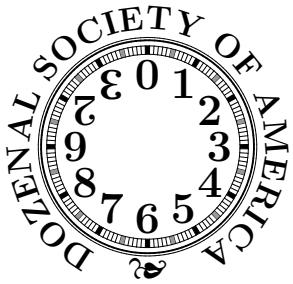

The Dozenal Society of America

Against the Metric System

Herbert Spencer

Introduction

During the Parliamentary Session of 1896 an association which has for some time past sought to establish the Metric System in England, had obtained from the Parliamentary Secretary of the Board of Trade, a promise that a Bill conforming to their desire should be presently introduced. Holding strongly the opinion that adoption of the Metric System is undesirable, I published in *The Times*, as special articles "From a Correspondent," four letters setting forth the reasons for this opinion; and immediately afterwards issued these letters in the form of a pamphlet, which was distributed to all members of the House of Commons and a few members of the House of Lords here, and also to members of the United States Congress, before which a Bill to establish the Metric System in America was pending. The contents of this pamphlet, including certain explanatory lines introducing the letters, are now reproduced.

On the 20th inst., in answer to a question, Mr. Balfour implied that the Government did not contemplate compulsory enactment of the metric system. At that date this pamphlet was in the press, and I was at first inclined to stay further progress; thinking that issue of it would be superffiuous. Second thoughts, however, led to persistence.

On the 24th March, at the Annual Meeting of the Associated Chambers of Commerce, a motion urging adoption of the metric system was carried; and the Earl of Dudley, Parliamentary Secretary of the Board of Trade, responding to its embodied wish, announced that "a Bill was now in course of preparation which would be brought in at no distant date, and which would give effect to the wishes expressed in the motion." The provisions of such a Bill should it be brought forward, will be subject to criticisms irrespective of their characters as compulsory or permissive. Hence it seems still desirable to bring together, in a convenient form for reference, the facts and arguments which go to show that the metric system is ill-adapted for industrial and trading purposes.

Of the four following letters, the first, which discusses the claims of the English yard versus the French mètre, may be passed over by those who have little time for reading, since it does not essentially concern the main issue.

This article is taken from Herbert Spencer, Various Fragments (D. Appleton and Company: New York, 1122). Text courtesy of the Internet Archive, http://www.archive.org.

I

Advocates of the metric system allege that all opposition to it results from "ignorant prejudice." This is far from being the fact. There are strong grounds for rational opposition, special and general; some already assigned and others which remain to be assigned. I may fitly put first a carefully-reasoned expression of dissent from a late man of science of high authority.

In 1863 Sir John Herschel published an essay in which, after referring to an attempt made during the preceding Session to carry through Parliament a Bill establishing the French metric system in this country, and anticipating that the Bill (said to have been confirmed in principle) would be again brought forward, he proceeded to contrast that system with a better one to be reached by making a minute modification in our own unit of measure. The following extract will sufficiently indicate the line of his argument:

"Let us now see how far the French mètre as it stands fulfils the requirements of scientific and ideal perfection. It professes to be the 10,000,000th part of the quadrant of the meridian passing through France from Dunkirk to Formentera, and is, therefore, scientifically speaking, a local and national and not a universal measure . . . The mètre, as represented by the material standard adopted as its representative, is too short by a sensible and measurable quantity, though one which certainly might be easily corrected."

[In the appendix it is shown that according to the latest measurements the error is 1-163rd part of an inch on the mètre.]

Sir John goes on to say that "were the question an open one what standard a new nation, unprovided with one and unfettered by usages of any sort, should select, there could be no hesitation as to its adoption (with that very slight correction above pointed out)"; and he then continues:

"The question now arising is quite another thing, viz.: Whether we are to throw overboard an existing, established, and, so to speak, ingrained system—adopt the mètre as it stands for our standard—adopt, moreover, its decimal subdivisions, and carry out the change into all its train of consequences, to the rejection of our entire system of weights, measures, and coins. If we adopt the mètre we cannot stop short of this. It would be a standing reproach and anomaly—a change for changing's sake. The change, if we make it, must be complete and thorough. And this, in the face of the fact that England is beyond all question the nation whose commercial relations, both internal and external, are the greatest in the world, and that the British system of measures is received and used, not only throughout the whole British Empire (for the Indian 'Hath' or revenue standard is defined by law to be 18 British Imperial inches), but throughout the whole North American continent, and (so far as the measure of length is concerned) also throughout the Russian Empire. . . . Taking commerce, population, and area of soil then into account, there would seem to be far better reason for our Continental neighbours to conform to our linear unit could it advance the same or a better *a priori* claim, than for the move to come from our side. (I say nothing at present of decimalization.)"

Sir John Herschel then argues that the 10,000,000th part of the quadrant of a meridian, which is the specified length of the mètre, is, on the face of it, not a good unit of measure, inasmuch as it refers to a natural dimension not of the simplest kind, and he continues thus:

"Taking the polar axis of the earth as the best unit of dimension which the terrestrial spheroid affords (a better *a priori* unit than that of the metrical system), we have seen that it consists of 41,708,088 imperial feet, which, reduced to inches, is 500,497,056 imperial inches. Now this differs only by 2,944 inches, or by 82 yards, from 500,500,000 such inches, and this would be the whole error on a length of 8,000 miles, which would arise from the adoption of this precise round number of inches for its length, or from making the inch, so defined, our fundamental unit of length.["]

After pointing out that the calculation required for correlating a dimension so stated with the Earth's axis, is shorter than that required for correlating a kindred dimension with the quadrant of a meridian, Sir John Herschel argues that:

"If we are to legislate at all on the subject, then the enactment ought to be to increase our present standard yard (and, of course, all its multiples and submultiples) by one precise thousandth part of their present lengths, and we should then be in possession of a system of linear measure the purest and the most ideally perfect imaginable. The change, so far as relates to any practical transaction, commercial, engineering, or architectural, would be absolutely unfelt, as there is no contract for work even on the largest scale, and no question of ordinary mercantile profit or loss, in which one *per mille* in measure or in coin would create the smallest difficulty."

"Hitherto I have said nothing about our weights and measures of capacity. Now, as they stand at present, nothing can be more clumsy and awkward than the numerical connection between these and our unit of length."

And then, after pointing out the way in which the slight modification of the unit of linear measure described by him, could be readily brought into such relation with the measures of capacity and weight as to regularize them, he goes on:

"And thus the change which would place our system of linear measure on a perfectly faultless basis would, at the same time, rescue our weights and measures of capacity from their present utter confusion."

In presence of the opinion thus expressed, and thus supported by evidence, we ought, I think, to hear nothing more about "ignorant prejudice" as the only ground for opposition to the metric system, now being urged upon us. But, before proceeding to give adverse reasons of my own, let me quote a further objection—not, it may be, of the gravest kind, but one which must be taken into account. Writing from Washington, Professor H. A. Hazen, of the United States Weather Bureau, published in *Nature* of January 2, this year, a letter of which the following extracts convey the essential points:

"The metric system usually carries with it the Centigrade scale on the thermometer, and here the whole English-speaking world should give no uncertain sound. In meteorology it would be difficult to find a worse scale than the Centigrade. The plea that we must have just 100° between the freezing and boiling points does not hold; any convenient number of degrees would do. The Centigrade degree (1°.8f.) is just twice too large for ordinary studies. The worst difficulty, however, is in the use of the Centigrade scale below freezing. Any one who has had to study figures half of which have *minus* signs before them knows the amount of labour involved. To average a column of 30 figures half of which are *minus* takes nearly double the time that figures all on one side would take, and the liability to error is more than twice as great. I have found scores of errors in foreign publications where the Centigrade scale was employed, all due to this most inconvenient *minus* sign. If any one ever gets a

'bee in his bonnet' on this subject and desires to make the change on general principles it is very much to be hoped that he will write down a column of 30 figures half below 32° F., then convert them to the Centigrade scale, and try to average them. I am sure no English meteorologist who has ever used the Centigrade scale will ever desire to touch it."

But, now having noted these defects, which may perhaps be considered defects of detail, since they do not touch the fundamental principle of the metric system, I propose, with your permission, to show that its fundamental principle is essentially imperfect and that its faults are great and incurable.

II

In reply to my enquiries, a French friend, member of the Conseil d'État, after giving instances of nonconformity to the metric system, ended by saying: "En adoptant le systeme mètrique dècimal, on n'a pas fait disparaître tout à fait les dénominations anciennes, mais on en a fortement réduit l'emploi."*

It is now more than a century since, in the midst of the French revolution, the metric system was established. Adoption of it has been in the main compulsory. As French citizens have been obliged to use francs and centimes, so must they have been obliged to use the State-authorized weights and measures. But the implication of the above statement is that the old customs have survived where survival was possible: the people can still talk in sous and ask for fourths, and they do so. Doubtless 'ignorant prejudice' will be assigned as the cause for this. But one might have thought that, after three generations, daily use of the new system would have entailed entire disappearance of the old, had it been in all respects better.

Allied evidence exists. While in the land of its origin the triumph of the metric system is still incomplete, in one of the lands of its partial adoption, the United States, the system has been departed from. It will be admitted that men engaged in active business are, by their experience, rendered the best judges of convenience in monetary transactions; and it will be admitted that a Stock Exchange is, above all places, the focus of business where facilitation is most important. Well, what has happened on the New York Stock Exchange? Are the quotations of prices in dollars, tenths, and cents? Not at all. They are in dollars, halves, quarters, eighths, and the list of prices in American securities in England shows that on the English Stock Exchange quotations are not only in quarters and eighths, but in sixteenths and even thirty-seconds. That is to say, the decimal divisions of the dollar are in both countries absolutely ignored, and the division into parts produced by halving, re-halving, and again halving is adopted. Worse has happened. A friend writes: "When I was in California some 20 years ago the ordinary usage was to give prices in 'bits,' the eighth of a dollar—a 'long bit' was 15 cents, a 'short bit' was 10 cents. If one had a long bit and paid it one got no change—if one gave a short one no supplement was asked." Thus, lack of appropriate divisibility led to inexact payments—a retrogression.

Perhaps an imaginary dialogue will most convenient1y bring out the various reasons for

* "In adopting the decimal metric system, we did not completely destroy the old measurements, but we heavily reduced their use." —Ed.

dissent. Let us suppose that one who is urging adoption of the metric system, is put under cross-examination by a sceptical official. Some of his questions might run thus: What do you propose to do with the circle? At present it is divided into 360 degrees, each degree into 60 minutes, and each minute into 60 seconds. I suppose you would divide it into 100 degrees, each degree into 100 minutes, and each of these into 100 seconds?

The French have decimalized the quadrant, but I fear their division will not be adopted. Astronomical observations throughout a long past have been registered by the existing mode of measurement, and works for nautical guidance are based upon it. It would be impracticable to alter this arrangement.

You are right. The arrangement was practically dictated by Nature. The division of the circle was the outcome of the Chaldean division of the heavens to fit their calendar: a degree being, within 1-60th, equivalent to a day's apparent motion of the Sun on the ecliptic. And that reminds me that I do not find in your scheme any proposal for re-division of the year. Why do you not make 10 months instead of 12?

A partial decimalization of the calendar was attempted at the time of the French Revolution: a week of ten days was appointed, but the plan failed. Of course, the 365 days of the year do not admit of division into tenths; or if ten months were made, there could be no tenths of these. Moreover, even were it otherwise, certain deeply-rooted customs stand in the way. Many trading transactions, especially the letting of houses and the hiring of assistants, have brought the quarter-year into such constant use that it would be very difficult to introduce a redivision of the year into tenths.

Just so; and it occurs to me that there is a deeper reason. Ignoring the slight ellipticity of the Earth's orbit, a quarter of a year is the period in which the Earth describes a fourth of its annual journey round the Sun, and the seasons are thus determined—the interval between the shortest day and the vernal equinox, between that and the longest day, and so on with the other divisions.

The order of Nature is doubtless against us here.

It is against you here in a double way. Not only the behaviour of the Earth, but also the behaviour of the Moon conflicts with your scheme. By an astronomical accident it happens that there are 12 full moons, or approximately 12 synodic lunations, in the year; and this, first recognized by the Chaldeans, originated the 12-month calendar, which civilized peoples in general have adopted after compromising the disagreements in one or other way. But there is another division of time in which you are not so obviously thus restrained. You have not, so far as I see, preposed to substitute 10 hours for 12, or to make the day and night 20 hours instead of 24. Why not?

Centuries ago it might have been practicable to do this; but now that time-keepers have become universal we could not make such a re-division. We might get all the church-clocks altered, but people would refuse to replace their old watches by new ones.

I fancy conservatism will be too strong for you in another case—that of the compass. The divisions of this are, like many other sets of divisions, made by halving and re-halving and again halving, until 32 points are obtained. Is it that the habits of sailors are so fixed as to make hopeless the adoption of decimal divisions?

Another reason has prevented—the natural relations of the cardinal points. The intervals included between them are necessarily four right angles, and this precludes a division into tenths.

Exactly. Here, as before, Nature is against you. The quadrant results from space-relations which are unchangeable and necessarily impose, in this as in other cases, division into quarters. Nature's lead has been followed by mankind in various ways. Beyond the quarter of a year we have the moon's four quarters. The quarter of an hour is a familiar division, and so is the quarter of a mile. Then there are the quartern loaf, and the quarter of a hundredweight. Though the yard is divided into feet and inches, yet in every draper's shop yards are measured out in halves, quarters, eighths, and sixteenths or nails. Then we have a wine merchant's quarter-cask, we have the fourth of a gallon or quart, and, beyond that, we have for wine and beer, the quarter of a quart, or half-pint.

Even that does not end the quartering of measures, for at the bar of a tavern quarterns of gin, that is quarter-pints of gin, are sold. Evidently we must have quarters. What do you do about them? Ten will not divide by four.

The Americans have quarter dollars.

And are inconsistent in having them. Just as in France, notwithstanding the metric system, they speak of a quarter of a litre, and a quarter of a livre, so in the United States, they divide the dollar into quarters, and in so doing depart from the professed mode of division in the very act of adopting it—depart in a double way. For the tenths of the dollar play but an inconspicuous part. They do not quote prices in dollars and dimes. I continually see books advertised at 25c., 75c., $1.25c., $1.75c., and so forth; but I do not see any advertised at $1.3 dimes or 4 dimes, etc. So that while not practically using the division theoretically appointed, they use the division theoretically ignored.

It may be somewhat inconsistent, but there is no practical inconvenience.

I beg your pardon. If they had a 12-division of the dollar, instead of a 10-division, these prices $1.25 and $1.75 would be $1..3 and $1..9. And not only would there be a saving in speech, writing, and printing, but there would be a saving in calculation. Only one column of figures would need adding up where now there are two to add up; and, besides decreased time and trouble, there would be fewer mistakes. But leaving this case of the dollar, let us pass to other cases. Are we in all weights, all measures of length, all areas and volumes, to have no quarters?

Quarters can always be marked as .25.

So that in our trading transactions of every kind we are to make this familiar quantity, a quarter, by taking two-tenths and five-hundredths! But now let me ask a further question—What about thirds? In our daily life division by three often occurs. Not uncommonly there are three persons to whom equal shares of property have to be given. Then in talk about wills of intestates one hears of widows' thirds; and in Acts of Parliament the two-thirds majority often figures. Occasionally a buyer will say—"A half is more than I want and a quarter is not enough; I will take a third." Frequently, too, of medicines, where half a grain is too much or not enough, one-third of a grain or two-thirds of a grain is ordered. Continually thirds are wanted. How do you arrange? Three threes do not make ten.

We cannot make a complete third.

You mean we must use a make-shift third, as a make-shift quarter is to be used?

No; unfortunately that cannot be done. We signify a third by .3333, etc.

That is to say, you make a third by taking 3 tenths, *plus* 3 hundredths, *plus* 3 thousandths, *plus* 3 ten-thousandths, and so on to infinity!

Doubtless the method is unsatisfactory, but we can do no better.

Nevertheless you really think it desirable to adopt universally for measurements of weight, length, area, capacity, value, a system which gives us only a make shift quarter and no exact third?

These inconveniences are merely set-offs against the great conveniences.

Set-offs you call them! To me it seems that the inconveniences outweigh the conveniences.

But surely you cannot deny those enormous evils entailed by our present mixed system, which the proposed change would exclude.

I demur to your assertion. I have shown you that the mixed system would in large part remain. You cannot get rid of the established divisions of the circle and the points of the compass. You cannot escape from those quarters which the order of Nature in several ways forces on us. You cannot change the divisions of the year and the day and the hour. It is impossible to avoid all these incongruities by your method, but here is another by which they may be avoided.

You astonish me. What else is possible?

I will tell you. We agree in condemning the existing arrangements under which our scheme of numeration and our modes of calculation based on it, proceed in one way, while our various measures of length, area, capacity, weight, value, proceed in other ways. Doubtless, the two methods of procedure should be unified; but how? You assume that, as a matter of course, the measure-system should be made to agree with the numeration-system; but it may be contended that, conversely, the numeration system should be made to agree with the measure-system—with the dominant measure-system, I mean.

I do not see how that can be done.

Perhaps you will see if you join me in looking back upon the origins of these systems. Unable to count by giving a name to each additional unit, men fell into the habit of counting by groups of units and compound groups. Ten is a bundle of fingers, as you may still see in the Roman numerals, where the joined fingers of one hand and the joined fingers of the two hands are symbolized. Then, above these, the numbering was continued by counting two tens, three tens, four tens, etc., or 20, 30, 40 as we call them, until ten bundles of ten had been reached. Proceeding similarly, these compound bundles of tens, called hundreds, were accumulated until there came a doubly-compound bundle of a thousand; and so on. Now, this process of counting by groups and compound groups, tied together by names, is equally practicable with other groups than 10. We may form our numerical system by taking a group of 12, then 12 groups of 12, then 12 of these compound groups; and so on as before. The 12-group has an enormous advantage over the 10-group. Ten is divisible only by 5 and 2. Twelve is divisible by 2, 3, 4, and 6. If the fifth in the one case and the sixth in the other be eliminated as of no great use, it remains that the one group has three times the divisibility of the other. Doubtless it is this great divisibility which has made men in such various cases fall into the habit of dividing into twelfths. For beyond the 12 divisions of the zodiac and the originally-associated twelve-month, and beyond the twelfths of the day, and beyond those fourths—sub-multiples of 12—which in sundry cases Nature insists upon, and which in so many cases are adopted in trade, we have 12 ounces to the pound troy, 12 inches to a foot, 12 lines to the inch, 12 sacks to the last; and of multiples of 12 we have 24 grains to the pennyweight, 24 sheets to the quire. Moreover, large sales of small articles are habitually made by the gross (12 times 12) and great gross ($12\times12\times12$). Again, we have made our multiplication table go up to 12 times 12, and we habitually talk of dozens. Now, though

these particular 12-divisions are undesirable, as being most of them arbitrary and unrelated to one another, yet the facts make it clear that a general system of twelfths is called for by trading needs and industrial needs; and such a system might claim something like universality, since it would fall into harmony with these natural divisions of twelfths and fourths which the metric system necessarily leaves outside as incongruities.

But what about the immense facilities which the method of decimal calculation gives us? You seem ready to sacrifice all these?

Not in the least. It needs only a small alteration in our method of numbering to make calculation by groups of 12 exactly similar to calculation by groups of 10; yielding just the same facilities as those now supposed to belong only to decimals. This seems a surprising statement; but I leave you to think about it, and if you cannot make out how it may be I will explain presently.

III

THE PROMISED EXPLANATION MAY MOST conveniently be given by reproducing, with various alterations and additions, a letter I wrote about the matter last November twelvemonth to a distinguished man of science. Omitting the name, the letter ran thus:

"The enclosed memoranda concerning advantages to be derived from the use of 12 as a fundamental number, were written more than 50 years ago, and have since been lying unused among my papers.

"I send them to you because you have lately been expressing a strong opinion in favour of the metric system, and of course your opinion will weigh heavily. From the days when the accompanying memoranda were set down, I have never ceased to regret the spreading adoption of a system which has such great defects, and I hold that its universal adoption would be an immense disaster.

"Of course I do not call in question the great advantages to be derived from the ability to carry the method of decimal calculation into quantities and values, and of course I do not call in question the desirableness of having some rationally-originated unit from which all measures of lengths, weights, forces, etc., shall be derived. That, as promising to end the present chaos, the metric system has merits, goes without saying. But I object to it on the ground that it is inconvenient for various purposes of daily life, and that the conveniences it achieves may be achieved without entailing any inconveniences.

"One single fact should suffice to give us pause. This fact is that, notwithstanding the existence of the decimal notation, men have in so many cases fallen into systems of division at variance with it, and especially duodecimal division. Numeration by tens and multiples of ten has prevailed among civilized races from early times. What, then, has made them desert this mode of numeration in their tables of weights, measures, and values? They cannot have done this without a strong reason. The strong reason is conspicuous—the need for easy division into aliquot parts. For a long period they were hindered in regularizing their weights and measures by the circumstance that these had been derived from organic bodies and organic lengths—the carat and grain, for instance, or the cubit, foot, and digit. Organic weights and lengths thus derived were not definite multiples one of another, and Where

they were approximate multiples the numbers of these were irregular—would not conform to any system. But there early began, as among the Chaldeans, arrangements for bringing these natural measures into commensurable relations. By sexagesimal division (60 being the first number divisible both by 10 and 12) the Babylonian cubit was brought into relation with the Babylonian foot. The stages of change from nation to nation and from age to age, cannot, of course, be traced; but it suffices to recognize the fact that the tendency has been towards systems of easily-divisible quantities—the avoirdupois pound of 16 ounces, for instance, which is divisible into halves, into quarters, into eighths. But, above all, men have gravitated towards a 12-division, because 12 is more divisible into aliquot parts than any other number—halves, quarters, thirds, sixths; and their reason for having in so many cases adopted the duodecimal division, is that this divisibility has greatly facilitated their transactions. When counting by twelves instead of by tens, they have been in far fewer cases troubled by fragmentary numbers. There has been an economy of time and mental effort. These practical advantages are of greater importance than the advantages of theoretical completeness. Thus, even were there no means of combining the benefits achieved by a method like that of decimals with the benefits achieved by duodecimal division, it would still be a question whether the benefits of the one with its evils were or were not to be preferred to the benefits of the other with its evils—a question to be carefully considered before making any change.

"But now the important fact, at present ignored, and to which I draw your attention, is that it is perfectly possible to have all the facilities which a method of notation like that of decimals gives, along with all the facilities which duodecimal division gives. It needs only to introduce two additional digits for 10 and 11 to unite the advantages of both systems. The methods of calculation which now go along with the decimal system of numeration would be equally available were 12 made the basic number instead of 10. In consequence of the association of ideas established in them in early days and perpetually repeated throughout life, nearly all people suppose that there is something natural in a method of calculation by tens and compoundings of tens. But I need hardly say that this current notion is utterly baseless. The existing system has resulted from the fact that we have five fingers on each hand. If we had had six on each there would never have been any trouble. No man would ever have dreamt of numbering by tens, and the advantages of duodecimal division with a mode of calculation like that of decimals, would have come as a matter of course.

"Even while writing I am still more struck with the way in which predominant needs have affected our usages. Take our coinage as an example. Beginning at the bottom we have the farthing ($\frac{1}{4}$ penny), the halfpenny and penny (or one-twelfth of a shilling); next we have the threepenny piece ($\frac{1}{4}$ shilling), the 6*d.* piece ($\frac{1}{2}$ shilling), and the shilling; and then above them we have the eighth of a pound (2*s.* 6*d*), the quarter of a pound (5*s.*), and half-pound (10*s.*). That is to say, daily usage has made us gravitate into a system of doubling and again doubling and re-doubling; and when, until recently, there existed the 4*d.* piece, we had the convenience of a third as well as a half and a quarter—a convenience which would have been retained but for the likeness of the 3*d.* and 4*d.* coins. And observe that this system of multiples and sub-multiples has its most conspicuous illustration in the commonest of all processes—retail payments—and that, too, in the usages of a nation which is above all others mercantile.

[Since this letter was written I have been struck by the fact that the ancient wise men

of the East and the modern working men of the West, have agreed upon the importance of great divisibility in numerical groups. The Chaldean priests, to whom we owe so much, doubtless swayed in part by their astronomical arrangements, adopted the sexagesimal system of numeration, which at the same time facilitates in a special manner the division into aliquot parts. For 60 may be divided by ten different numbers—2, 3, 4, 5, 6, 10, 12, 15, 20, 30. From this significant fact turn now to the fact presented in our ordinary foot-rule. Each of its 12 inches is halved and re-halved, giving halves, quarters, and eighths. And then, if we consider the sub-divided foot as a whole, it gives us ten sets of aliquot parts. Beyond its 12ths the divisions yield $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{8}$ ($1\frac{1}{2}$ inch), $\frac{1}{16}$ ($\frac{3}{4}$ inch), $\frac{1}{24}$ ($\frac{1}{2}$ inch), $\frac{1}{32}$ ($\frac{3}{8}$ inch), and $\frac{1}{48}$ ($\frac{1}{4}$ inch). And this ordinary mode of dividing the foot-rule results from the experience of centuries; for builders, carpenters, and mechanics, always buying footrules which best serve their needs, have gradually established the most useful set of divisions. And yet, though the early man of science and the modern men of practice are at one in recognizing the importance of great divisibility, it is proposed to establish a form of measure characterized by relative indivisibility!]

"Now it seems to me that the two facts—first, that in early days men diverged from the decimal division into modes of division which furnished convenient aliquot parts, and second, that where, as in America, the decimal system has been adopted for coinage, they have in the focus of business fallen into the use of aliquot parts in spite of the tacit governmental dictation—not only prove the need for this mode of division, but imply that, if the metric system were universally established, it would be everywhere traversed by other systems. To ignore this need, and to ignore the consequences of disregarding it, is surely unwise. Inevitably the result must be a prevention of the desired unity of method: there will be perpetual inconveniences from the conflict of two irreconcilable systems. [At the time this prophecy was made, I did not know that in California the "long bits" and "short bits" of the dollar, already illustrated this conflict of systems and its evils.]

"I fully recognize the difficulties that stand in the way of making such changes as those indicated—difficulties greater than those implied by the changes which adoption of the metric system involves. The two have in common to overcome the resistance to altering our tables of weights, measures, and values; and they both have the inconvenience that all distances, quantities, and values, named in records of the past, must be differently expressed. But there would be futher obstacles in the way of a 12-notation system. To prevent confusion different names and different symbols would be needed for the digits, and to acquire familiarity with these, and with the resulting multiplication-table would, of course, be troublesome: perhaps not more troublesome, however, than learning the present system of numeration and calculation as carried on in another language. There would also be the serious evil that, throughout all historical statements, the dates would have to be differently expressed; though this inconvenience, so long as it lasted, would be without difficulty met by enclosing in parenthesis in each case the equivalent number in the old notation. But, admitting all this, it may still be reasonably held that it would be a great misfortune were there established for all peoples and for all time a very imperfect system, when with a little more trouble a perfect system might be established."

Thus far the letter. And now let me sum up the evidence. Professedly aiming to introduce uniformity of method, the metric system cannot be brought into harmony with certain unalterable divisions of space nor with certain natural divisions of time, nor with the artificial

divisions of time which all civilized men have adopted. As 10 is divisible only by 5 and 2 (of which the resulting fifth is useless), its divisibility is of the smallest; and having only a makeshift fourth and no exact third, it will not lend itself to that division into aliquot parts so needful for the purposes of daily life. From this indivisibility it has resulted that, though men from the beginning had in their ten fingers the decimal system ready made, they have, in proportion as civilization has progressed, adopted, for purposes of measurement and exchange, easily divisible groups of units; and in a recent case, where the 10-division of money has been imposed upon them, they have, under pressure of business needs, abandoned it for the system of division into halves, quarters, eighths, sixteenths. On the other hand, the number 12 is unique in its divisibility—yields two classes of aliquot parts; and for this reason has been in so many cases adopted for weights, measures, and values. At the same time it harmonizes with those chief divisions of time which Nature has imposed upon us and with the artificial divisions of time by which men have supplemented them; while its sub-multiple, 4, harmonizes with certain unalterable divisions of space, and with those divisions into quarters which men use in so many cases. Meanwhile, if two new digits for 10 and 11 be used, there arises a system of calculation perfectly parallel to the system known as decimals, and yielding just the same facilities for computation—sometimes, indeed, greater facilities, for, as shown in the memoranda named in the above letter, it is even better for certain arithmetical processes.

Do I think this system will be adopted? Certainly not at present—certainly not for generations. In our days the mass of people, educated as well as uneducated, think only of immediate results: their imaginations of remote consequences are too shadowy to influence their acts. Little effect will be produced upon them by showing that, if the metric system should be established universally, myriads of transactions every day will for untold thousands of years be impeded by a very imperfect system. But it is, I think, not an unreasonable belief that further intellectual progress may bring the conviction that since a better system would facilitate both the thoughts and actions of men, and in so far diminish the friction of life throughout the future, the task of establishing it should be undertaken.

Hence I contend that adoption of the metric system, while it would entail a long period of trouble and confusion, would increase the obstacles to the adoption of a perfect system—perhaps even rendering them insuperable—and that, therefore, it will be far better to submit for a time to the evils which our present mixed system entails.

P.S.—A mathematician and astronomer, who writes: "I am much interested in your letters and agree with almost everything," makes some comments. He says: "It has always been an astonishing thing to me that the advocates of deeimalization do not perceive that its only advantage is in computation. In every other process it is a detriment." Concerning the 12-notation, he remarks that "the advantages are notorious to all mathematicians." Apparently less impressed than I am with the advance of knowledge from uncivilized times to our own and the breaking down of habits, now going on with accelerating rapidity, he does not share the expectation that the 12-notation "will ever be adopted in practice": the obstacles to the change being too great. But without opposing the metric system, as threatening to stand in the way of a more perfect system, he opposes it as intrinsically undesirable, saying: "I think that all that can be done is to make our coinage and measures as little decimal as possible, and our computation as decimal as may be."

IV

From one who every month has to act as auditor, I have received a letter in which he says: "I had to go over more than £20,000 of accounts yesterday and was very thankful that it was not in francs."

This statement, coming from a man of business, has suggested to me the question—By whose advice is it that the metric system of weights, measures, and values is to be adopted? Is it by the advice of those who spend their lives in weighing and measuring and receiving payments for goods? Is it that the men who alone are concerned in portioning out commodities of one or other kind to customers and who have every minute need for using this or that division or sub-division of weights or measures, have demanded to use the decimal system? Far from it. I venture to say that in no case has the retail trader been consulted. There lies before me an imposing list of the countries that have followed the lead of France. It is headed "Progress of the Metric System." It might fitly have been headed "Progress of Bureaucratic Coercion." When fifty years after its nominal establishment in France, the metric system was made compulsory it was not because those who had to measure out commodities over the counter wished to use it but because the Government commanded them to do so, and when it was adopted in Germany under the Bismarckian *régime*, we may be sure that the opinions of shopkeepers were not asked. Similarly elsewhere, its adoption has resulted from the official will and not from the popular will.

Why has this happened? For an answer we must go back to the time of the French Revolution, when scientific men were entrusted with the task of forming a rational system of weights, measures, and values for universal use. The idea was a great one, and, allowing for the fundamental defect on which I have been insisting, it was admirably carried out. As this defect does not diminish its great convenience for scientific purposes the system has been gradually adopted by scientific men all over the world: the great advantage being that measurements registered by a scientific man of one nation are without any trouble made intelligible to men of other nations. Evidently moved by the desire for human welfare at large, scientific men have been of late years urging that the metric system should be made universal, in the belief that immense advantages, like those which they themselves find, will be found by all who are engaged in trade. Here comes in the error. They have identified two quite different requirements. For what purpose does the man of science use the metric system? For processes of measurement. For what purpose is the trader to use it? For processes of measurement plus processes of exchange. This additional element alters the problem essentially. It matters not to a chemist whether the volumes he specifies in cubic-centimètres or the weights he gives in grammes, are or are not easily divisible with exactness. Whether the quantities of liquids or gases which the physicist states in litres can or cannot be readily divided into aliquot parts is indifferent. And to the morphologist or microscopist who writes down dimensions in sub-divisions of the mètre, the easy divisibility of the lengths he states is utterly irrelevant. But it is far otherwise with the man who all day long has to portion out commodities to customers and receive money in return. To satisfy the various wants of those multitudes whose purchases are in small quantities, he needs measures that fall into easy divisions and a coinage which facilitates calculation and the giving of change. Force him to do his business in tenths and he will inevitably be impeded.

"But you forget that the metric system is approved by many mercantile men and that its adoption is urged by Chambers of Commerce." No, I have not forgotten; and if I had I should have been reminded of the fact by the fears now expressed that our commerce will suffer if we do not follow in the steps of sundry other nations. The fears are absurd. French and German merchants, when sending goods to England, find no difficulty in marking them or invoicing them in English measures. And if English merchants imply that they are too stupid to follow the example in a converse way, they can scarcely expect to be believed. Surely the manufacturers who supply them with piece-goods will make these up in so many mètres instead of in so many yards if asked to do so; and similarly in all cases. Or if not, it needs but a table on the wall in the clerks' office, giving in parallel columns the equivalents of quantity in English denominations and French denominations, to make easy the needful invoicing and labelling. But it is not on this flimsiest of reasons that I wish chiefly to comment. The fact here to be specially emphasized is that merchants are not in the least concerned with the chief uses of the metric system. Their bales and chests and casks contain large quantities—dozens of yards, hundredweights, gallons. They do not deal with sub-divisions of these. Whether the retailer is or is not facilitated in portioning out these large quantities into small quantities is a question having no business interest for them. More than this is true. Not only have they never in their lives measured out fractional amounts in return for small sums of money, but they have rarely witnessed the process. Their domestic supplies are obtained by deputy, usually in considerable quantities; and neither behind the counter nor before it have they with frequency seen the need for easy divisibility into aliquot parts. Their testimony is supposed to be that of practical men, while in respect of the essential issue—the use of weights and measures for retail trade—they have had no practice whatever.

See then the strange position. The vast majority of our population consists of working people, people of narrow incomes, and the minor shopkeepers who minister to their wants. And these wants daily lead to myriads of purchases of small quantities for small sums, involving fractional divisions of measures and money—measuring transactions probably fifty times as numerous as those of the men of science and the wholesale traders put together. These two small classes, however, unfamiliar with retail buying and selling, have decided that they will be better carried on by the metric system than by the existing system. Those who have no experimental knowledge of the matter propose to regulate those who have! The methods followed by the experienced are to be rearranged by the inexperienced!

Intentionally or unintentionally those who have bad cases to defend very commonly raise false issues. It has been so in this case. Such responses as I have seen to the foregoing arguments have assumed or asserted that I uphold our existing system of weights, measures, and moneys; and they assert this because I have pointed to various conveniences which these have. But if this ascription does not result from a wilful misrepresentation, it results from an unintelligent attention to the argument. The chaotic character of our modes of specifying quantities is as manifest to me as to the metricists. When instancing as convenient these or those tables now in use, I have referred to the *mode of division*; not at all intending to imply approval of the particular sizes or amounts of the divisions: these being in many cases very undesirable.

All who do not perversely misinterpret must surely recognize my thesis as having been that, rather than establish a fundamentally imperfect system based upon 10 as a radix, it will be better to wait until we can change our system of nuineration into one with 12 as a radix;

and then on that to base our system of weights, measures, and values: tolerating present inconveniences as well as we may. Opponents do not deny that a 12-system of numeration would be better than is the 10-system, and do not deny that weights, measures, and values would be more conveniently expressed in terms of a 12-system. Their contention is that the change to a 12-system of numeration is not practicable. Tacitly they assume that because people are not now sufficiently intelligent to perceive its advantages, and to take the trouble of making the needful changes, they never will be sufficiently intelligent.

It is strange that with past experiences before them their imagination should thus fail them. See what lessons history reads us. If our cannibal ancestors, who in the forests of Northern Europe two thousand or more years ago sheltered in wigwams and clothed themselves in skins, had been told that some of their descendants would live in massive towers of stone and cover their bodies with metal plates, explanations, even could they have been understood, would have left them utterly incredulous. Or, again, if the mediæval barons had been told that in a few centuries after their deaths, nobles, instead of needing castles and armour, would live in houses which even a solitary thief could break into, and would walk about unarmed without attendants, they would have thought their informant insane. Yet with such cases before them, cultivated classes in our own day suppose that future usages will be like present ones, and that the culture, ideas, and sentiments now prevailing will always prevail; and they suppose this though men's feelings and thoughts have become more plastic than they ever were before. They cannot conceive that hereafter people may think it worthwhile to make a revolution (not much more troublesome than that which they advocate) for the purpose of greatly facilitating the billions of transactions, commercial, industrial, and other, daily gone through by mankind.

If, as seems probable, they should have their way—if the Act of Parliament just passed, giving permission to use the Metric System, should presently be followed, as they intend it to be, by an Act making the use of the Metric System compulsory—if in the United States as well as in England and it colonies, governments prompted by bureaucracies, but not consulting the people and clearly against their wishes, should make universal this gravely defective system, very possibly it will remain thereafter unalterable. When the trade within each nation as well as all international commerce has been unified in method, the obstacles to a radical change may be insuperable; even though most should come to see the great superiority of another method. And should this happen, then men of the future looking back on men of the present will say of them that, having before them a system which they recognized as relatively perfect, they deliberately imposed a relatively imperfect system on all mankind for all time.
