in convention assembled, that we condemn this bill as wholly mischievous in its tendencies.

Resolved, That we condemn all legislation intended to bring about a radical change in our system of weights and measures.

RESULT OF A BALLOT BY MAIL TAKEN BY THE NATIONAL METAL TRADES' ASSOCIATION.

In favor of the adoption of the metric system of weights and measures as the legal standard of the United States	22
Against the adoption of the metric system of weights and measures as the legal standard in the United States	128
In favor of the adoption of the metric system in the departments of the Federal Government	22
Against the adoption of the metric system in the departments of the Federal Government	128
In favor of legislation which would promote the adoption of the metric system	22
Against any legislation which would promote the adoption of the metric system	128

RESOLUTIONS BY THE PROVIDENCE ASSOCIATION OF MECHANICAL ENGINEERS.

Whereas, Renewed attempts are being made to bring about the adoption of the metric system of weights and measures through its enforced use in the departments of the Federal Government;

Whereas, We regard a change in the system of weights and measures used by the people at large to be practically impossible, thus making a change by the government alone, uncalled for, therefore be it

Resolved, By the Providence Association of Mechanical Engineers, that we condemn this law as one that will introduce further diversity and confusion, especially affecting linear measures;

Resolved, That we regard the proposed legislative action affecting our established system of weights and measures as unwise.

RESOLUTIONS BY THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

Whereas, A bill for the adoption of the metric system in the departments of the Federal Government has been favorably reported to the House of Representatives:

Whereas, We consider that the only effect of such a law will be the creation of a government metric system and the continuation of the existing system in ordinary trade and industry;

Whereas, The confusion resulting from such a condition of things would be intolerable;

Whereas, We believe the adoption of the metric system of weights and measures by the people at large to be impracticable, therefore be it

Resolved, By the Society of Naval Architects and Marine Engineers, assembled in annual meeting, that we condemn all legislation intended to promote the adoption of the metric system in this country;

Resolved, That we especially condemn the bill which was reported to the last House of Representatives as one which can do nothing but introduce confusion where we now have uniformity.

RESULT OF A BALLOT BY MAIL TAKEN BY THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

In favor of the adoption of the Metric System of Weights and Measures as the legal standard in the United States	34
Against the adoption of the Metric System of Weights and Measures as the legal standard in the United States	45
In favor of the adoption of the Metric System in the departments of the Federal Government	37
Against the adoption of the Metric System in the departments of the Federal Government	42
In favor of legislation which would promote the adoption of the Metric System	41
Against any legislation which would promote the adoption of the Metric System	39