work was necessarily tentative, and that indeed is part of its value. Each local authority has started the work in its own way, according to its own circumstances, industries, and resources; so that the country has for two years been one great experimental station, with some hundreds of separate plots of educational varieties." The sums spent upon the erection of important technical schools during the last six or seven years will astonish many people. To quote Mr. Rae: "Bolton has built a technical school at a cost of £15,000; Bury, at a cost of £16,000; Blackburn, of £40,000. Oldham and Rochdale are now spending £12,000 each in building one; Halifax and Derby are spending £20,000 each; Bath, £21,000; Worcester and West Ham, £40,000; Birmingham, £48,000; and Manchester, on a site worth £100,000, is erecting a technical school estimated to cost £130,000 more, the most elaborate and magnificent product of the whole movement." So far as we can gather from the article, the work which has been done shows good promise of practical fruit. It is pointed out that the grant should be secured permanently for education by statute, and this should be done as soon as possible. Mr. Rae thinks that the worst deficiencies which the experience of the past three years has revealed are (1) the startling illiteracy of the men and the lads who have passed the standards of elementary schools, and (2) the general want of the means of good secondary education. These are the deficiencies which must prevent the effectual diffusion of technical instruction. Mr. Rae's article should certainly be read by everyone interested in the progress of technical instruction.

Another article in the *Contemporary* is entitled "Joseph Priestley in Domestic Life," by Madame Belloc. The mother of the authoress was taught to read by Priestley, and she gave her daughter a very clear idea of his personality. The article thus contains a description of the investigator as he really was according to the last echo of oral tradition. And though it deals chiefly with Priestley's private life, students of the history of chemical science will find parts of it interesting. The *Contemporary* also contains an article by Mr. Herbert Spencer, whose theme is "Weismannism Once More." Mr. Spencer harks back to the original points of discussion between Prof. Weismann and himself, in order to show (1) that certain leading propositions having been passed by unnoticed, remain outstanding; and (2) that when leading propositions have been dealt with, the replies given are invalid.

In the *National Review*, Mr. F. W. H. Myers writes on "The Drift of Psychical Research." Wonderful things are told of telepathy and kindred powers, and the author is very sanguine as to future developments. He recognises that men of science fight shy of the "glum researches," and are ever ready to put their fingers upon the weak points in psychical reasoning and investigation. This dislike is accounted for by the rude approximate character of the work carried on by its votaries; but, on the other hand, Mr. Myers holds that psychology is a new science, and has, therefore, to grope its way up to the exactness of older branches of knowledge. He inclines to the opinion that the methods of science cannot at present be extended to the realm in which he is an explorer. After Mr. Myers' article, and as an antidote to it, one contributed by Mr. Ernest Hart to the *Century* should be read. Mr. Hart's paper should convince every even-minded person of the imposture widely practised under the names of hypnotism, spiritualism, telepathy, "spookism" in its various manifestations, Mahatmism, Matteism, and other phenomena of an occult character. The same magazine contains the conclusion of the series of articles, "Across Asia on a Bicycle," contributed by Messrs. T. G. Allen and W. L. Sachtleben; and Mrs. C. L. Franklin gives a short biography of Sophie Germain, whose mathematical works and philosophical writings gained for her such a high reputation at the beginning of this century.

Sir Robert Ball continues his articles on "The Great Astronomers," in *Good Words*, the subject this month being Galileo. He handles the matter of Galileo's trial for heresy very carefully, and does not give vent to the feelings which every astronomer must experience when describing the events which led up to the abjuration which the founder of physical astronomy was forced to pronounce. Mr. T. Munro combines imagination with science in an article, "Sun-rise or the Morn," in *Cassell's Family Magazine*. The Mammoth Cave of Kentucky is the subject of an article, by Prof. W. G. Blaikie, in the same magazine. Under the alliterative title, "Seers of Science," Mr. Munro shows, in the *Leisure Hour*, how poets and story-tellers have anticipated some of the discoveries of science. It would have been strange if, in all the vague speculations which have been given to the world, some coincidences of the kind referred to had not been found. Salt, and sleeplessness are the subjects of two other articles in the *Leisure Hour*.

An extremely interesting account of "Tarahumari Dances and Plant Worship" is given by Dr. Carl Lumholtz in *Scribner*, with illustrations from photographs by the author. Another article of ethnographical importance is "Customs connected with Burial among the Sihanaka," by the Rev. J. Pearse, in the *Sunday Magazine*, which also contains a paper entitled "A Thousand Miles up the Irrawaddy," by the Rev. W. R. Winston. *Chambers's Journal* contains, as usual, a number of short and popular articles on more or less scientific subjects. Among those we note a description of some remarkable artesian wells, and a paper on the utilisation of waste products. Mr. Grant Allen writes pleasantly on "The Night Jar," in the *English Illustrated*, and Colonel Howard Vincent describes the scientific measurement and identification of criminals.

In addition to the magazines mentioned in the foregoing, we have received the *Fortnightly*, *Longman's*, and the *Humanitarian*, neither of which, however, contain articles that call for comment here. The first number of the *Phonographic Quarterly Review* has also been sent to us. The *Review* is edited by Mr. T. Allen Reed, and it bids fair to take a permanent stand among phonographic literature. Some of the articles have been furnished by phonographers, and others by well-known writers, the writings of the latter having been transcribed. The editor evidently recognises the importance of a knowledge of science to the shorthand writer of the present day, for among the articles we note "The Native Tribes of East Africa," by Dr. J. W. Gregory; "Experiences of a Naturalist," by Dr. A. S. Murray; "The Myths of the Unicorn and the Griffin," by Sir Henry Howorth; and "The Formation of Flints," by Canon Bonney. The publication of articles of this kind will help on the time when scientific lectures will be reported without being caricatured.

MEASUREMENTS OF PRECISION.[1]

MORE than two thousand years ago there lived in the far East a philosopher who established his claim to the possession of a good measure of both wisdom and wit, when he wrote: "Avoid even the appearance of evil: do not stop to tie your shoe in the melon patch of an enemy."

Suppressing the humour but not the sentiment of the Oriental teacher, it is easy to see that Confucius meant to impress upon his followers the importance of taking care that, even in the performance of trivial acts, the time and place should be such as would give rise to no suspicions as to motive or design.

I am honoured by being permitted the freedom of your academic groves to-day. I realise that the opportunity of defending a theme under such circumstances is not to be lightly esteemed, and I wish, in the beginning, to make terms with everybody, by declaring that in bringing before you a proposition so simple as to need no argument, I am innocent of ulterior motive or deep design.

My desire to give formal expression to this proposition grows out of the frequency with which it has presented itself in the course of official duties during the past few years.

I wish to consider "Precise Measurement" as one of the agencies through which man has advanced from a condition of savagery to his present state; and the metrology of any age as an exponent of the civilisation of that age.

The brief time during which I can venture to ask your attention to this subject fortunately releases me from all obligations to consider literary excellence or rhetorical ornamentation, and compels me even to deviate in some degree from the logical order of presentation. It is safe, however, to take liberties with an audience so largely composed of those who are not only familiar with the facts to be presented, but who are accustomed to arrange, digest, and put in orderly sequence materials which are found in a more or less chaotic condition.

The first form of measurement to which primitive man resorted was undoubtedly simple enumeration. In narration or barter the number of units in a group was alone considered, regardless of differences among individuals. The recognition

[1] An address delivered at the Johns Hopkins University, Baltimore, by Prof. T. C. Mendenhall.

of the fact that one quantity is greater or less than another is not measurement. Measurement implies the ability to represent numerically, so that ratios can be accurately expressed. Among primitive races measurement by enumeraton is very restricted. Tribes bordering on savagery at the present time are often found to be unable to enumerate beyond three or four. This statement is quite positively made by competent authorities, in spite of the fact that the ability to enumerate the number of fingers on at least one hand would appear to be necessary to even the lowest order of intelligence. It is curious to note in this connection that experiment has apparently proved that four is the maximum number of objects whose accurate enumeration is possible *at a single glance* and without *counting*, by the most highly cultivated man.

As man emerges from savagery his powers of enumeration increase. He soon discovers the necessity for units of a higher order which themselves represent a collection, and easily finds such units provided by nature in the groups of fingers on his two hands. Thus the decimal system of arithmetic is invented; not in one place or by one people, but everywhere and whenever man finds that somewhat extensive enumeration is desirable or necessary. It is a singular exception to this general rule, however, that the Greeks failed to invent a decimal arithmetic.

With systems of notation capable of indefinite extension, measurement by enumeration becomes rigorously exact; that is, barring blunders, which can always be discovered and avoided, the number of units in a group, if capable of being counted at all, can be counted with absolute accuracy. Thus, the cash in the Treasury of the United States may be more than a hundred million dollars, that is more than ten thousand million cents, and the exact quantity can be ascertained to a single cent. By simple enumeration, therefore, this quantity of money is measured so accurately that the error cannot be as much as one part in ten thousand millions, and this might be extended in any degree, if only the cash is there to be counted.

At a comparatively early stage, therefore, this kind of measurement was perfected, but there are two systems or methods of measurement derived from it that are worthy of brief comment. The first includes that variety of mensuration in which the numerical value of a magnitude cannot be obtained by simple counting, but is derived by calculation based on rigorously exact relationship. This is of a distinctly higher order than that just considered, and it is only found among highly intelligent people, those, in short, who have cultivated a knowledge of pure mathematics. A very simple illustration is the determination of the area of a triangle when its base and altitude are known. In this and similar cases a rigorously accurate result is attainable when the data are absolutely correct, but simple counting would be impossible. There are cases, however, and these constitute another step along the line in which we are travelling, in which an absolutely accurate evaluation is impossible, but in which any *desirable degree* of accuracy, however high, may be reached. Perhaps the best known example of this is the determination of the circumference of a circle when its diameter is known. The ratio of the former to the latter, which cannot be exactly expressed, has been determined with a degree of approximation by modern computers, which makes it possible to reduce the outstanding error to an inconceivably small quantity. An attempt to illustrate this may not be without interest.

In a display of mathematical genius which has perhaps never been surpassed, Archimedes more than two thousand years ago discovered the first real approximation to the value of this constant. The accuracy of his result may be shown in the fact that if the diameter of a circle be exactly one inch, its circumference as determined by the value of the constant found by Archimedes will not be in error more than the thickness of a human hair. If the value of the constant is more accurately known, it will be possible to compute the circumference of a proportionately larger circle so that the error shall not exceed a hair's-breadth. Let us go at once from the circle one inch in diameter to one having a radius equal to the distance from the earth to the sun and a circumference of nearly 600 millions of miles. It is difficult to form any adequate conception of the enormous stretch of 93 millions of miles which separates the earth from the sun. The immensity of it is in some degree realised on reflecting that if it were possible for a child to extend an arm across this space, and plunge his hand into the white hot layer of the sun from which light is radiated, he might grow to youth, manhood, old age, and unless he lived through the almost unprecedented period of 125 years, death would come before he would feel the pain of burning, so great is the distance through which the sensation must travel. But even this circle, of 600 millions of miles in circumference, is almost immeasurably small in comparison with the one for which we are seeking. Multiply it by a million; a million million; a million, million million; in fact multiply it by a number expressed by the word million repeated 98 times, and we reach a circle of utterly inconceivable dimensions; yet so precisely do we know the ratio of the circumference to the diameter of a circle, that having given the diameter of such a circle, its circumference can be determined within the breadth of a hair. For all ordinary, practical purposes this is sufficient.

A very modern and an extremely important species of measurement involving only enumeration is to be found in the statistical method of treating certain classes of problems in which the object is to follow the fortunes of a group rather than an individual. It has long been advantageously applied to social, political, and economical questions, and within a few years, in the hands of such men as Clerk Maxwell, Boltzmann, and others, it has proved to be a powerful agent in physical investigations.

It depends in great measure on what may be called the principle of the "long run," which is, that phenomena of apparently the most accidental and lawless character will, *in the long run*, occur with regularity and obedience to law, to such an extent as to render their prediction quite possible. At least one great railroad system in this country has so tabulated and investigated all accidents happening to its employés and patrons that it is able to foretell with a good degree of accuracy the number of people who will, during the next year, meet with death on its line; how many will lose a foot, how many an arm, and so on; and its Board of Directors is thus always ready to weigh the cost of a new invention to add to the safety of travel, against the probable damages to be paid for fatal and other injuries which said invention might prevent.

Further argument is unnecessary to show that measurement by enumeration, the first to appear in the evolution of man and his accomplishments, has advanced with man and kept pace with his accomplishments; that it has contributed greatly to his advancement, and that at any given period it may fairly stand as an exponent of his condition.

But in a far greater degree is this true of the second of the two forms of measurement to which men have resorted, namely, that in which a conventional unit embodying the particular quality to be measured is compared to the magnitude to be evaluated. Nearly all operations ordinarily called measurements belong to this class, and its necessity must have followed closely upon the introduction of measurement by enumeration. Of the three fundamental measures, from which it is convenient to derive all others, namely, length, mass and time, the first and last were undoubtedly the earliest to receive attention, and it is more than likely that some rude system of time measurement constituted the earliest contribution to metrology. Nature is lavish in the number and variety of time units which she has furnished man, some of which satisfy the most rigorous demands of modern science. In the early stages of chronometric development the method of enumeration was alone available. By taking the solar day as the unit, counting the number of days in a lunar period furnished the month. The year was similarly obtained, at first from the mere cycle of the seasons, but in a somewhat more advanced stage of development, from more exact observations upon the sun. Before this, there must have existed a demand for the division of the day into smaller units of time. Much ingenuity and often genius of a high order was shown in the invention of chronometric devices. A remarkably clever determination of the angular diameter of the sun was made by the Chaldeans by the use of one of the earliest forms of time-measuring apparatus. At the moment the sun's disk appeared in the eastern horizon a fine stream of water flowing from the bottom of a vessel in which the level was kept constant, was caught in a small cup, into which it was allowed to flow until the lower limb of the sun was visible. The small cup being instantly withdrawn, another much larger receptacle was substituted for it, and into this the small stream fell during all the day and until the sun appeared in the east again on the following morning. It was found that the water in the large vessel was 720 times that in the smaller, from which it appeared that the apparent diameter of the sun was $\frac{1}{720}$ of the circumference of the heavens, or one half a degree of arc.

It is impossible here to trace the evolution of time-measuring from the earliest period to the present, and it is unnecessary, because most of the steps are doubtless well known to you all. You are requested to reflect, however, upon the close relation of the various stages of this evolution to the progress of the human race from savagery to enlightenment.

Hardly anything is a more certain and sensitive index of the advancement of a people than the precision required in the time schedule of the ordinary events of life. Improvement in time-measuring instruments, watches and clocks, is in response to a demand for this precision, and not the cause of it, as is sometimes asserted. Watches are now regulated to seconds where formerly minutes were near enough, and the few remaining civilised people among whom the hour has been the smallest division of time in common use, are fast mending their ways in this respect.

Unfortunately in the development of systems of measurement of length and mass, we have not succeeded as well as with the measurement of time. The greater excellence of the latter is unquestionably due to the universality of the fundamental unit, which is everywhere the day. While there have existed some differences among different nations as to the divisions and multiples of this unit, certain natural phenomena have directed all, along nearly the same lines, and at this moment, in all essential particulars, the chronometric systems of nearly all civilised nations are identical. Although not the best that could have been devised had existing knowledge and experience been available in the beginning, the prevailing subdivisions of the time unit are not seriously objectionable, and as they are so nearly universal and so firmly established by long usage, they are almost certain to continue unchanged.

In measures of length and mass or weight, the tendency from the beginning, up to a very recent period, has been, as in the case of time, towards the selection of natural units.

Dimly comprehending the importance and necessity of invariable units of measure, primitive man looked to nature to find the invariable. The nomenclature of every system of measure known bears testimony to the original use of natural units. Of measures of length familiar to all may be mentioned the hand, foot, pace, fathom, cubit, ell and span, all of which are derived from the dimensions of the human body. The inch, as everybody knows, was originally the length of three barley-corns from the middle of the ear, placed end to end. At a later period among some of the Oriental nations the unit of length was the length of a bamboo pipe, which when blown would produce a certain musical pitch. This argues a reckless indifference as to units of length, or an extraordinary power of detecting variation in the pitch of musical tones.

Units of weight or mass also had their origin in natural magnitudes, although in this case much greater difficulty is experienced. Almost the only natural unit of mass that was suggested or used was the mass of a grain of wheat from the middle of the ear, and from this our use of the grain weight of to-day is derived.

But all men are not alike in stature, nor are grains of wheat of great uniformity in dimensions or mass. As might have been anticipated, under such conditions there grew up, not only in different parts of the world, but in different sections of the same country, a variety of systems of weight and measure having no exact relations to each other, or among themselves, and which developed, as intercourse between nations became easier and more general, into one of the greatest calamities ever visited upon mankind. Various efforts were made at various times by various nations, each to improve its own system, but little good resulted up to almost exactly one hundred years ago. At the close of the Revolutionary War the weights, measures and coins in use in this country were almost innumerable in kind. Although mostly inherited from our Anglo-Saxon ancestors, many other European systems had gained a foothold, and considerable diversity in names and values had grown up throughout the colonies. An opportunity was presented at that time which we shall never see again, and which was lost by what one is forced to call the moral cowardice of men in high places. No one appreciated this opportunity more thoroughly than Thomas Jefferson, perhaps the most scholarly man of his time; the patron and friend of science and scientific men.

Jefferson recognised the incongruities of existing systems of weight and measure, but not wishing to depart sensibly from the foot as a unit of length he offered ingenious suggestions for a perfected scheme of linear measurement in which the foot was to be related decimally to the length of a seconds' pendulum and was to be decimally subdivided.

The Constitution of the United States provides that Congress shall have power to coin money, regulate the value thereof, and to fix the standard of weights and measures. At an early day this power was wisely exercised to provide escape from the bondage of the unphilosophical pounds, shillings and pence of the mother country by the establishment of a decimal system of coin ratios, the use of which during the past hundred years has been a greater gain, as compared with the discarded system, than the value of all the money in the country at the time of its adoption.

The second prerogative, that of "fixing a standard of weights and measures," was not at that time and, as a matter of fact, has never yet been exercised by Congress; indeed, considering the great danger which continually existed that when Congress did act it would act wrongly, it is a matter of congratulation that legislation on this important matter has thus far practically gone by default. But the opportunity existing during the early days of our national life was great, for the reason that just at this time there was conceived and perfected on the other side of the Atlantic the most decided, the most important, and the most far-reaching advance in metrology that the world has ever seen.

It had its beginning in the wisdom and foresight of the distinguished Talleyrand, who in 1790, while still a bishop, impressed by the excessive diversity and confusion of the weights and measures then prevailing, proposed to the Assembly of France a scheme for their reformation. Realising that not only national but international reformation was desirable, other nations were invited to join in the development and execution of this magnificent scheme. The co-operation of the Royal Society of London and of the English Government was sought, but unfortunately the English were not then in the mood for giving support to the French.

For the preliminary steps, looking to the determination of the value of the fundamental units and their relation to each other, a committee of the French Academy, including the most eminent mathematicians of Europe, was appointed, among its members being Borda, Lagrange, Laplace and Condorcet. Others engaged in the various measurements necessary to this determination were Lavoisier, Coulomb and Delambre.

Throughout the stormy scenes that accompanied the great political and social changes which occurred in France during the last decade of the eighteenth century, these noble scholars steadfastly pursued the problem upon the solution of which they had set out. At one time Borda, Lavoisier, Laplace, Coulomb and Delambre were dismissed from this public service by Robespierre's Committee of Safety, because their political views were suspected of being not quite in harmony with those of the aggressive party in power. (That was a hundred years ago.) But Robespierre was ambitious as well as cruel, and the project was afterwards allowed to go on. Finally, on June 22, 1799, the two new perfected standards—a metre, the unit of length, made of platinum, and a kilogramme, the unit of mass, of the same metal, were presented with great solemnity at the bar of both houses of the National Assembly of France by the celebrated Laplace, who addressed the assembled legislators; and on the same day the two standards were deposited in the archives of France, destined to be, a century later, the accepted units of measure of more than half of the civilised world, and eventually to become universal. In a report filed just seventy-three years ago to-day, John Quincy Adams, then Secretary of State, says of this event: "The spectacle is at once so rare and so sublime . . . that not to pause for a moment, were it even from occupations not essentially connected with it, to enjoy the contemplation of a scene so honourable to the character and capacities of our species, would argue a want of sensibility to appreciate its worth." "This scene," he says, "formed an epoch in the history of man, and an example and an admonition to the legislators of every nation, and of all after-times."

Just one hundred years ago, in 1794, copies of the preliminary metric standards were sent to this country, and our Government was urged to join in this memorable undertaking. Then, and during the thirty years following, the question of our adopting a system of weights and measures in harmony with our admirable monetary system was much agitated; but the counsel of the timid prevailed, and the wretched system which we had inherited mainly from England, but which is not in harmony with the English, was allowed to fasten itself upon the industrial interests of the country. The report on the subject by John Quincy Adams, already referred to, is a monument of exhaustive research and philosophical discussion. Nowhere is the decimal system praised so highly as in this report. In it he says of this system that, "considered merely as a labour-saving machine, it is a new power, offered to man, incomparably greater than that which he has acquired by the new agency which he has given to steam. It is in design the greatest *invention* of human ingenuity, since that of printing." This is high praise, and it is difficult to understand how the author of this and much more like it, could lack the courage to recommend that his country should at once put itself in the way of sharing the benefits of so remarkable a reformation. The spirit of conservatism, which came from his ancestors along with the yard and the pound, led him to advise that it was better to await the action of other nations, especially Great Britain.

At the close of the last century, in different parts of the world, the word *pound* was applied to 391 different units of weight, and the word foot to 292 different units of length. Not only were no two of these identical, but in only a few cases were their relative values known with anything like precision. In the wonderful march of the nineteenth century, most of these have been swept away; until now, of the enlightened nations of the earth, only the English-speaking people cling to what Lord Kelvin has so felicitously characterised as our "brain-wearying and intellect-wasting system of weights and measures."

I must now return to a very brief consideration of the indirect influence of precise measurement upon the welfare of man. Thus far the development of exact standards has been considered in relation to man's convenience, as facilitating the transaction of business, by diminishing the uncertainty and labour involved in commerce and trade. But indirectly it has been even more powerful. The use of correct standards of weight and measure has been regarded from the beginning as necessary to and indicative of integrity and fair dealing, among nations as well as individuals. Ultimate standards of reference, even in the earliest history of metrology, were carefully guarded and usually considered a part of the paraphernalia or accessories of the king or ruler. Although these standards were, until a comparatively recent period, very rude in their construction, they represented in a large measure the integrity of the nation, and to depart from or modify them was regarded as akin to a crime. According to Josephus, when Cain had settled in the land of Nod, and built a city, he invented weights and measures. In the law as given to Moses it is declared, "Thou shalt not have in thine house divers measures, a great and a small." The renowned Chinese Emperor, Yeo, who flourished 4000 years ago, kept the weights and measures which were used in the markets in a part of his own palace. In many countries standards were deposited in temples, and priests were their custodians. One of the principal objects sought to be secured by the Magna Charta was uniformity of weights and measures throughout the kingdom, and the one small spot in the world to-day whose neutrality is secured by the joint agreement of all civilised nations, including even the United States and Great Britain, is a bit of land near Paris, where stands the building in which the international prototype metre and kilogramme are preserved.

But in a far greater degree has precise measurement influenced the character, condition and destiny of man through its relation to the development of modern science. Volumes might be written about this, although not much is necessary before an audience to many of whom it is almost a daily lesson, and before another, smaller, audience of those who have contributed so largely during the past quarter of a century to the advancement of science and the improvement of the art of measuring.

Precision in measures demands and produces precision in language, and exact language makes exact thinking possible.

One cannot but admire the genius which enabled some of the philosophers of a few centuries ago to triumph over the obstacles growing out of the lack of exactness both in language and experiment. When Newton was converting his theory of the spheroidal form of the earth into established fact, he could only ascertain the possible effect of change of temperature upon the period of a pendulum by means of comparisons of the length of an iron bar when exposed to the sun's rays on a hot summer's day, with its length on a frosty morning in winter. Even in the earlier Transactions of the Royal Society of London, one may find time measured in *misereres* and temperature in inches. In the wonderful progress that has characterised the present age, by which business methods and social life have been well-nigh revolutionised, exact science has been the dominant factor. It is impossible here even to mention the many interesting devices by means of which during the last half century the precision of measurements has been enormously increased. They are to be seen in nearly every laboratory, and are familiar to you all. Their invention has made possible many brilliant and useful discoveries in science, and it is gratifying to know that on this line our own country has been and is well to the front. Many proofs of this might be given, but among the most notable contributions of modern times to the science and art of delicate and precise measurement, one cannot fail to note the splendid work of Rowland in his measurement of light wave-lengths, of Langley in his solar researches, and of Michelson in his determination of the metre in terms of the ether vibration. The glory of the nineteenth century is exact experiment and honest logic, and precision in measurement has done much to make both possible.

In the matter of the metrology of the affairs of daily life, however, it is humiliating to confess that we are still skulking in the rear. Our sixty millions of intelligent citizens are far less intelligent, and less fit for the responsibilities that rest upon them, than they might be, were they not continually wearying their brains and wasting their intellects in constant struggle with the difficulties inherent in the system of metrology to which we so blindly cling. I yield to no one in my appreciation of the accurate learning and profound scholarship of the gentlemen of the Faculty of the institution before which I have the honour of appearing to-day, but I unhesitatingly affirm that not one of them, not even all of them together, can correctly set forth the system of weights and measures in common use at the present time in this country. Let us hope that this burden will be lifted in the near future, and that the pound and yard with their innumerable and irrational derivatives, relics of the dawn of civilisation, will be replaced by the beautifully simple kilogramme and metre. We can then rest with the pleasing assurance that when the next cataclysm shall have passed, and the archæologist of the future shall be burrowing among the ruins of the present age, he will not be misled by the crudeness of our metrology to catalogue us along with earlier civilisations. At best he will exhume much which we could wish to remain for ever buried, but let us hope that the evidence of integrity and simplicity in commercial transactions, of delicacy and precision in scientific investigations, and especially of honest and independent thinking, will be such that he will be compelled to put us down as a race in which, to apply the eloquent words of Buckle, "the greatness of men has no connection with the splendour of their titles, or the dignity of their birth; it is not concerned with their quarterings, their escutcheons, their descents, their dexter-chiefs, their sinister-chiefs, their chevrons, their bends, their azures, their gules, and the other trumperies of their heraldry; but it depends upon the largeness of their minds, the powers of their intellect, and the fulness of their knowledge."

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 1.—M. Lœwy in the chair.—The mass of Mercury and the acceleration of the mean movement of Encke's comet, according to the recent work of M. O. Backlund. A note by M. O. Callandreau.—On the automatic transmitter of steering directions, by Lieut. H. Bersier. The alternating current from a Ruhmkorff's coil passes from the pivot of a compass through the aluminium pointer, and leaps from the extremity of this needle to one of six vertical plates placed at intervals round the inside of the compass-box. This alternating current has no effect on the magnet, but serves to work six corresponding relays, and hence to cause the illumination of corresponding signal lamps placed in various parts of a vessel, and to set in motion the steering apparatus. The least deviation from the set course is automatically and immediately corrected in this way. The course is altered by simply rotating