THE

BATTLE OF THE STANDARDS:

THE ANCIENT, OF FOUR THOUSAND YEARS, AGAINST THE MODERN, OF THE LAST FIFTY YEARS—THE LESS PERFECT OF THE TWO.

BY JOHN TAYLOR,

AUTHOR OF
"THE GREAT PYRAMID, WHY WAS IT BUILT?"
ETC., ETC.

"THOU SHALT HAVE A PERFECT AND JUST WEIGHT, A PERFECT AND JUST MEASURE SHALT THOU HAVE: THAT THY DAYS MAY BE LENGTHENED IN THE LAND WHICH THE LORD THY GOD GIVETH THEE."—*Deut.* xxv. 15.

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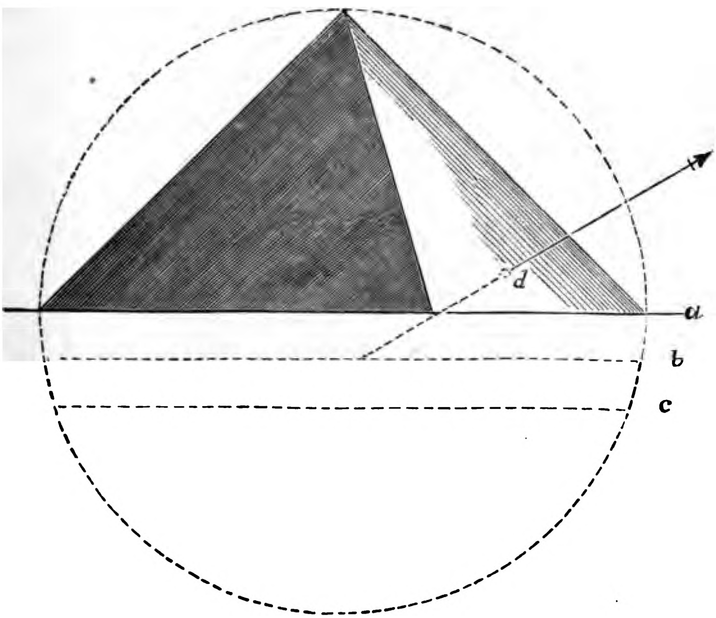
PROJECTION OF THE GREAT PYRAMID WHEN ENTIRE AND COVERED WITH THE CASING STONES.

Length of each of the four sides at the base, 764 feet.
Vertical height, 486 feet, to the apex.



a. Level of Surface of Ground.
b. Level of Chamber in Rock.
c. Level of Low Water in the Nile.
d. Descending Passage, in a straight line to Entrance of Chamber in Rock.
* Polar Star, as seen from the bottom of the descending passage.

CONTENTS.

*** As the Bill for legalizing the *Metric System of Weights and Measures* did not receive the Queen's assent, Mr. W. Ewart gave notice on July 28, 1863, that he should move for leave to bring in a new Bill for that purpose, at the next session; but "that, as the general opinion of the House seemed to be in favour of a permissive Bill, he should limit his motion to such a measure."—*Times.* Nos. 1, 2, 3, and 4, relate to this subject, which is most interesting to every Englishman.

PREFACE.

OUR Motto, from Deuteronomy, points to a very important consideration: viz.—That the people who maintain a *perfect* and *just weight*, and a *perfect* and *just measure*, may expect *lengthened days* in the land which God giveth them. If any people were ever entitled to so great a favour, it might be the Inhabitants of this Country. They have had the same measures of *Length, Capacity*, and *Weight*, from the earliest times; and they have been blessed with a long and unbroken series of peaceful Governments. Greater freedom from external foes, and from internal dissensions, has not fallen to the lot of any other nation.

Another remarkable peculiarity of our Country is, that it has been the *home of the oppressed*, when they have been exiled from other nations. Here, they have met with personal safety and kind treatment. The fetters of the slave fall from him, as soon as he lands on our shores; yet we interfere not with the Laws of other countries. We set them a good example, and would help them to follow ours, as far as we may; but without interfering with their internal regulations, because we should object to their intermeddling with ours. If they wish to become one with us, we shall be glad to see them enjoy the same liberty, and that kind of Government which suits them best; but we presume not to dictate to any nation.

Four of the great *Empires of the World* have risen, flourished, and passed away, since the *Great Pyramid* was constructed. Our Government, which is that of a *National Brotherhood*, alone is left, as if to shew Mankind, that it is possible to belong to the same *original Family of Man*, without absorbing other states, or being absorbed by any of them. We are advancing towards the end of the Christian Dispensation; and it is most satisfactory to see that we still retain the same Standards of Length, Capacity and Weight, which were first established, by an *Unwritten Revelation*, about 700 years before the Jews were formed into a Nation by Moses under the Laws of a *Written Revelation.*

It is to be hoped, that Wars may cease, Conquests be disclaimed; and instead of one Country becoming greater at the expense of another, or by its downfall, all may make common cause, and try to lessen, by the interchange of kind offices, the sudden and unavoidable calamities which each may have to endure. We have had happy experience of this good feeling among the greater part of the Colonies and Countries with which we are associated, by the bounty which has been extended to our own land in aid of our distressed operatives; and we are generally willing to shew the same good feeling toward others.

> "Oh! might we all our lineage prove,
> Give, and forgive,—do good, and love;
> By soft endearments, in kind strife,
> Lightening the load of daily life!"

SEPTEMBER, 1863.

THE GREAT PYRAMID,

A POEM,

WRITTEN FOR THIS WORK BY PATRICK SCOTT, ESQ.

AUTHOR OF "A POET'S CHILDREN," "FOOTPATHS BETWEEN TWO WORLDS," ETC., ETC.

1.

DWELLING, like greatest things, alone,
Nearest to Heaven of earthly buildings, thou
Dost lift thine ancient brow
In all the grandeur of immortal stone,
And, like the Centuries' Beacon, stand—
Up-springing as a tongue of Fire,
To light the Course of Time through Egypt's mystic land!

2.

'Tis not for Poet to inquire
Why thou wast built? and *when*?
Whether, in monumental state,
So great thyself to tomb the great
Beyond their fellow men?
Or whether thou dost still endure,
Work of dark times which thee did raise,
To carry on to future days
The notions of a natural Faith impure?—
Or dost thou, in thy bodily Magnitude,
Not uninform'd nor rude,
Declare the abstract ties which Science finds,
Seen by the light of *geometric* minds,
In fix'd proportions, each allied to each?
Or dost thou still, in inferential speech,
Reveal unto mankind the *girth*
Of the vastly rounded Earth;

And to the busy human race
Bequeath a rule, to guide the range
Of all the minor Measurements of Space,
Which Traffic gets, and gives, in endless interchange?

3.

Thou pointest, like an Index, to th' extremes
Of Time and Life. For ever in thy sight
Rolls that great River, the High Priest of Streams,
As consecrated by old Night
To minister to Memories of the past.
He comes on like a Conqueror,—not for blood,
But to subdue the waste. His waves have cast
More riches round them, as the stream has roll'd
Through many climes its solitary flood,
Than if they surged in gold.
O blessèd Spirit! of which no eyes behold
The Source whence thou descendest in thy power
To bid the Desert flower.
Thus, from a Fountain veil'd to mortal eye,
Heaven's bounty streams from high
To fertilize two worlds, and cause to bloom
The waste of Life, the desert of the Tomb.

4.

And near thee the Grand City spreads, where dwell
Sprouts from all modern nations, making there
A mixture of moralities and creeds,
And customs and costumes, that needs
Much time to comprehend, nor less to tell;
And half-suggests a prayer,
That the indignant Nile would rise, and hide
Th' Augean sights that shock the purer-eyed,
And through the chok'd streets flush its purifying tide.

5.

A thin line parts the living from the dead—
A few steps forward, and we tread
Where the long waste of ages wears the pall
Of Desolation—at our footsteps'-fall
The Locust, rising from his rocky bed,
Flits to some other spot, where he alone
May share, without a peer, his Desert-bounded throne.

6.

Stupendous pile! the things which thou hast seen,
In thy long life, pass by thee as a dream—
This forms the Poet's theme.
From thy old Kings, till now, the Great have been
Subjected to thy gaze. That wondrous man,
Miscall'd the MADMAN, in thy land began
To work his schemes, when Commerce rose,
By long-foreseeing Thought compell'd
To choose her Habitation; and the East
And Learning, in descending ages, held
In Alexandria's bowers her intellectual feast.

7.

Different was he, that Brand of War, whose breath
Chang'd, like the fell Simoom, the verdant sod
Into a waste — Genius of Crime and Death,
He the World's demon, and his Soldiers' god!
For still Reflection asks, for what great good
The First NAPOLEON stain'd the peaceful Earth with blood.

8.

And in this land the Traveller yet may hear,
Attentive with historic ear —
As o'er the keel-plough'd deep
The battle-clamours sweep,
The Voice of NELSON cry aloud, to slip
The iron thunder-shower from each recoiling ship.

9.

Enduring pile! Thou art the link that binds
The Memories of reflective minds—
Vast mass of monumental rock sublime,
That to the present Age dost join the Youth of Time.

*** This beautiful Poem was not received till after the Author had published his First Edition of the "Great Pyramid." He has much pleasure in adding it now.—The various causes, which have made the *Pyramid* famous, are touched on by Mr. SCOTT, with that consummate Poetic Art, of which he is so profound a master.

The Sonnet, which follows, was originally sent by Mr. Strong to the *London Magazine*, which the Editor conducted (from 1821 to 1824) with the aid of the late John Hamilton Reynolds and the late Thomas Hood, his valuable coadjutors.

SONNET FROM PETROCCHI.

Io chiesi al TEMPO; ed a chi sorse il grande
Amplo edifizio che qui al suol traesti?
Ei non risponde, e più veloci e presti
Fuggitivo per l'aere i vanni spande.
Dico alla FAMA; O tu che all' ammirande
Cose dài vita e questi avanzi e questi!
China ella gli occhi conturbati e mesti,
Qual chi dogliosi alti sospiri tramande.
Io già volgea maravigliando il passo,
Quando sull' alta mole, altero in mostra,
Visto girsene OBBLIO di sasso in sasso;
Ah tu, gridai, forse apristi, ah! mostra—
Ma in tuono ei m'interruppe, orrido e basso,
Io di chi fu non curo; adesso è nostra.

TRANSLATED BY MY FRIEND, THE REV. CHARLES STRONG, M.A. F.R.A.S.; AND SINCE REPUBLISHED IN THE SECOND EDITION OF HIS "SONNETS," 1862.

I ask'd of TIME; "To whom arose this high
Majestic pile, here mouldering in decay?"
He answer'd not, but swifter sped his way,
With ceaseless pinions winnowing the sky.
To FAME I turn'd: "Speak Thou, whose sons defy
The waste of years, and deathless works essay!"
She heaved a sigh, as one to grief a prey,
And silent, downward cast her tearful eye.
Onward I pass'd, but sad and thoughtful grown,
When, stern in aspect, o'er the ruin'd shrine
I saw OBLIVION stalk from stone to stone.
"Dread Power!" I cried, "Tell me, whose vast design—"
He check'd my further speech, in sullen tone;
"Whose *once* it was, I care not; *now* 'tis mine!"

AN

ESSAY ON THE STANDARDS,

ETC.

THE appearance of the *Great Pyramid* was sufficiently striking to arrest the attention of all strangers visiting Egypt, even if the purport of its erection were unknown. On the left bank of the Nile, about seven miles from Cairo, is still to be seen a group of Pyramids of various sizes, called the *Pyramids of Gizeh*, the largest of which, when perfect, was about 764 feet in length, on each of the four sides at the base, and about 486 feet in vertical height at the apex. It was originally cased over with a dark-coloured marble, like the black marble of Ashford in Derbyshire, the same that is called *Swinestone* by mineralogists; but this became white by the action of the sun in the course of years, and where it is now seen, it is of a bright straw-colour. The black marble of Ashford has changed to a whitish tint even in thirty years. There are two truncated columns of this marble, supporting two beautiful antique vases in the gardens at Chatsworth, which columns are now bleached throughout of a *dead white*—yet they have not been there, in that position, more than thirty years, as Sir Joseph Paxton informed me, when I saw them about three years ago.

The Swinestone of Egypt was brought from the Mokattam quarry, about fifteen miles higher up the

River Nile, and was, like the black marble of Derbyshire, capable of receiving a very high polish. It has often been asserted by some persons, that there never had been any prismatic casing-stones placed between the limestone blocks of which the kernel of the Pyramid is constructed; but, in 1837, Colonel Howard Vyse was so fortunate as to settle this question. He discovered, under the *débris* on the Northern side of the Great Pyramid, two of the casing-stones in their original position; and, before any change was made in them, Mr. Brettell, a civil engineer, ascertained the angle of their face with reference to its base, and found it to be exactly 51° 50′ 00″. The following remarks, on this discovery, are made by Sir John Herschel, in the last edition of his *Outlines of Astronomy*, 8vo, 1859, page 205:—

"At the date of the erection of the Great Pyramid "of Gizeh, which precedes by 3,970 years (say 4,000), "the present epoch, the longitudes of all the Stars were "less by 55° 45′ than at present. Calculating from this "datum the place of the pole of the heavens among the "stars, it will be found to fall near *α Draconis:* its "distance from that star being 3° 44′ 25″. This "being the *most* conspicuous star* in the immediate "neighbourhood, was therefore the Pole Star at that "epoch. And the latitude of Gizeh being just 30° "North, and consequently the altitude of the North "Pole there also 30°, it follows that the Star in question "must have had, at its lower culmination at Gizeh, an "altitude of 26° 15′ 35″. Now it is a remarkable fact, "ascertained by the late researches of Colonel Vyse,

* "*α Draconis* is now an *in*conspicuous star of the fourth magnitude, but there is distinct evidence to shew that it was formerly brighter."

" that of the nine Pyramids still existing at Gizeh, six " (including all the largest), have the narrow passages " by which alone they can be entered (all of which open " out on the northern faces of their respective Pyra- " mids), inclined to the horizon downwards, at angles as " follows:—

" First, or Pyramid of Cheops . . .	26° 41′
" Second, or Pyramid of Cephren . . .	25° 55′
" Third, or Pyramid of Mycerinus . . .	26° 2′
" Fourth, " " . . .	27° 0′
" Fifth " " . . .	27° 12′
" Ninth " " . . .	28° 0′
" Mean	26° 47′

" Of the two Pyramids at Aboussеir also, which alone " exist in a state of sufficient preservation to admit " of the inclinations of their entrance passages being " determined, one has the angle 27° 5′, the other 26°.

" At the bottom of every one of these passages, there- " fore, the *then* Pole Star must have been visible at its " lower culmination, a circumstance which can hardly " be supposed to have been unintentional, and was " doubtless connected (perhaps superstitiously), with " the *astronomical observation* of that star, of whose " proximity to the pole, *at the erection of these wonderful* " *structures,* we are thus furnished with a *monumental* " *record of the most imperishable nature.*"

It appears, from these observations, that 4,000 years ago, or about 2,160 years B.C., while Noah was still living, the Great Pyramid was constructed. It had been revealed to the Builders of that wonderful structure that the Earth was a *sphere,* the measurement of which they then made with great exactness; that it revolved daily on its *axis,* which was inclined 30° above the level of the horizon; that the axis was in a line with the Polar Star; and that the Earth's orbit was completed round the Sun in the course of a year.

Admitting all this for the present, it may be asked: "What proof have we that the same knowledge was not "possessed by the Philosophers of Greece or Rome?" We answer: "There is not the least reason to believe "that they, for more than *fifteen hundred* years "later, had any conception of these things." But, to answer this question in the most satisfactory manner, we extract the following passages from "The Students' Manual of Ancient Geography," published under the superintendence of Dr. William Smith, in 1861, as the latest authority on the subject:—

"*Homer* had no idea of the *spherical form* of the "Earth: he conceived it to be the upper surface of a "body of great thickness, which was as *round* as the "shield of Achilles, and so *flat* that it could be looked "across. This circular surface was edged by a river "named *Oceanus*, just as a shield is bordered by its rim." (p. 17).

"*Hecatæus* of Miletus (who flourished about 500 "B.C.) supposed the habitable world to be an *exact circle*, "surrounded by the Ocean, with which the Nile was "connected at its source." (p. 26).

"The true view of the *spherical form* of the Earth "originated with the *Pythagoreans*, and obtained general "belief: its exact form (an oblate spheroid), was not "known, although the revolution of the Earth on its "axis, which leads to the compression of the surface at "the poles, appears to have been surmised by *Aris*-"*tarchus*, B.C. 280." (p. 60).

Herodotus, "as far as we can gather from his descrip-"tion, supposed the world to be *oval*, rather than "circular, Greece holding a central position." (p. 28).

" *Eratosthenes* (B.C. 276 to 196), a native of Cyrene, " and educated at Athens, held the post of Librarian at " Alexandria under Ptolemy Euergetes. He brought " Mathematics and Astronomy to bear on the subject of " Geography, and was thus enabled to construct a very " much improved Chart of the World." (p. 46).

" *Strabo*, of Amasia in Pontus (B.C. 66 to A.D. 24), " agrees generally with the views of Eratosthenes. He " holds the Earth to be spherical, concentric with the " outer sphere of the Heavens, but immoveable." (p. 49).

" *Claudius Ptolemy* completed the science of Geography " in a work which served as a Text Book on the subject, " not only in his own age, but down to the fifteenth " century, when the progress of maritime discovery led " to its disuse. . . . . He flourished at Alexandria about " A.D. 150." (p. 55).

This is what is taught in our schools; but it is now seen, from the evidence of the Great Pyramid, that a *thousand* years before the time assigned to Homer, and more than *fifteen hundred* before Pythagoras or Hecatæus or Herodotus flourished, the Great Pyramid had been constructed, so as to embody records of the Earth's *form, size,* and *motion,* far more accurate than any of those to which the Greeks or Romans ever attained.

Yet the Greeks of Alexandria, under Ptolemy Euergetes, in whose reign (276 to 196 B.C.), the Septuagint Translation of the Hebrew Scriptures was made, could hardly be ignorant of some of those discoveries which had been made by the sons, or grandsons, of Noah two thousand years before.

What shall we say then? Shall we admit, as evidence of this wonderful Revelation, a *monumental Record of the* *most imperishable nature?* or shall we ignore its existence, and be content with what is taught, erroneously, as the Truth, in our Schools and Universities?

It is not possible to do justice here to the testimony of the Great Pyramid, but we may insert a *Memoir* on the subject which was drawn up in 1859, with the view of being read before the Royal Society. That Paper was *not* read, because it was thought more proper for the Royal Society of Antiquaries; but, as it contains the *scientific* grounds of the Author's belief, that the *Revelation thus embodied in Stone* was worthy of the notice of the Royal Society, he hopes he may be permitted to publish the *Memoir* here, and to appeal to the common sense of mankind for his justification.

It seems almost incredible, that a country, so recent as England appears to be from its history, should yet have had, from the earliest times, a Measure of Length (the *Inch*), which received its determination more than 4,000 years ago. Whether the *Inch* was brought to this country by any of those descendants of Noah, "by whom the isles "of the Gentiles were divided in their lands; every one "after his tongue, after their families, in their nations," (Gen. x. 5), we presume not to determine; but as it came from Egypt, where the custom of the country was to use a *Cubit*, and not a Foot, or a Yard, the *Inch* most probably formed a portion of that larger measure. In the estimation of Sir Isaac Newton, the Sacred Cubit was the length of 24·88 English inches. We have some reason to suppose that it a little exceeded this, being equal to 24·8832. But this measure forms so nearly 25 of our inches, that four Sacred Cubits (equal to 99·533 inches), are less by only half an inch than 100 inches.

Additional proof of the Antiquity of the English inch, is found in the measures of the Earth, as given in Herschel's Astronomy, (8vo, 6th Edit. p. 139).

There is a slight difference between the Estimates of Mr. Airy and M. Bessel; but it is too trifling to affect our present question.

	English Feet.	English Miles.
Greater or Equatorial Diameter	41,847,192(*426)	—7925·604(*648)
Lesser or Polar Diameter . .	41,707,324(*620)	—7899·114(*170)
Mean Diameter	41,777,253(*523)	—7912·309(*409)

The figures to which an Asterisk is prefixed, are those in which Mr. Airy's Estimate differs from M. Bessel's. We proceed now to place before our readers the true state of the case, by reducing these measures into English inches.

	Airy. English Inches.	Bessel. English Inches.
Greater or Equatorial Diameter . .	502,169,112*	—502,166,304
Lesser or Polar Diameter	500,491,440*	—500,487,888
Mean Diameter	501,330,276*	—501,327,096

We were induced to make this change, by the conviction at which we had arrived, from studying the Great Pyramid, that an *even number of Inches* was intended to be represented; and that this number was 500 Millions.

The difference between the English inches of the present day, and the original inches of 4000 years ago, may be seen by dividing the mean diameter of 501,330,000, by 500,000,000. The latter number requires the addition of 1 and $\frac{1}{3}$ in 1000 parts of an inch, to be made equal to the earlier inch.

In the measure of the Diameter of the Earth before the Flood, which amounted very nearly to the same number of inches contained in the present Earth, were 20 millions of Sacred Cubits, of 24·8832 English inches;

and, in the Diameter of the present Earth, are 20 millions of a Cubit Measure of 25 English inches.

It would have required 2,366,000 inches to bring up the Diameter before the Flood, to 500,000,000 of inches; but after the Flood, the *mean* measure of the Diameter is found to be 1,330,000, or 1,327,000, above 500 Millions. If the Ten Foot Rule taken out by Greaves, for the measure of the Pyramids, in 1636, were, as he says, perhaps *two*, in 1000 parts of an inch, less than it should have been, this difference would more than make up for the above number.

A similar increase is required for the same reason, in the estimate of the *cubic inch*, as contained in the *Porphyry Coffer*. We had previously shown, in the Great Pyramid, that the Coffer was intended to be 90 digits long, 40 digits deep, and 30 digits wide, also that each digit was equal to ·864 parts of the English inch. The total is 69,657 English cubic inches; but this number, in order to make up the cubic inches in the Karnak cubit, requires a little more than 2 in 1000 parts.

The Author had remarked ("Great Pyramid," p. 37) that *one* English foot bears the same ratio to the side of the Great Pyramid, which the circumference of the Earth bears to *one hundred thousand millions of English feet*. "This curious and novel relation," says Sir John Herschel, "may be most intelligibly expressed under "the following form of announcement, viz: — That a "*belt* encircling the *globe*, of the breadth of the base "of the Great Pyramid, would contain one hundred "thousand millions of square feet. . . . If we suppose "the *belt* meridional, and the area expressed in "*modular* square feet, the approximation is within one "part in 1,100. The fact is interesting, as offering "the only tolerable approach, in round numbers, to an

" arithmetical relation between any of the dimensions " of the Pyramid and those of the Earth." But in his next Letter to the *Athenæum* (May 1, 1860), Sir John qualifies this opinion by observing, " There is another " and a remarkable one, which I do not find noticed by " Mr. Taylor, or elsewhere ; viz.: that the height of the " Pyramid, including the casing, and measured from base " to apex, supposed to terminate in a point, is the two " hundred and seventy thousandth part of the Earth's " circumference. Taking the *equatorial* circumference " as unity, the error of this aliquot is one part in 736; " but if the *polar*, is only one in 3,506, the former error " being in defect, the latter in excess; so there exists " somewhere or other on the globe, a *diametral* section " whose circumference is *exactly* 270,000 times the ori- " ginal height of the building. Though not a meridian, " it is not very remote from one." The *proportion* here stated, had been noticed by the Author, at pp. 26 and 27 of the " Great Pyramid," where he shows that there are 270,000 Roman *miles* (not 31,500, as Eratosthenes erroneously imagined) contained in the Earth's circumference of 130,909,000 English feet.

If the circumference of the Earth were divided by 763·9, it is equal to 130,907,200 English feet; if by 764, to 130,890,100 English feet. The Roman mile is equal to 4848·5 English feet: 270,000 miles are 130,909.500 feet.

The English inch does not appear to have been in existence before the Flood. At that time, we find the Sacred Cubit the only measure recorded. When the Great Pyramid was constructed, and the new Earth measured, the Cubit of 25 inches would take the place of the Sacred Cubit in the East; and, perhaps a 25-inch Rule may have been adopted in England. A *two-foot* Rule has long since superseded this Cubit, if it ever prevailed with us; but, it is worth restoring now, if it be only to shew mankind the size of the Sacred Cubit, and how correctly the 20-millionth part of the Earth's diameter may be represented by the 25-inch Rule, which is only the *eighth* of an *inch* longer than that Sacred Cubit, by which the Ark was measured, when it was built by Noah, under the direction of the Almighty. According to the measure of the Sacred Cubit, the size of the Ark a little exceeded that of the "Great Eastern" Iron Ship (see p. 308).

From what has been said in the preceding pages, it will be perceived, that a *Divine Revelation* was made to mankind, of which the *Great Pyramid* is the Record, about 700 years before the *Revelation* of which the *Pentateuch* is the Record. Although the *Art of Writing* was not communicated to mankind, until it was employed by Moses to reveal the word of God, in order that after-ages might have no reason to doubt the verity and authority of the communication; still the earlier Stone Revelation was quite as precise and indubitable. We cannot misunderstand its purport, nor hesitate to believe the Truths it was capable of imparting. No one has been so bold hitherto, as to deny the validity of the Evidences embodied in the Marble Monument, though some persons are to be found who appear to doubt the validity of the Written Memorial, and strive to discredit its Testimony.

There had been, of old time, *Revelations* made to certain persons chosen out for that purpose, before the communication which was made to the Founders of the Great Pyramid; and unless these Revelations had been made, that work could not have been completed. One related to the *Art of Number*, by means of the so-called *Arabic Numerals*. Without their aid, the various combinations of figures, increasing ten-fold in power as each preceded another, (reckoned in order from right to left), could not have been denoted. *The Art of Writing* was then unknown, while *Number* had been long resorted to. 2. *Geometry* was understood, and practised, before the Flood as well as after. 3. The use of the *Mechanical Powers,* with the *Art of Shipbuilding,* must have been made known to NOAH by means of a Divine Revelation; since he could not otherwise have built the Ark.

We may go farther back, and say that the knowledge of the *Arts of Common Life* must have been communicated by Revelation to the *First Man;* and that, without a full command of Language, he could not have given "*Names* to all cattle, and to the birds of the air, "and to every beast of the field"; for "whatsoever "Adam called every living creature, that was the name "thereof." He was at once inspired with the *Art of Language* in perfection, and had not to learn it by slow degrees, as a child now learns it by the patient teaching and long continued care of its parents. The *First* Man could never have attained to the right use of *words* by this process, any more than an infant, without father or mother to take care of and instruct it, could ever learn to clothe, feed, and protect itself. In all these cases, Man's boasted *Reason* would prove but a sorry substitute for that *Instinct* with which the Almighty has endowed the inferior creatures. They never fall below what is required of them, but they never rise above it; they never fail, but they never improve. Man is able to surpass himself; but it is only by receiving *Divine Instruction,* when he feels the need of it, and asks it from his *Heavenly* Father.

The *Knowledge* revealed to Man, by the favour of God, is essentially different from that knowledge which men are able to acquire for themselves. "Lo, this "have I found, that God hath made man *upright*; but they "have sought out many inventions" (Eccles. vii. 29.) These are the words of "the Preacher, the Son of "David," and they express a great Truth, which is too much lost sight of (it may be feared) in the present day. By the *upright*, Solomon means the *righteous*, (JASHER), a name applied to Noah. By "*Inventions*" he means such *engines* or *machines* as Uzziah employed, when it is said, "He made in Jerusalem *engines* in-"vented by cunning men, to be in the towers, and upon "the bulwarks, to shoot arrows and great stones withal" (2 Chron. xxvi. 15). *Inventions* here especially meant those *engines* by which men's lives may be *destroyed*; but the word is also applicable to those *engines* or *machines* by which men's lives may be *preserved*, or by which they themselves may be made more *comfortable* while they live.

In some important particulars the two kinds of Knowledge greatly differ. That peculiar *knowledge*, which is granted to the *upright*, is of a nature to which Man, by his own unaided reason, could never have attained: it is *above his powers*, and even *beyond his imagination*. Man's *inventions*, on the contrary, are *beneath* his powers, and *under* his own conception and control. Again, the knowledge *revealed* to man is *perfect* at the first; but that which is the effect of man's discovery is in a state of *progressive improvement*. These differences are well exemplified in the Great Pyramid. Although the divine knowledge indicated by that wonderful structure had been imparted so long, and though it exhibited such amazing evidence, as we now see, of those scientific truths which no one endeavours to gainsay or deny—yet all other men, except the few with whom the Pyramid originated, remained totally unmoved, uninfluenced, and uninstructed by its teaching. It was not till about 2,000 years afterwards, that the knowledge it was capable of communicating was gradually made known, and this was probably done at Alexandria by means of the Hebrew Scriptures, and their translation into Greek. Even then the *form* of the Earth, and its *revolution* on its axis, as well as round the Sun, was not commonly known; nor were these facts generally believed in Europe till after the age of Galileo and Copernicus.

MOSES was an *upright* or righteous man, and to him GOD said: "Come up to me in the Mount, and "be there; and I will give thee Tables of Stone, and a "Law and Commandments which I have written, that "thou mayst teach them." They were *written*, in order that they might be *taught*. The necessity for this was the origin of all alphabetic writing. The Commandments were first written on two Tables of Stone by the "finger of God." Moses, in consequence of the sins of which the Israelites had been guilty, during his absence in the Mount, brake the Tables by casting them from him on his return. The Lord then said to him: "Hew thee two Tables of Stone like unto the first, and "come up unto me into the Mount, and make thee an "ark of wood. And *I will write* on the Tables the words "which were on the First Tables which thou brakedst, "and thou shalt put them in the ark" (Deut. x. 1, 2). Here we see the commencement of all *writing in alphabetic* characters; and that it was revealed first to an *upright* or *righteous* man.

Some persons have supposed that because the *art of* *writing,* by means of *Hieroglyphics*, is evidently more imperfect than that of *Alphabetic* writing, it may be more ancient. Upon this subject, the late Sir George Cornewall Lewis makes some valuable remarks in his "Historical Survey."

"The Egyptologists do not indeed pretend that any "great amount of historical knowledge has been "hitherto derived from hieroglyphic inscriptions. They "profess to have read certain names of kings which "they identify variously with names in Manetho's lists; "but they do not assert that the inscriptions furnish "either a coherent chronology, or events in the reigns "of the kings. Brugsch, in his work on the *Primeval* "*History of Egypt*, lays it down, that the ancient "Egyptians had no Era, that they denoted events only "by the year of the king's reign, and that this mode of "reckoning affords no materials for a chronological "system. The meagreness of the historical information "which Bunsen and Brugsch profess to have extracted "from the hieroglyphical inscriptions must be apparent "to every reader. Bunsen, indeed, speaks of ancient "Egypt as the 'monumental' nation; but its monu-"ments are colossal buildings, not intelligible inscrip-"tions containing historical records. If the hiero-"glyphical writings, which have been interpreted, have "been interpreted correctly, and if they may be taken "as a sample of the rest, we may be satisfied that *there* "*is nothing worth knowing*. The work of Sir Gardner "Wilkinson, upon *Ancient Egypt*, which speaks to "the *eye*, is far more instructive than the efforts to "address the *mind* through the restored language of "the Egyptians. It may be feared that the future "discoveries of the Egyptologists will be attended with "results as worthless and as uncertain as those "which have hitherto attended their ill-requited and "barren labours."*

Greaves, in his "*Discourse of the Romane foot and "Denarius;* from whence, as from two principles, the "Measures and Weights, used by the Ancients, may be "deduced,"† makes the following important statement:—

"If any shall find some little difference from some "originals, as *five or six grains in the English pound,* "and it may be *one or two parts of a thousand in the "English foot,* different from the *standards* in the "Exchequer, or the Tower, or at Winchester, or some "other place, it is not much to be wondered. For I "have found as great differences in collating the *English "standards* themselves."

Thus Greaves prepares us to expect that difference in his measure which Raper affirmed he had found, and which Dr. Hussey supposed to be as much as *two* in 1,000 parts of the English foot or inch.

The same difference is doubtless to be expected at the present day, but it is of less moment now than it formerly was, since we can restore the full measure whenever we please, as Sir John Herschel has shown us, in his Letter on the *Modular Unit;*‡ and whether we add the *thousandth part* of an inch, or *twice* that quantity, it is practically of no real importance. The Man of Science can supply the defect at any time, when he is engaged in calculations which require the addition to be made; and, on all other occasions, it is not worth naming.

The *Unwritten* Revelation, made to mankind 4,000 *years* ago, gave rise to most of the *measures* which have since

* *Historical Survey of the Astronomy of the Ancients.* 8vo 1862, p. 395.

† London, small 4to, 1647, page 120. ‡ See p. 39, following.

occupied the minds of men, however diversified they seem. By that Revelation it was made known, to a few persons at first, that *Time* was a Measure of *Space*, and that, while the Earth was revolving on its axis, it made a perfect measurement of itself every twenty-four hours. It would be easy to shew in what manner this was done; but the following results, with regard to the Pyramid foot of 1·0909 English, the Greek foot of 1·0101 English, and the English foot, may be sufficient for this place.

The EARTH, in twenty-four hours, reveals itself in a direct line under the SUN, to the extent of—

120,000,000 Pyramid feet of 1·0909; or, of
129,600,000 Greek feet of 1·0101; or, of
130,908,960 English feet of 1·000—.

which are all the same measure. *This is the Circumference of the Earth.* But this measure may be as perfectly represented by 1,570,907,520 Inches, which will serve the better for comparison. *To denote the Diameter*, requires TWENTY MILLIONS OF CUBITS, each of TWENTY-FIVE ENGLISH INCHES,—a *New Measure* with us, but probably the *earliest of all Measures.* The total is 500 Millions of Inches which, multiplied by 3·1416,* is equal to 1,570,800,000. The difference is 107,520 Inches, in the entire circumference, being very nearly the thousandth part of an Inch, required to be added to Greaves's measure, and possibly to the *Inch* of the present day, to compensate for what it may have lost in 4,000 years. If we wish to make the *Inch theoretically* perfect, we have only to add *one-thousandth* part to it, as Sir John Herschel proposes.† It must be admitted, that within this limit, all measures are *identical* for any useful purpose.

* See *Great Pyramid*, p. 81, Hindoo Ratio.
† See *Supplementary Papers*, p. 39.

BRIEF MEMOIR OF THE GREAT PYRAMID.

Why it was Built.

Offered as a Communication to be read before The Royal Society in 1859.

AN opinion has long been entertained, that the Pyramids of Gizeh were intended for the Tombs of Kings, and that the Stone Coffers, found in them, were their Sarcophagi. But, at the commencement of the present century, certain men of science, who accompanied the French expedition into Egypt, endeavoured to show that the Great Pyramid might have had a scientific object. M. Jomard thought that the present Egyptian cubit was intended to be contained 400 times in the side of the base of the Great Pyramid, and the common cubit, 500 times; as also that the side was the 480th part of a degree of the meridian proper to Egypt. The real Measures, however, fail to support any of these conclusions; and, after a lapse of more than fifty years, this theory is held to be as far from verification as it was at the commencement of the century; yet, it is in this direction, if in any, that we may hope to find a satisfactory answer to the question, "*Why was the Great Pyramid built?*" For if it were constructed on *scientific* principles, an accurate estimate of its *measures* would, perhaps, reveal its purpose. As a Sepulchre, of course, we could not expect it to be constructed on any well-defined system of proportion; and further scrutiny would be hopeless on that supposition.

The measures of the *side of the base* of the Great Pyramid, made by many different persons, at different times, seem so little to correspond with each other, that, at first sight, we can discover no chance of reconciling them. In English feet, they are represented, according to the best authorities, by the following figures; 693, 728, 746, and 764 feet, the smallest of these numbers being the earliest of all recent measurements making any claims to accuracy; and the largest being the latest of all. These several stages have one striking peculiarity running through them — they differ from each other apparently by a regular series of increasing numbers. From 693 to 728, there is an increment of 35 feet (or twice 17½); from 728 to 746, of 18 feet; and from 746 to 764, of 18 feet. We might suppose, from this general result, that in some way or other the various measures are capable of adjustment; and, that if the right principle of increase were ascertained, the whole might be brought into some kind of harmonious relation. Unless this could be done, we should have no ground to proceed upon; but, if it could be satisfactorily established, that the various measures formed part of one uniform system, the difference between them, instead of obstructing, would assist us in our inquiries after that original measure, which must first be discovered before we can advance any farther.

The blocks of stones, which constitute the four lowest tiers of the Great Pyramid, as it now stands, are about 4 feet 10 inches in perpendicular height, and gradually diminish, as they approach the top of the structure, to 2 feet 2 inches.

In 1637, Mr. John Greaves, Savilian Professor of Astronomy in the University of Oxford, measured the

Great Pyramid with extreme care, and made the side of the base 693 English feet.

Between 1646 and 1693, the French Mathematicians, from various measures made by de Monconys, Thévenot, de Chazelles, Fulgentius of Tours, de Nointel, etc., found the base to be 682 French feet, or 728 English.

Two Englishmen are named as confirming this measure, viz.: Melton and Graves.

In 1763, Davison, our Consul at Algiers, records the base as being equal to 746 feet. This measure was remarkably confirmed by M. Jomard in 1798, who found the base to be 227·32 *mètres*, or 745·8 English feet.

A year after this, Le Père, the architect, and Colonel Coutelle, carefully surveying the platform on which the Great Pyramid was built, perceived two indentations in the rock, 8 inches deep, one at each extremity, in which a corner-stone might have been originally placed; and measuring carefully the base again with this addition, they affirmed it to be equal to 232·747 *mètres*, or 763·6 English feet.

Finally, in 1837, about 200 years after Greaves had made his first attempt to determine the true measure of the base, Colonel Howard Vyse discovered two of the *actual Casing-stones* in their original position, under the *débris* which had been thrown down on the north side by forcing the present entrance. "The size and angle " of the building could therefore be exactly determined " and all doubts were removed respecting a *revêtement*" (*Vyse's Operations*, vol. i. p. 261). Each of the casing-stones was equal to 8 feet 3 inches at the bottom, 4 feet 3 inches at the top, 4 feet 11 inches in perpendicular height, and 6 feet 3 inches in sloping height. Mr. Perring, the English surveyor employed by Colonel Howard Vyse, now measured the base to the extremity of the casing-stones, and made it 764 feet; thus establishing, in the most conclusive manner, the truth of the conjecture of the French *Savans* in 1799, that the indentation at each end of the base had been occupied by a corner-stone, and confirming their measure of 763·6 English feet.

To Colonel Howard Vyse we are indebted for the discovery, that the casing-stones, being about 8 feet 3 inches wide at the bottom, and only 4 feet 3 inches at the top, must have sloped gradually upwards from the base of the Great Pyramid (where they were brought in contact with a pavement extending 33 feet 6 inches beyond the casing-stones), to the topmost-stone of the entire building.

The complete measure of the side of the base, including the casing-stones, is thus, by the French estimate, 763·6 English feet, and by the English, 764 feet. Exclusive of the casing-stones, the French made the base 745·8 English feet, and the English, 746 feet. The difference between the two measurements is only 5 inches in the entire measure, and 2½ inches in the measure without the casing stones. The English and the French nations are both alike entitled to great credit in bringing about this result, after the Pyramid had existed for about forty centuries without any light being thrown on it.

If we deduct the measure allowed by the French mathematicians in 1798, for the casing-stones, viz.: —17·8 English feet from 745·8 English feet, we have 728 English feet left. This would be the measure of the base, if the lowest tier of stones were hidden by the sand; and this was the measure arrived at by the French authorities in 1693. Allowing for the next tier 17·5 English feet, of which there is no positive measure extant, and for the third tier of stones from the bottom, 17·5 English feet, we have to deduct 35 feet from 728; and this leaves 693 feet, which was the measure so carefully estimated by Greaves about 1637. At this time, therefore, we may suppose, the three lowest tiers of stones, as they are now seen, were hidden by the sand. Thus all the various measurements are found to corroborate each other, though they were formerly thought to present irreconcileable differences; and the latest measurements, being those in which we are chiefly interested, are all but identical with each other, differing only about five inches in a line of 9,168 inches; though recorded in the measures of two different countries, France and England—measures which cannot easily be brought into exact agreement with each other.

The various estimates which have been made of the *height* of the Great Pyramid, are incapable of any nice adjustment. Greaves, in the first edition of his *Pyramidographia*, comes the nearest to the truth, when he affirms the perpendicular height to be 481 feet, and in his "*Observations*," published after his death, in which he states it to be 490 feet: it is about midway between the two *numbers*. But by the discovery of the casing-stones *in situ*, all doubt as to the original height is now removed. The angle which the face made with the base, was most exactly ascertained by Mr. Brettell, Civil Engineer, to be 51° 50′. This angle, with a base line of 764 feet, gives for the vertical height, supposing the Pyramid ended in a point, 486 feet; or with a base line of 763·6 English feet (the French measure), 485·85 English feet.

What reason, it may be asked, can be assigned for the Founders of the Great Pyramid giving its face this angle with the base, and not making each face, as Greaves and others conjectured it to be, an *equilateral* triangle? The only reason we can assign is, that they imagined the Earth to be a perfect sphere, and as they knew that the radius of a circle must bear a certain proportion to its circumference, they then built a four-sided Pyramid of such a height in proportion to its base, that its perpendicular would be equal to the radius of a circle, whose circumference was equal to the perimeter of the base. We can hardly imagine that the Founders of the Great Pyramid were able to determine the angle of the face of such a Pyramid with quite as much accuracy as it might be done at the present time; but if they had such an object in view as that which we are supposing, they would construct the Great Pyramid, so as to make the angle of each face with the base bear some near relation to the angle of $51^\circ\ 51'\ 14''$, which is that ascribed to such a Pyramid by modern science. The actual angle of the face, according to the casing stones, was $51^\circ\ 50'$. Can any proof be required more conclusive than this, that the reason which is here assigned for the building of the Great Pyramid, was the true reason? It was *to make a Record of the measure of the Earth* that it was built.

Herodotus says of the Great Pyramid, when he saw it (about 440 B. C.) "that, it is made of polished stone, "jointed with the greatest exactness; and none of the "stones are less than 30 feet." He saw the Pyramid when it was covered all over with the casing-stones, for his measure of the stones is evidently surface-measure. The lowest of the casing-stones, being 6 feet 3 inches in sloping height, would, with a width of 5 feet, yield 30 feet in superficial measure; and the highest of the casing-stones, with a sloping height of 2 feet 10 inches, would, on a length of 12 feet, yield the same surface. When the casing-stones were first seen by Colonel Howard Vyse, "they were quite perfect, had "been hewn into the required angle before they were "built in, and had then been polished down to one "uniform surface; the joints were scarcely perceptible, "and not wider than the thickness of silver paper; and "such is the tenacity of the cement with which they are "held together, that a fragment of one that has been "destroyed remained firmly fixed in its original *aligne-"ment*, notwithstanding the lapse of time, and the "violence to which it had been exposed. The pavement, "beyond the line of the building, was well laid and "beautifully finished, but, beneath the edifice, it was "worked with even greater exactness, and to the most "perfect level; in order probably to obtain a lasting "foundation for the magnificent structure to be built "upon it. I consider (says Colonel Vyse) that the "workmanship displayed in the *King's Chamber*, in this "*pavement*, and in the *casing-stones*, is perfectly unrivalled; "and that there is no reason to doubt that the whole "exterior of this vast structure was covered over with "the same excellent masonry." *

The stones of which the *body* of the Great Pyramid consists, were quarried from the rock on which it stands. They are a free limestone, and abound with fossil remains. The *casing-stones* are a kind of marble, brought from a rock on the other side of the river, called the Mokattam Quarry. This rock is a compact limestone, which contains few fossils, and is termed, by Geologists, Swinestone or Stinkstein. It is at first of a dark colour; but the portions seen in the British Museum are now of a yellowish white, or cream colour, bleached throughout by the Sun in the course of so many centuries. It takes a very high polish; and if the purpose of the Founders had been to construct a building

* *Vyse*, vol. i. p. 261.

which should remain unimpaired for all future time, they would endeavour to cover it with casing-stones of remarkable hardness, whatever might be the colour. They would join these stones together with the thinnest cement of extreme tenacity; they would so arrange the blocks, that all should expose a surface of equal extent in square feet; they would make the structure end in a point, to prevent the lodgment of anything on the top which might injure the permanency of the edifice; they would do, in short, all that has been done by the Founders of the Great Pyramid to preserve it from disintegration or decay, arising from the action of of the elements, or from the violence of man.

Let us now enquire for what probable reason they would take such extraordinary pains. Was it to raise an imperishable monument, to which all nations, before they became too widely dispersed, might appeal for a *standard* of measure? If so, we might expect to find embodied in the building some unequivocal proofs that this was their design: we might expect, that, as the *proportion* which the diameter of a circle bears to its circumference is now known to be that of 1 to 3·141592, something near this proportion would be that of twice the perpendicular height of the Great Pyramid to its perimeter. Let us try the question by this test.

The perpendicular height is 486 feet, and twice that number is 972 English feet. The perimeter is 3,056 feet. If we take the French measure, it gives us 485·85 English feet for the height; 971·7 for the double of that number; and 3,054 for the perimeter. In the diameter of a circle equal to 3,056 feet, there are 1,000 feet of ·972 parts of the English foot; and in its circumference are 3,144 of such feet. Is there any ancient foot which comes near this measure?

This is (we find), the *earlier Roman foot,* sometimes called the *Italian.* Greaves says: "In the year 1639, I "went into Italy, to view, as the other antiquities of "the Romans, so especially those of weights and "measures; and, to take them with as much exactness "as it was possible, I carried instruments with me "made by the best artizans.

"My first inquiry was after that monument of "*T. Statilius Vol. Aper*, in the Vatican gardens, from "whence *Philander* took the dimensions of the Roman "foot, as others have since borrowed it from him. In "the copying out of this upon an English foot in brass, "divided into 2,000 parts, I spent at least two hours "(which I mention to shew with what diligence I pro-"ceeded in this and the rest), so often comparing the "several divisions and digits of it respectively one with "another, that I think more circumspection could not "have been used. It contains 1,944 such parts as the "English foot contains 2,000."* This is precisely 972 parts of 1,000, equal to 11·664 English inches. Many other authorities might be quoted in corroboration of this measure.

"My next search," says Greaves, "was for the foot "on the Monument of *Cossutius, in hortis Colotianis,* "from whence it hath since received its denomination "(though it be now removed), being termed by writers "*Pes Colotianus.* This foot I took with great care, as it "did well deserve, being very fair and perfect; afterwards, "collating it with that Roman foot which *Lucas Pætus* "caused to be engraven in the Capitol, on a white "marble stone, I found them exactly to agree. Now "this of *Cossutius* is 1934 such parts as the English

* *Greaves's Works by Dr. Birch,* p. 207.

"foot contains 2,000."* This foot, therefore, contains 967 parts in 1,000, equal to 11·604 English inches. How may this difference between 972 and 967 be explained?

There is a passage in Pliny which throws light upon it. "Eratosthenes, who was skilful in all kinds of "learning, but especially in this wherein he excels all "other persons, and is by all esteemed a great authority, "sets down the entire compass of the Earth at 252,000 "stades, which measure, by the Roman computation, "makes 31,500 miles. A startling conclusion! but yet "so well supported by skilful reasoning, that we should "be ashamed not to believe him."† There is, however, a great mistake in this statement. If we regard the *proportion* which the perimeter of the Great Pyramid bears to twice its perpendicular height, and divide 3,056 English feet by 3,150 Roman feet, we obtain for the latter a foot of 970 of the English foot, or 11·640 inches. This was the measure of the *Roman foot* obtained by Raper, "from a measurement of the most ancient buildings in "Rome"; and it is also that of many other eminent authorities. This is sometimes called the *later* Roman foot, in contradistinction to the *earlier*, which is then called the Italian.

There is a mistake, as we have said, in Pliny's statement, which arose from a misconception as to the length of the Roman *mile*. In 5,000 Roman feet of ·970 English feet are 4,850 English feet. This may be equal to a Roman mile; but 31,500 of these *miles* are equal to 152,775,000 English feet; and this number exceeds by *one-seventh* the actual measure of the Earth's circumference. There are only 27,000 Roman miles of 4,850 English feet in

* *Greaves's Works by Birch*, p. 208.

† *Plin. Hist. Nat.* l. ii., c. 112.

130,950,000 English feet; which number is a little more than the measure of the Earth's circumference, when it is estimated in the latitude of the Great Pyramid. If we deduct *one-seventh* from 152,775,000, it leaves for the measure 130,950,000 English feet.

Nouet, who accompanied the French expedition into Egypt in 1798, calculated the latitude of the Great Pyramid, and found it to be 29° 59′ 49″; only 11″ short of 30°. Perring says, that the Pyramids extend from 29° 16′ 56″ to 30° 2′ 30″, and that they occupy a space of fifty-three miles from North to South. Pinkerton calculates the degree, in latitude 30°, to contain 363,724 feet; and the circumference is, therefore, equal to 130,940,640 feet.

It is a remarkable property of the English foot, in its connexion with the base of the Great Pyramid, that if we divide *unity* by 764 (the number of feet contained in the side of the base), the quotient exhibits, very nearly, the number of feet contained in the circumference of the Earth, namely, $\frac{1}{764}$ = ·00,130,890,052 English feet = $\frac{130{,}890{,}052}{100{,}000{,}000{,}000}$ — that is to say, one English foot bears the same ratio to the side of the base of the Great Pyramid, that the circumference of the Earth bears to *one hundred thousand millions* of English feet.

The *Greek foot*, as well as the Roman, is found in the measures of the Great Pyramid. Eratosthenes erred in reckoning 252,000 Greek stades in the circumference of the Earth, as much as he erred in the Roman measure. Deducting *one-seventh*, as before, leaves 216,000 for the number of Greek stades, which, reckoning 606·06 feet for the stade, is equal to 130,908,960 English feet. This is the smaller Greek foot, equal to 1·0101 English feet. The larger Greek foot is that which Stuart derived from the measure of the *Hecatompedon* at Athens. He made that foot equal to 1·0115 English feet, or 12·138 inches; but Mr. F. Penrose estimates it at 1·01336 English feet, or 12·16 inches. The smaller Greek foot is called the *Ptolemaic* foot. Eight stades of this foot are equal to one Roman mile, of 4,848·5 English feet.

A measure is recorded by Herodotus, as found in the Great Pyramid; but it is *superficial* or *square* measure, and not *linear* measure. He describes the Great Pyramid as being "four-sided, each face on every side "is eight plethra, and the height is equal" (*Her.*11.124.) As square measure, the *plethron* is often employed to represent the Latin *jugerum*, though this is said to have contained only 28,800 square feet. It is used by Herodotus for that quantity of land which in Egypt was called the *Aroura*; this was the square of 100 royal cubits. One of the smaller Pyramids, the middle one on the east side of the Great Pyramid, had a *base* originally equal to the square of 100 royal cubits, or 172 feet 6 inches, as it was measured by Mr. Perring. It would, in that case, contain 29,655 square feet.

The words of Herodotus, in the above extract, require some explanation. If each *face* of the Great Pyramid is eight plethra, and the *height* is equal, the height must be equal to eight plethra also. In this case, he must mean to say, that the number of *square feet* in the measure of each *face*, and the number of *square feet* in the measure of the *height*, are equal; but, if so, he must mean the *square* of the height, since he alludes only to superficial measure.

A sloping height of 618 feet, with a base of 764 feet, (at an angle of 51° 50′) allows for the content of each face, 236,076 square feet; and a perpendicular height of 486 feet yields, for the square of that height, 236,196 square feet. In the content of each *face*, are eight plethra of 29,510 square feet, and in the content of the *square* of the height are eight plethra, of 29,525 square feet. The angle required to make the square of the height equal in content to the content of each face is 51° 49′ 46″, a difference only 14″ less than the angle of 51° 50′, as measured by Mr. Brettell.

Diodorus Siculus assigns 700 feet to the side of the Great Pyramid. He says, "It is in shape four-sided, " and each side, at the base, contains 7 plethra," meaning linear measure. Each foot is equal therefore to 1·0909 of the English foot:—700 of these feet are 763·63, nearly 764 English feet.

Sir Isaac Newton says, that "the oldest feet of which " any account has been transmitted to us, are the *Roman*, " the *Ptolemaic*, and the *Drusian* foot, at Tongeren in " Germany, the last of which is equal to 13½ *Unciæ* of " the English foot" (Newton's *Dissertation on Cubits*, in Greaves's Works by Dr. Birch, p. 419). If we add to the Roman foot of 970 English feet, *one inch and a half*, it gives us exactly 1·0909 for this *foot of Drusus*.

The foot of Drusus, or of Diodorus Siculus, might properly be called the *Pyramid foot*. In the side of the base of the Great Pyramid are 700 feet of 1·0909 English feet, or 763·630 feet. In the circumference of the Earth are 120 millions of these Pyramid feet, of 1·0909, equal to 130,908,000 English feet. The *English foot* is most closely connected with this Pyramid foot: if we deduct *one twelfth* part from the Pyramid foot of 1·0909, it leaves the *English foot* without any remainder (1·0000).

The *English Inch*, finds its place most wonderfully at such a time among these measures of the greatest antiquity. If the circumference of the Earth be represented by 130,908,000 English feet, its diameter will be equal to 41,667,000 English feet, or 500 millions of English inches,— the only difference being that we must divide the circumference by 3·141792, instead of 3·141592, a difference of 2 in the fifth place.

Pliny says, "there are 883 feet in each side of the "Great Pyramid." His words are, "Amplissima octo "jugera obtinet soli, quatuor angulorum paribus inter- "vallis, per octingentos octoginta tres pedes singulorum "laterum." *Greaves*, mistaking the meaning of the word *soli*, which in this case means *surface*, says, "Certainly Pliny is much mistaken in assigning the "measure of the side to be 883 feet, and the *basis* of "the Pyramid to be but 8 jugera, or Roman acres." He thinks that "Pliny writ 28 jugera, instead of 8; "or else in his proportion of the *side* to the *area of the* "*basis* he hath greatly erred." As a means of correcting this supposed error in the number of feet in the side, M. Jomard would change the number 883, to 833, imagining that Pliny meant Roman feet, but this correction only brings up the measure to about *five-sixths* of the Roman foot. Pliny's measure, as it stands, is the right one. In the side of the Great Pyramid, when estimated at 763 feet, are 883 of ·864 English feet; or 10·368 inches; but this is properly a *Royal Span*, one of the most ancient of all measures. The *eight jugera of surface* which are said by Pliny to exist *in the equal intervals of the four angles*, are the same as the *eight plethra* of Herodotus above mentioned, and both mean *eight arouræ*, that same Egyptian measure which is equal to the square of 100 royal cubits.

The *Royal Cubit* is composed of 2 *Royal Spans*. It is equal to 1·728 English feet, or 20·736 inches. This measure is so commonly employed in the interior of the Great Pyramid, that Sir Isaac Newton, in his Dissertation on Cubits (*Greaves's Works by Dr. Birch*, p. 405), after mentioning nine eminent examples, varying from

21 inches to 20·400 inches (the average being 20·662 inches), concludes with saying, "It is my opinion, that "the Pyramid was built throughout, after the measure "of this cubit."

The *Cubit of Karnak* is equal to 2 *Royal Cubits*, or 4 *Royal Spans*. It is equal therefore to 3·456 English feet, or 41·472 inches. There are four square passages lined with granite in the interior of the Great Pyramid, which Greaves found to be all of an equal breadth, viz: 3·463 English feet, or 41·556 inches; and, over one square hole of this breadth, "are five lines cut *parallel* and *perpendicular*," as if they were intended to intimate that the entire space was divisible into four equal parts.

The smallest division is equal to a *royal span*, the half is equal to a *royal cubit*, and the whole is equal to the *cubit of Karnak*. An original measure of this largest kind was lately discovered, in Egypt, "at Karnak, on "the removal of some stones from one of the towers of a "propylon, between which it appears to have been acci-"dentally left by the masons at the time of its erection, "at the remote period of the 18th dynasty." Sir Gardner Wilkinson, who gives this account, attributes these towers to Horus (or Amun-men), who reigned from 1408 to 1395, B.C. This *cubit of Karnak* is now in the British Museum; and measures 41·46 inches, very nearly 41·472.

The *Royal* or *Philetærian foot* is the foot of the *Royal cubit*. It is equal therefore, to 1·152 English feet, or 13·824inches. The fragment of *Heron* alludes to this foot, when it states, that the *Italian foot* contains 13½ digits of that foot, of which the Royal or Philetærian foot contains 16 digits. In 13·824 inches are 16 digits of ·864 inches; and 13½ digits of ·864 inches are equal to 11·664 inches, which is the measure we have before assigned to the *Italian* foot; as derived from the perpendicular height of the Great Pyramid, viz.: ·972 of the English foot, or 11·664 inches.

The *Pyramid meter* is equal to 3 *Pyramid feet* of 1·0909 English feet, or 3·2727 English feet; 100 Pyramid meters are equal to 327·27 English feet. This measure is also called a *Stade.*

The Stade of 327·27 English feet is the *Egyptian Stade* according to Herodotus. It is also the *Stade of Aristotle;* his estimate of the degree establishes this fact. The number of 1,111 stades, which Major Rennell thought to be a purely imaginary measure of Aristotle, gives a *degree* of 363·630 English feet, which, in 360 degrees, produces a circumference of 130,908,000 English feet.

Aristotle says, that the *most ancient* measurement of the Earth's circumference was that adopted by *Thales* and *Anaximander*, who divided it into 400,000 stades. In 130,908,000 English feet, are 400,000 stades of 327·27, each containing as we have seen, 100 Pyramid meters of 3·2727 English feet, or 39·2724 inches. The new French metre is *one-tenth* of an inch longer than this, being 39·370 English feet.

The *Common Oriental Cubit* is the *half* of this *most ancient Pyramid meter*; it is equal therefore, to 1·6363 English feet or 19·6356 inches. It is contained 80 millions of times in the circumference of 130,908,000 English feet. Captain Jervis * states "the cubit universally" to be 19·5489 inches, or *one-tenth* of an inch less than this.

The *half* of this Common Oriental Cubit, is the *Oriental Span* of ·8181 of an English foot, equal to 9·8175 inches. This is that same *Geometrical foot,* which Mr. De Morgan finds mentioned in some mathematical works of the early part of the 16th century, wherein it is said to be equal

* *Records of Ancient Science.* Calcutta, 1835.

to the breadth of 64 barley-corns.* From all his enquiries and experiments, Mr. De Morgan comes to the conclusion, "that the *Geometrical foot* is anything the "reader pleases between 9·7 and 9·9 English inches," adding "the result from modern barley, gives 9·8." The *Oriental Span*, being 9·8175 inches, is contained 160 millions of times in the circumference of 130,908,000 English feet.

By the *Table of Constants*, the number of seconds in the circumference of the Earth, is expressed by the figures 1296000. These figures are regarded as those of *proportion* merely, and as having no reference to any actual measure. But if we look upon them as Greek feet, and multiply 360,000 feet by 360 for the degrees, we shall have the number of 129,600,000 *Greek feet*, which, multiplied by 1·0101 for the English foot, will make a total of 130,908,000 English feet, for the circumference of the Earth.

In this circumference of the Earth, are 1570,896,000 English inches. Twice this number is 3141,792,000 inches. In the *Table of Constants*, the figures 3·1415927 are made use of to denote the *proportion* which the circumference of a *circle* bears to its diameter, according to modern science. Taking the *half* of this latter number to mean *inches* of the English foot, the measure is only 100,000 inches less than the actual measure made in Egypt, when the Great Pyramid was constructed; at which time, the Circumference of the Earth was considered equal to 1,570,796,350 English inches.

It is a remarkable circumstance, that, in all these measures connected with the Great Pyramid, or deducible from the measurement of the Earth's circumference and diameter, made in the latitude of the

* *Arithmetical Books*, p. 9.

Great Pyramid, we find nothing to reveal the origin of the *Paris foot*. It is a measure of very great antiquity, yet we do not meet with any traces of it in Egypt. But when Greaves was at Constantinople in 1638, he measured the *Persian Arish*, and found it to be 3·197 of the English foot. He measured also the *larger Turkish Pike*, and made it equal to 2·200 English feet. He ascertained, besides, that the *smaller Turkish Pike* was in proportion to the larger, as 31 is to 32; but he draws no inference from any of these statements. Now it is worthy of notice, that as, in the *Table of Constants*, the *Paris foot* is reckoned at 1·0657654 of the English foot, or 12·789 inches, so, on comparing the measure with the *smaller Turkish Pike*, this is equal to *two* Paris feet, (of 12·7881 English inches), and the *Persian Arish* is equal to *three* Paris feet (of 12·788 inches). To what may we attribute this coincidence? Was the foot of Tyre brought by Phœnicians to the coasts of Gaul? It would seem so.

TWO LETTERS,

TO THE EDITOR OF THE ATHENÆUM,

ON A

BRITISH MODULAR STANDARD OF LENGTH,

BY

SIR J. F. W. HERSCHEL, BART.

(Reprinted by the Author's permission.)

COLLINGWOOD, *April* 23, 1860.

IT may not be unwelcome to the scientific portion of your readers to have their attention directed to a simple numerical relation between our actual parliamentary standard of length and the dimensions of the earth, which, in effect, puts us in easy possession of a "modular" system, which might be decimalized, and which, abstractedly considered, is more scientific in its origin, and, numerically, very far more accurate than the boasted metrical system of our French neighbours. It is simply this,—if the British Imperial standard inch were increased by one thousandth part, it would be, with all but mathematical precision, one five-hundred-millionth part of the earth's axis of rotation.

The calculations of the present Astronomer Royal, published in the year 1830, have determined the length of this axis at 41,707,620 feet, that is to say, 500,491,440 inches of our Imperial standard. Those of Bessel, published in 1841, at 500,487,744 such inches. More recently, an elaborate *résumé* of the whole subject, by M. Schubert, has conducted him to three separate and independent conclusions, based on arcs measured each in, or near, a meridian appropriate to the country in which they have been performed; viz., the Russian, the British Indian, and the French arcs. The Russian and the Indian combinations give respectively 500,532,120 and 500,550,168, while the French arc gives only 500,368,920. M. Schubert rejects the latter altogether; but the propriety of doing so appears to Mr. Airy questionable, on grounds which we consider so far reasonable as to entitle it to at least half the weight of either of the former. On the other hand, M. Schubert, in computing his mean result, assigns to the Russian result double the weight of the Indian,—a decision in which I can by no means acquiesce. Allowing to each of the former the weight 2, and to the latter 1, the final conclusion from this calculation is 500,506,699; and from the mean of Airy, Bessel, and Schubert, 500,495,294, which differs from 500,500,000 by *less than its hundred-and-six-thousandth part.* This, then, is the fractional error of our "modular" unit in proportion to its own length of 1·001 British standard inch, or that of a "module" of 50·05 such inches, which, in this view of the subject, might be taken for the British unit of linear measure, or one ten-millionth of the earth's axis. The Astronomer Royal, in discussing these computations of M. Schubert, *Notices of the R. Astron. Soc.* (vol. xx. p. 105), insists, very properly, on the individuality of the polar diameter of the earth as compared with its equatorial diameters, which differ materially in different meridians (having regard to an imaginary sea-level, and independently of the heights of mountains or continents). If any axis be chosen for a scientific unit it should assuredly be the polar axis. The nature of things gives this an absolute, indefeasible preference to every other, not excepting even that of the equator in the meridian of Paris itself.

Every geometer will agree that the radius of a circle is a more fundamental or primary parameter, or unit of linear dimensions, than its circumference. To beings of other psychological constitution than man, it may be otherwise; but take the genus *homo* and the species *geometer* as they stand, this is a fact. *A fortiori*, the axis, major or minor, of an ellipse is a more primary and fundamental unit of its dimensions than its periphery, leaving the question as to *which* axis, major or minor, to be decided on its own grounds.

The French mètre is assumed to be the ten-millionth part of the quadrant of the earth's elliptic meridian passing through Paris. Its value is authoritatively stated in the Annuary of the French Board of Longitude at 39·37079 British Imperial standard inches; and, therefore, in reference to the natural unit in which it originates, is erroneous by one part in 8,400 of its proper length, that is to say, between 12 and 13 times more in proportion than our proposed module.

The adoption of such a "British Modular System" of measure requires no Act of Parliament. It is so easy to convert "Imperial standard" lengths, of whatever denomination, into "British modular" lengths of the same denomination by subtracting (or modular into imperial by adding) one thousandth, that it is not worth while to legislate on the subject, so far as measures of length are concerned. The difference between one part in 1,000 and one in 999, in the conversion and reconversion, being only one in 999,000, is of no importance whatever. Nor is it worth while to change our ordinary parlance. 1 foot, or 1 yard, in 1,000 is a difference telling as nothing in any practical contract for work on a great scale. On a small one it is quite inappreciable. The scientific man only is interested in it; and it suffices him to know (and the knowledge, to him, is important) that he can refer all his measurements to the best unit nature affords, by subtracting a thousandth (that is, by writing his figures twice over, in two lines, one under the other, shifting the lower three figures to the right, and executing a subtraction sum) far better than by referring to the *Annuaires des Bureaux* of metricized countries, and performing a calculation of greater complexity, landing him in twelve or thirteen times the amount of error. Of course, I am not speaking of a system of *decimalization*. To decimalize our measures we must reduce them to "modular inches," or to "modules" of 50 such inches; but we may speak of modular miles, yards, feet, or inches with reference to a modular unit, while retaining the associations of our actual metrical system A similar remark applies to the Russian metrical system, which is based upon the English—the fundamental unit being the *Sagene* of 7 British feet.

I ought in fairness to mention, that my attention was drawn in the first instance to this *rapprochement* by the statement, over and over again repeated in Mr. Taylor's recent work, entitled, "The Great Pyramid, Why was it Built? etc." (Longman, 1859, pp. 35, 36, 37, 87, 280, 298, etc.) that the diameter of the earth in the latitude of the Pyramid is 41,666,667 English feet, or 500,000,000 of English inches; which it is not: and it is singular that the reduction of Mr. Airy's polar axis from feet to inches, in page 87, which is rightly performed, does not appear to have suggested the least misgiving as to the correctness of the statement, or (which is more to our present purpose) led him to notice the important practical facility of reduction from the parliamentary to the modular standard above insisted on. It is not my object here to criticize the work in question, which, in the midst of much confusion, not perhaps unmixed with error, contains some valuable and (so far as we are aware) original remarks. Of these, I may mention the conclusion its author has drawn from the angle of slope of the casing-stones discovered by Col. Vyse, that the builders of the Pyramid were acquainted with the ratio of the circumference of a circle to its diameter—a piece of knowledge they were desirous to embody in its dimensions. In fact, the slope of the original faces of the Pyramid comes out from Vyse's (or Perring's) measurement of the linear dimensions of these stones, 51° 52′ 15½″, and by Brettel's measure of their augle, 51° 50′ 0″, the mean of which differs *only by a single second* from the angle whose cotangent is the length of an arc of 45° of the circle, so as to make the whole periphery of the base all but mathematically equal to the circumference of a circle described with the height for a radius. So stated, the coincidence is certainly very striking. It by no means follows, however, that the ancient Egyptians were in possession of any *calculus* by which they could have arrived at a theoretical knowledge of the true ratio. It should be observed that the linear measures above mentioned are given only to entire inches, and those, inches of a scale which may or may not have been verified with extreme precision, and therefore can lay no claim to minute accuracy. Computing, moreover, on these measures alone, the ratio of the periphery to the height, comes out 6·2784, while that resulting from the direct measure of the angle is 6·2878, the true ratio being 6·2832. The individual results differ by one 640th part of the whole quantity; and as we do not know with what instruments or what precautions the angle was measured, and it is given only to the nearest minute, it seems but reasonable to admit an equal proportional latitude of uncertainty in the original workmanship, and in the numerical relation to which it was intended to conform. Now, this is a very considerable approximation, much better than that of Archimedes a thousand years later. Still, it would be easy for people in possession of such appliances as they must have had at command, to ascertain the ratio in question to this, or even to a greater degree of precision, by tracing, for instance, on a flat pavement a circle of 100 feet in diameter, and actually measuring the circumference. This they certainly might have done to the nearest half-foot, which, on a length of 314 feet, would correspond to such a latitude of error. If aware of the importance of the problem, they might have gone much further.

But, again, it by no means follows, from anything which the dimensions of the Pyramid indicate, that they did possess a knowledge of the ratio of the circumference of a circle to its diameter, even approximately. By a very remarkable coincidence, which Mr. Taylor has the merit of having pointed out, the same slope, or one practically undistinguishable from it (51° 49′ 46″) belongs to a pyramid characterized by the property of having each of its faces equal to the square described upon its height. This is the characteristic relation which Herodotus distinctly tells us, it was the intention of its builders that it should embody, and which we now know that it did embody, in a manner quite as creditable to their workmanship as the solution of such a problem was to their geometry. This problem, however, has no relation to that of the rectification of the circle. The coincidence is one as purely accidental as anything relating to abstract number can be; and although in solving the one problem, which we know they did intend, they at the same time, practically speaking, resolved another, which stands in no rational connexion with it, or any connexion, beyond that of happening to have, very approximately, the same numerical solution,—we are not entitled to conclude that they were aware of this coincidence, and intending to embody *both* results in their building.

Another curious and novel relation, for pointing out which we are indebted to Mr. Taylor, is one (see "Great Pyramid," page 37) which may be most intelligibly expressed under the following form of announcement, viz.:—that a belt, encircling the globe, of the breadth of the base of the Great Pyramid, would contain one hundred thousand millions of square feet.* If the feet be Imperial Standard, and the belt Equatorial, this is approximate only to one part in 288 of the whole. But if we suppose the belt meridional, and the area expressed in "modular" square feet, the approximation is within one part in 1,100. The fact is interesting as offering the only tolerable approach in round numbers to an arithmetical relation between any of the dimensions of this Pyramid and those of the Earth.

J. F. W. HERSCHEL.

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* Mr. Taylor has (*in words*) *one hundred millions*, which is a misprint.

STANDARD OF MEASURE.

COLLINGWOOD, *May* 1, 1860.

Allow me to correct an oversight in the last paragraph of my proposal of a British Modular Standard of Measure in your last number, where it is stated that the only tolerable approach in round numbers to an arithmetical relation between any of the dimensions of the Great Pyramid and those of the Earth is that therein mentioned. There is another, and a remarkable one which I do not find noticed by Mr. Taylor or elsewhere; viz, that the height of the Pyramid, including the casing, and measured from base to apex, supposed to terminate in a point, is one two-hundred-and-seventy-thousandth part (1-270,000th) of the earth's circumference. Taking the *equatorial* circumference as unity, the error of this aliquot is one part in 736; but if the *Polar*, only one in 3,506: the former error being in defect, the latter in excess, so there exists somewhere or other on the globe a diametral section whose circumference is *exactly* 270,000 times the original height of the building. Though not a meridian, it is not very remote from one.

J. F. W. HERSCHEL.

LEADING ARTICLE ON THE DEBATE ON WEIGHTS AND MEASURES.

From the Times of Thursday, July 9, 1863.

A very great trial is impending over this free and happy country. It is not the loss of our cotton trade, of our colonies, of our prestige, or our maritime supremacy. It is not the exhaustion of our coal fields, the deterioration of our racehorses, or the downfall of the Established Church. It is a change that would strike far deeper and wider than any of these; for there is not a household it would not fill with perplexity, confusion, and shame. From a division in the House of Commons yesterday, it appears that we are seriously threatened with a complete assimilation of all our weights and measures to the French system. Three years are given to unlearn all the tables upon which all our buying and selling, hiring and letting, are now done. At the end of that period—that is, in the year 1866—if this Bill should pass, there are to be no more yards, feet, inches, ells, nails, fathoms, furlongs, miles, chains, acres, roods, poles, gallons, quarts, pints, gills, pounds, ounces, pennyweights, drams, tons, hundredweights, quarters, stones, sacks, coombs, bushels, or any of the measures with which dealing is now regulated. Every one of these terms will be not only obsolete, but illegal, insomuch as the obstinate use of them will involve fine and imprisonment. It is of no use to urge that other countries have undergone this revolution, and survive. What are France, the Zollverein, and Portugal to us? They are accustomed to revolutions, earthquakes, and wars. The Englishman finds it physically impossible to learn things so fast, and forget things so fast. We have been tried hard for a thousand years, and we cannot fall into a uniform measure of wheat, of land, of ale, or even of bread and butter. So in three years it is wholly out of the question that we should forget a hundred familiar measures, and become equally familiar with new ones. The arithmetical process involved in the very act of change is something tremendous. The very first step is the adoption of a new unit as the base of all other measures of length, surface, solidity, and weight. That unit, without which it will be penal for a shopkeeper to sell the smallest quantity of tape, bread, sugar, or oil, is thirty-nine inches and thirty-seven thousand and seventy-nine hundred thonsandth parts of an inch of the Imperial standard measure, and its name, we need not say, is to be "Metre." We will not here insist on the principle involved in adopting a basis selected on so recondite a principle as the calculation of the length of a quadrant of the earth's meridian. Why that should govern all transactions in comestibles and potables, in clothing, and every other affair of buying and selling, it is impossible to say. But we let that pass. Let one yard be as good as another. We speak on behalf of the already overworked and not very quick wits of our countrymen. We tremble to think of the softening of the brain, the confusion of ideas, the mistakes, the losses, this will occasion. How is Lord Dundreary ever to make it out? His is a much larger family than is generally supposed. He will certainly find that on the new system he has not so many fingers, or birthdays, as he thought he had, and that he will have to send a larger birthday present to his brother Charles.

As to the French, they like change, they like arithmetic, they like grand ideas, and an astronomical basis. They are always making little purchases, counting up small savings, and subdividing small properties. They certainly succeed in giving a most imposing appearance to an hotel bill for a night's lodging, and even a washing bill. The smallest transaction in sugar or soap seems to suspend you somewhere between the millions and the millesimals. In this country our village shopkeeping is done with very little arithmetic. The wants of the customers are few; their orders are small and frequent; and it often takes several visits to the shop before the account gets beyond the simple calculations of pennies and farthings. The orders are easily adapted to the copper standard. Candles are "dipped" to that length, and neat packets of sugar, coffee, and tea, are piled in anticipation of the regular demand. There are many village shopkeepers who cannot even write, and who can only just do the little mental arithmetic which suffices for a ready-money transaction, or a few hieroglyphics on a suspended slate. What will these poor creatures say when they are told that all their quantities and demominations are changed, that they must buy new weights and measures, learn new names, and divide the next hogshead of sugar that arrives in entirely new proportions? What will all the small housekeepers say? They have ascertained that the family requires just so many pounds of meat and all other solids, just so many pints of milk and of other drinkables; but for the future they must adjust their natural proportion in litres and grams. We are sorry for them. The only comfort we can suggest is, that by the time this revolution is enforced, there will probably be not less than thirty or forty thousand pupil-teachers adrift with nothing to do, and with no useful accomplishment, except, perhaps, a very slight acquaintance with vulgar and decimal fractions, the very gift required for this emergency. As they will by that time have ripened and soured into an insurgent and dangerous class, they will be the proper instruments of this great arithmetical revolution.

Three years are supposed to be amply snfficient for undoing and obliterating the traditions of every trade, the accounts of every concern, the engagements of every contract, and the habits of every individual. Why three years? Perhaps that period is chosen because till lately a Dissenting preacher or offending clergyman was condemned to three years' silence before he could be permitted to officiate in the Church of England. Three years are the period of residence requisite for a degree at the universities. But we very much doubt whether the general shopkeepers, who take possession of the corners of our small streets, or the greengrocers, will be able in three years to translate their accounts into Decas, Hectos, Kilos, Myrias, Steres, and Litres, Metres, Millimetres, and Centimetres, and the hundred other terms extracted by our ingenious neighbours from Latin or Greek, as may happen to suit their purpose. Before the House of Commons amuses itself and the public by voting the introduction of the system, it would be as well if some attempt were made to realize it by drawing up a few accounts and describing some business transaction in the new phraseology. It is admitted that decimal weights and measures inevitably entail a decimal coinage, as the whole of the present inconvenience would survive if the measure of value were not assimilated to the measure of the articles valued. Is the House of Commons, then, really prepared to see the votes, the reports, the returns of the revenue, the figures of the national debt, rents, tithes, rates, taxes, and every other figure, all run up in paper francs, and actually paid in gold Napoleons? That is the necessary consequence of yesterday afternoon, unless it be considered as a holyday diversion of no consequence whatever. Travellers, of course, will find themselves saved a little trouble by having no necessity to change their money as they pass from London to Paris, and thence to Belgium, Germany, Italy, and a good way further. But though travellers are many, they that stop at home are more, and they are a trifle more fixed in their ways. We cannot help suspecting that if this change is ever to be, it will not be in our time. It took England a century and a half to follow the example of Gregory in correcting our style, and adapting it to the facts of astronomy. It will hardly take less to persuade England to square all her commercial transactions to an imaginary basis drawn from astronomy in a matter with which astronomy happens to have nothing to do.

THE DECIMAL AND METRIC SYSTEMS IN PRACTICE.

A Letter in the "TIMES" *of July 9th,* 1863.

The House of Commons have given their sanction to the second reading of a Bill to compel the English people to abandon their old system of weights and measures, mode of reckoning, and coinage, and to adopt, within three years from the passing of the Act, under pecuniary penalties, the decimal and metric systems that have been introduced into France. The arguments, or rather allegations, put forward to justify this revolution, and on which the House acted, were, according to Mr. Ewart, whose knowledge of France and French affords infinite amusement to the *habitués* of Meurice's, that the metric system "proceeded by decimals up and down in a regular tabular form, and with such extreme accuracy that it was almost impossible to make a mistake in the calculation;" that "it was now admitted to be one of the greatest blessings ever bestowed on France;" "that our trade was larger with countries using the metric system than with countries using the English system; that it would effect a saving of labour to one Belgian merchant of two clerks; and that it was a perfect decimal system, which experience had shown to be a system not theoretical but eminently practical." According to Mr. Cobden, who is too apt to adopt without investigation the statements of "mon ami, M. Michel Chevalier," the eminent expounder of other men's discoveries in politico-economical science, Englishmen are to be coerced into the use of French weights and measures, because when negotiating the commercial treaty he "felt humiliated; for, while the French system was symmetrical, logical, and consistent, the English was dislocated, incoherent, and utterly inconsistent;" because it was recommended by Sir Rowland Hill, Dr. Farr, and Mr. Anderson; because it promised a great economy of time and labour; because "the logical sequence with which the decimals in the French metric system followed one another afforded satisfaction to the reason, and it gave a constant triumph to the reason;" and because certain eminent scientific men, whose names he quoted, believed boys at school would save half their time in the study of arithmetic, or "two years at least."

Now, despite these confident assertions, it will not be difficult to show to all who have something more than a superficial knowledge of the habits and customs of Frenchmen that, according to their experience, the decimal system is not the most convenient one for trade, and that the metric system is not uniformly and generally carried out in a symmetrical, logical and consistent manner, either in trade or in scientific calculations; but that the metric system is impracticable in detail, and that in retail trade the petty purchases and sales, which after all constitute the mass of trading operations of the people, it renders exactness in dealing impossible, and entails a loss to either seller or buyer, or else creates a mass of petty credits that from their number cannot be controlled, and breed endless disputes, insignificant as is the amount which causes them.

Before, during, and after the metric system was made compulsory I happened to be following the scientific course—for at that time the *bifurcation d'études* existed in the Collège St. Louis, now the Lycée d'Harcourt, which then boasted a high mathematical reputation and of turning out more successful candidates for the Ecole Polytechnique than any one of the other colleges. One of the professors of Mathématiques Spéciales was M. Vincent, well known to the English reader for his *Géometrie*, and chief assistant to his father-in-law M. Bourdon in composing the textbook of arithmetic adopted by the University for the use of schools and colleges throughout France. The first Professor of Mathématiques Elémentaires—not very elementary, by the bye

—was M. Darville, a mathematician of great promise had his life been spared, and a teacher for whom I, and I imagine his *élèves*, felt as Rugbeans do for Arnold. The metric system and the investigation of the theory on which it was constructed formed a leading feature in the course, and all the more importance was attached to it because it was just then coming into compulsory use. At the same time our system of notation was discussed and all the questions attached to it were analyzed. Perhaps it will assist the reader to better understand and estimate the importance of the revolution with which we are threatened in our calculations, the soundness of the views of Messrs. Ewart and Cobden, and the wisdom of the House of Commons, if I endeavour to give the heads of the lectures by one of the leading mathematicians of France at so critical a juncture. Nearly a quarter of a century has elapsed since I heard them; but their clear, distinct, and incisive logic has not faded from the memory, though I may be unable to do them justice. He did not begin in the style in vogue under the July Monarchy—"Parmi les prodiges qu'enfanta la première Révolution"—for even then it was unfortunately necessary to speak of the *first* Revolution; but he commenced by a luminous description of the confusion that reigned in France among weights and measures before the commencement of the present century—a confusion as great as that which exists in England. He bade us all turn out our pockets, when we would find perhaps centimes and liards, sous and pieces of four sous, half-francs and coppery pieces of 15 sous, francs, and pieces of 30 sous, écus of three francs, and pieces of five francs. Gold had we none. He next dwelt on the advantages of uniformity and the wisdom of having a common standard for reference — arguments now familiar to the public, and which no one disputes,—and explained how the Commission adopted, for the new standard for length, from which the other standards were deduced, the ten-millionth part of the distance from the Pole to the Equator, measured on the arc of the meridian, passing from Dunkirk to Bayonne. This part was called the metre, and to simplify arithmetical calculations it was decided to construct tables on the decimal system, the multiples being distinguished by Greek prefixes, and the submultiples by Latin prefixes. Thus, the ten times the unit became a decametre, and the tenth of a unit a decimetre; ten times the decametre, or a hundred times the unit, a hectometre; and a tenth of the decimetre, or hundredth of the unit, became a centimetre, and so on; the succeeding multiples receiving the names of kilometre and myriametre, and the submultiple the name of millimetre. Having determined the standard and nomenclature, the other tables were easily drawn out. For the unit of capacity they took a cubic decimetre, and called it a litre, employing the same Greek and Latin prefixes as in the previous instance, to designate its multiples and submultiples. Henceforward the uniformity (or what Mr. Cobden calls the logical sequence) of the system fails. The unit of weight is the weight of a cubic centimetre of distilled water at its *maximum* density, which was called a gramme, and received the usual nomenclature. But the necessities of commerce have compelled the introduction of new weights and new nomenclature—words not Greek or Latin, but French—beyond the extreme limit of the metric table; for after the myriagramme come the quintal of 100 kilogrammes, and the *millier*, or *tonneau*, for ship measurement, of 1,000 kilogrammes. The unit of superficial measure is the square of ten metres, called the *are*, because the square metre, which it would have been in uniformity, logical sequence, and consistency to employ, would have been inconveniently small for all practical purposes; therefore it is made a submultiple of the unit, and termed a *centiare.* The unit of solid measure is the *stere*, a cubic metre, and it has not the usual number of multiples and submultiples. In the coinage, the violation of uniformity and breach of logical sequence are greater. The unit is the franc, of which the sous multiples are the decime and centime; but it has no logically sequential multiple beyond the 10-franc-piece, which is without a name, and the 100-franc-piece, that is a mere curiosity, and not to be met with in circulation.

I well remember with what surprise, with what ludicrous incredulity, mingled with something akin to contempt for *idéologues*—for Napoleonism was then in the ascendant—we listened when the Professor, setting the spectacles more firmly on the bridge of his nose, and gathering himself up as though he were about to confront a danger, commenced the examination of the decimal in conjunction with the metric system by stating, "Il est à regretter, Messieurs, que quand l'on eut déterminé à abolir les anciens poids et mesures en faveur du système métrique l'on n'eut pas en même temps remplacé le systême décimal par le systême duodécimal." We did not receive this exordium with that noisy manifestation of disapprobation we were wont to exhibit in other classes, but we certainly allowed it to appear, that we thought, as the reader probably will, the proposition absurdly theoretical and impracticable to revolutionize the system of notation which seemed suggested by nature, and must have existed ever since men learned to count on their digits. However, we listened and learned: 10 was so inconvenient a number, from its having but two divisors (2 and 5) into aliquot parts that a change had been contemplated by arithmeticians for a long time past. Charles XII. proposed extending the notation table up to 64, because that number was both the square and cube of a number; but that was deemed preposterous, and 12 suggested instead, which is capable of division by four numbers into aliquot parts. We were then taught to construct a notation table, using α β to represent 10 11, and the ordinary 12 became our 10. We were repeatedly exercised in converting decimal accounts into duodecimal accounts, performing with them all the usual arithmetical calculations, and then converting the results obtained in duodecimals back into decimal amounts. In a few days we became quite expert in handling the system, though α β looked queer in a common sum to the youngsters and to the private soldiers, of whom we had several studying for St. Cyr. But, before we quitted that part of the course, scarcely more than a week, we could work as easily in duodecimals as in decimals. Of course, there was a reason given for devoting so long a time and so much study to master operations that apparently would never be used in practice, else youth and young men fagging—*piochant* is the term—to pass their examination for admission into the military and naval schools at St. Cyr and Brest, or to pass into the higher class of mathematics for competition the following year for admission into the Polytechnic and other special scientific schools, would not have done so, but would have skipped that part; and I distinctly remember that the reason given was in the Observatoire, under M. Arago. Duodecimals were used in carrying on astronomical operations as well, also, I think, as in other State establishments, on account of the great saving of time and labour they effected. I am unable to say whether or not this was a mere temporary experiment, undertaken at that very critical time when the use of the metric system was on the eve of being made compulsory. This digression into a college reminiscence has been a long one; its object, which will be its best excuse, has been to show that, even at the period referred to, French mathematicians regretted the combination of the metric with the decimal system, and that the decimal system was far from being considered in France so "perfect," so "eminently practical," so "economical," so "symmetrical," so "consistent," so "satisfactory to reason" as Mr. Ewart and Mr. Cobden have asserted it to be.

Let us now pass to the metric system, and if it can be shown to be not uniformly carried out even by the French, neither in scientific nor commercial calculations, nor in ordinary trade transactions; if it can be shown to be inadequate to represent what is in daily use, to supply the commonest daily wants, and to require to be supplemented or "tesselated" by recourse to old forms and figures and quantities; if it can be shown not yet to be uniformly used, not even by Government—popularly used, after the lapse of considerably more than half a century since its first introduction, and nearly a quarter of a century since its observance was attempted to be legally enforced,—and if it can be shown to be, except for matters of account—even in them entailing the employment of additional figures—impracticable to be carried out in the daily transactions of life, the cause of needless outlay and of unnecessary labour, the never ceasing source of deferred settlements, which means disputes between retail buyers and sellers,—then surely there will be just grounds to ask that the Gallo-mania of imperfectly informed persons may not be allowed to prevail over common sense to the great detriment of public convenience, and that the legitimate desire to obtain the simplification and uniformation of our weights and measures may not be made the pretext for their abandonment in favour of the adoption of a system which does not afford an adequate quarter or third of the units of admeasurement and weight.

In geographical and astronomical science not even at the Institute is the metrical system uniformly used, for the members speak of degrees and minutes, not of myriametres and kilometres, of longitude and latitude; of the areas of countries in square leagues, and not in hectares; of the *mille géographique* and the *mille marin*, and the *lieue marine*, by which last distances between countries are indicated, especially where the sea intervenes; for whoever heard a Frenchman specify the breadth of ocean that lies between Havre and New York in kilometres? In nautical science, naval architecture, over-sea commerce, and practical navigation, neither sailor, *savant*, nor trader, speaks of the run of a ship in kilometres, but in *nœuds*, nor of the burden of a ship in kilogrammes or myriagrammes, but in *tonneaux*, which, as the old *tonneau*, like our ton, happened by chance to be equal, within 20lb., to 1,000 kilogrammes, have been altered to consist (each) of the last named number of kilogrammes. The sailor does not name his soundings in metres, but in *brasses*, though in charts they are marked in metres. The kilogramme is too small, the myriagramme is too large, to designate the weight of cargo. Consequently, the sailor, shipper, and merchant speak of *tonnes*, or *milliers*, each of which is a thousand kilogrammes. The trade and navigation returns (*tableaux des douanes*) and all Government reports employ as unit of weight the metrical quintal, which is 100 kilogrammes. Thus, the State is a systematic offender against the metrical system, and employs a different standard from traders. Though the difference is removed by altering the decimal point, it is very palpable in speaking and manipulation; and it is a still more palpable violation of the "logical sequence" of the system. In chymical science and where minute quantities have to be measured or weighed, the metric system breaks down, and has to be supplemented by recurrence to the old system. As Mr. Whitworth is obliged to express the minute spaces he measures in millionths of an inch, so would he have to speak of the thousandth part of a millimetre under the metric system. If Professor Taylor is compelled to calculate the poison he has recovered from human tissues in almost infinitesimal fractions of a grain, so was Orfila obliged to use nearly as infinitesimal fractions of a millogramme.

Passing to the consideration of the metrical system, from a popular point of view, it will be found, notwithstanding what M. Michel Chevalier reported about postillions giving the postal distances in kilometres readily in 1841, that neither the metre nor the kilogramme, nor the *are*, nor the multiples and the submultiples of the litre are popular, or generally used. To the mass of the French people the sous holds the same relative position as the penny does in England. Jacques Bonhomme is more prone to count in sous, than John Bull is to count in pence. He rarely speaks of the coins of half-franc, franc, two-francs, and five-francs, other than as the *pièces de dix sous, de vingt sous, et de cent sous.* The people speak of the sous; the *épicier*, the omnibus conductor, post-office clerk, and the *employé* of the *pièce de cinq centimes.* But let us go among the people, into the market place—the *halles*, which Napoleon called the *Louvre du peuple.* If we ask the price of fresh butter, we shall be told *trente-deux sous la livre*, not *trois francs vingt centimes le kilogramme*, nor yet *un franc soixante centimes le demi-kilogramme*, or the cinq hectogrammes, or the cinq cent grammes, which the livre is, but the price in sous per pound, neither of which designations exist under the metrical system. A step further, and we ask the price of eggs—six liards apiece; but the liard, which is the fourth part of a sous, and, though not quite half the value, yet holds the same relative position as our farthing, no longer exists. By no combination of modern coins can we pay six liards. If we do not wish to buy more than one egg —and many can't afford or do not require more—we or the seller must lose or owe half a centime; but if we desire to take a quantity, we are told they are so much the *quarteron*, or quarter of a hundred (it also means quarter of a pound); and the *quarteron* does not consist of 25, but of 26. Potatoes, beans, peas, are priced by the *boisseau*, which answers to the bushel. Charcoal is bought by the *boisseau* also, and wood by the *cotret*, small faggot. Yet neither *quarteron*, *boisseau*, nor *cotret* is presumed to exist under the metrical system. Let us step into one of the neighbouring *marchands de vin* in the Rue Montorgueil, where the best oysters are to be had. We believe in Mr. Cobden's logical sequence of the decimal system, and in M. Chevalier's postillion's illustration of its universality, and call for *quatre dixaines de huitres.* As soon as the word *dixaine* is out, every head in the room is raised to look at us, and we catch remarks anything but complimentary, "Eh bien, par example! En v'là-t-il des drôles de particuliers!" and others more energetic. The *garçon* gently and benignantly corrects the blunder into which we have been betrayed by our confidence in the honourable member for Rochdale, and says, "Monsieur veut quatre douzaines de huitres." So here, in decimalized Paris, they buy and sell, not by tens, but by dozens, just as we do under the "dislocated, incoherent, and utterly inconsistent" system, which "mortified, worried, wearied, and humiliated" Mr. Cobden for two whole years. We have heard that white wine is the best to drink, and consequently order a bottle; but we notice our neighbours, who drink their wine from the wood, ask for a *chopine*, instead of for five decilitres, or a *demi-sétier*, instead of for 250 centilitres. They conclude their repast by calling for *demi-tasses de café* and *petits verres de cognac;* but do they know—does the *marchand de vin* know—can M. Chevalier tell, how many centilitres go to a *demi-tasse* or a *petit verre?* And yet is it not illegal to sell any liquid except by metrical admeasurement? The *garçon*, who has been conciliated by the humility with which we received his reproof, more, perhaps, by the *pièce* of *monnaie blanche* which we respectfully tendered for his acceptance, accompanies us to the doorway, and warns us against the casks of various dimensions that are being conveyed into the cellar. Encouraged by his condescension, we venture to seek for information, and are told, in answer to inquiries, that they are *pièces* and *feuillettes* and *demi-feuillettes* of wine, and *petits tonneaux* of beer. How much do they contain? "On ne sait pas au juste." That depends upon the size of the cask; for we are esteemed very simple. *Mais une pièce* may contain about 350 bottles, and the *feuillette* about 150 bottles. And the bottle? "Pas tout-à-fait un litre." The *pas tout-à-fait* gently covers the reduction in practice from a quart to a little over a pint. The "petits tonneaux, mon ami?" We venture to be familiar. They are about the size of four-and-a-half gallon casks. "Ma foi, Monsieur, je n'en sais rien," but we sell beer by the *choppe*, or the pint, and the *cannette*. We seek in vain for the first word in our *Spiers*, and are told by the *garçon* that it is a pint, while the latter is a quart. We linger before the counter, and we hear a soldier ask for his *goutte*, the *cocher* for a *cannon*, a provincial for a *poinçon*. We leave somewhat confused and dubious of the wisdom and information of our legislators. We enter a grocer's, to purchase some postage stamps, and while waiting hear people ask for *deux onces de café*, *un quart de sucre*, *un demi-quart de beurre salé*. Let us find a pretext to linger a little longer, and we may learn how inconvenient and costly and fruitful of annoyance the metrical system is. The sugar is fourteen sous the pound, the ordinary price at grocers' shops. The purchaser lays down four sous to pay three sous and a half, the price of the demi-quart. The *épicier* returns two centimes, and says—"Madame, je vous devrai un demi-centime." The poor sempstress gathers up her small coins, and goes out mumbling, "Mon dieu! sont-ils bêtes avec leurs centimes; en voilà six demi-centimes que je perds ce matin!" and her daily wage, if she be an apprentice or can only sew, is perhaps fifty centimes, rather more than one-eighth of which she loses in change under the symmetrical and money-saving coinage of the metrical system. Her neighbour asks for two ounces of coffee; the price is five sous and a half. The grocer repeats the same story about the half-centime in giving change, but the buyer exclaims—"Mais, Monsieur, vous me devez un demi-centime de hier; donnez-moi mes trois centimes." The grocer raises his eyebrows incredulously, and speaking with an air of injured dignity, as though he preferred submitting to imposition rather than enter into a discussion, remarks—"C'est bien, Madame, puisque vous le dites;" but grumbles in the ear of his spouse, *l'épicière*, "La crasseuse, de me réclamer un centime!" while the thrifty housewife goes out with her rescued coin, muttering, "Le vieux voleur, il a voulu me tromper d'un centime." Such is the amiable state of feeling between the shopkeeper and his customers, engendered by "the greatest blessing ever bestowed on France." Why, it keeps the tradesmen and their customers in constant ill-humour, spoils the digestion, and conduces to apoplexy among grocers. But does the customer get fair weight? The equivalent of a demi-quart would be 62·5 grammes. The dealer gives no more than 60. Consider the number of operations that are effected in a day in all France, and the amount of loss inflicted on the public customer will be found to be enormous. This leads to the consideration of the extra labour involved. I have before me an English series and a French series of weights. In the first there are 1lb., ½lb., ¼lb., 2oz., 1oz., ½oz., ¼oz. In the second, there are 500 grammes, or livre, 2 hectos, two of 1 hecto each, ½-hecto, 20 grammes, two of 10 grammes each, 5 grammes, 3 grammes, two of 1 gramme each. The milligrammes and the centigrammes are not used in the sale of articles of general use, any more than drams are in England. These divers weights make up the kilogramme. Thus, while with our incoherent system here we are enabled to satisfy every ordinary want with seven weights, the metrical system requires eleven. For the sale of liquids here, we want four measures—the quart, pint, half-pint, and gill. Our neighbours require five—the litre for the quart; five decilitres for the demilitre, *chopine*, or pint; two decilitres and five centilitres for the *demi-sétier*, or half-pint; and one decilitre: the *cannon* cannot be measured, but must be guessed at. In the English system, one weight will weigh each of the aliquot parts of a pound. In the metrical system, two are required to weigh half a pound—the one of two hectos and the one of 50 grammes, and three to measure the quarter—the hecto, the one of 20 grammes, and the one of 5 grammes. Fancy the additional thought, time, and labour that are required to select, pick up, and replace three separate weights instead of one, when multiplied by the number of a day's transactions, and the difficulty of one of the working classes recognizing and verifying the weights. It is nearly the same with liquid measures, for the half-pint, or *demi-sétier*, requires the 2-decilitre and 5-centilitre measures.

But, say the advocates of the metrical system, it is a great saving, in keeping accounts, of time and labour. We all know that decimals are easier to handle than vulgar fractions, but let us try to ascertain what saving results from it in accounts. We write down the same sum in francs, and in pounds, shillings, and pence,—153f. 60c., and 6*l*. 2*s*. 9*d*.

The metrical system gives us five figures, ours three only, and thereby saves us the trouble of writing two figures. 40,000*l*. are expressed by five figures, their equivalent in francs becomes 1,000,000, and requires seven figures; so that we may freely take as a general rule, that to write down an amount under the metrical system necessitates the use of two figures more for each item than would be required to express the same sum in our mode.

One point further, and I have finished. Will the thirty millions in the United and Confederate States, the millions in Canada, West Indies, Australia, and our colonies and possessions, consent to adopt the metrical system of weights and measures? If not, will the general commerce of England be facilitated, if the difficulties which are said to exist between us and the French, Greeks, Spaniards, Italians, and Dutch, are created between us and our American as well as our colonial customers? B.

THE METRICAL AND DECIMAL SYSTEMS.

From the Times, 15th and 17th Sept., 1863.

THE advocates of the introduction of French weights and measures into England, not much discouraged by the withdrawal of Mr. Ewart's ill-considered Bill of last Session, threaten a renewal of agitation in its favour. In the inaugural address of the President of the British Association, Sir William Armstrong, without entering into the comparative merits of the decimal and duodecimal systems of notation, declared that,—

"Science suffers by want of uniformity in weights and measures, because valuable observations made in one country are, in a great measure, lost to another, from the labour required to convert a series of quantities into new denominations. International commerce is also impeded by the same cause, which is productive of constant inconvenience and mistake. . . . . The metric system has already been adopted by other nations besides France, and is the only one which has any chance of becoming universal. We in England, therefore, have no alternative but to conform with France, if we desire general uniformity. . . . I am convinced that the decimal division of the French scale would be attended with great convenience both in science and commerce. . . . In the Elswick Works, as well as in some other large establishments of the same description, the inch is adopted as the unit, and all fractional parts are expressed in decimals. No difficulty has been experienced in habituating the workmen to the use of this method, and it has greatly contributed to the precision of workmanship. . . . As to our thermometric scale, it was originally founded in error; it is also most inconvenient in division, and ought at once to be abandoned in favour of the centigrade scale. The recognition of the metric system and of the centigrade scale by the numerous men of science composing the British Association would be a most important step towards effecting that universal adoption of the French standards in this country which, sooner or later, will inevitably take place; and the Association in its collective capacity might take the lead in this good work by excluding in future all other standards from their published proceedings."

Acting upon the suggestion of their President, a committee of the Economical Section of the Association resolved that a committee should be sent as a deputation to Lord Palmerston and Sir George Grey to impress upon them the importance of the introduction into the United Kingdom of a decimal system of weights and measures with a view to the interests of science. Under these circumstances, although the Association was not to be induced by its President's eloquence to ask for the introduction of French weights and measures, it may be of service to lay before the reader a condensed account of the origin and development of the metric system. But before doing so, it will not be amiss to notice Sir William Armstrong's speech, which, like most of those delivered by the partisans of French weights and measures, is characterized by misapprehension of the true facts of the case, by bare assertions unsupported by proof, and by assumptions without authority. Sir William confounds what all scientific and competent men, such as the Astronomer Royal and Professor de Morgan, insist should be kept apart—the decimalization of our own weights and measures, and the metric system. Because he, following the example of Mr. Whitworth, employs the inch divided decimally, it is not demonstrated that "the use of the French scale would be attended with great convenience," since the two have no necessary relationship. The President of the Association foretold that the universal adoption of the French standard in this country will inevitably take place. But how can he, as a hard matter-of-fact man of practical science, pretend to a knowledge of events yet in the womb of time? Nor was Sir William strictly accurate and ingenuous in his description of our thermometric scale when he described it as founded in error and most inconvenient in division. It is true that the zero of Fahrenheit was intended to mark what was then thought to be the greatest attainable degree of cold, and which was artificially produced. But the error was discovered, and the temperature of 32 deg., which is that of melting ice and the zero of the centigrade scale, was adopted as the *point de départ* from which all our thermometers are graduated, ascending and descending. As for the inconvenience of the divisions, the reader can judge for himself how far Sir William is right or wrong in his partiality for the centigrade. The boiling point stands on the Fahrenheit thermometer at 212 deg., and on the Centigrade at 100 deg. It consequently follows that the range of temperature between melting ice and boiling water is indicated by 100 divisions on the centigrade, and by 180 divisions on the Fahrenheit thermometer; and, therefore, that our thermometric scale is nearly twice as minute as the French scale, and contains 80 more divisions to indicate the variations of temperature. The superior nicety and convenience of Fahrenheit *sautent aux yeux*. But if such be the case, it will be asked, why do English chymists use the centigrade? They do so because they are distanced by French chymists—at all events in chymical literature; and for the same reason that French engineers, equestrians, and sailors use English terms, such as "rail," "stuffing-boxe," "stud-boke," "groome," "stopper" (stop her), and many others well known to the students of the French language. For the truth is, that the French have borrowed almost as many words from us as we have from them, with the difference that in incorporating them into their language they have so travestied them that they have become scarcely recognizable.

To make clearly intelligible the process of thought by which a society of French *savans* was led at the close of the 18th century, in the midst of wars and the agonies of revolution, to abolish the system of weights and measures which had descended to them from generation to generation, and to create a new one, based on a fraction of the earth's circumference, it will be necessary to glance briefly at the progress of astronomical and geometrical sciences, so far as regards the configuration of the earth. The first opinion was that which is still held by orthodox Moslems, that the earth is square. When men became convinced that the surface of the earth was curved, they jumped to the conclusion that it was a sphere, and this was the universal belief until the days of Huygens and Newton. On the occasion of the disputes relative to Newton's theory of the flattening of the globe, Colbert gave orders to have the Paris meridian measured through France. The operation was commenced in 1685, and terminated in 1718, under the direction of the younger Cassini, whose son, in company with Lacaille, in 1739-40, measured the meridian from Dunkirk to Perpignan. In 1737, Bouguer and Lacondamine measured degrees of meridian in Peru—as did Maupertuis in Lapland—and demonstrated the flatness of the earth at the poles. In the trigonometrical operations in Peru, the quadrant of the meridian was found to measure 5,130,740 toises, whence the Paris toise was also called the "Peru toise."

It should be here stated, that so far back as 1670 Picard joined the parallels of Malvoisine and Amiens, and in the same year Mouton of Lyons suggested a linear measure in connexion with a trigonometrical survey of the earth, which he proposed should be the minute of a degree divided decimally. Cassini also proposed a new unit of linear measurement—viz., a geometrical foot, which was to be 6-1,000ths of a minute of a great circle; or a fathom, being 10-1,000,000ths of half the diameter of the earth, so that the merit, if it be one, of suggesting the base of the metrical system belongs to the old monarchy of France, and not to the Revolution, as modern Frenchmen are fond of declaring. About the middle of the 18th century, as the fusion of the French provinces into a centralized whole was preparing, men's minds were agitated with a desire to obtain uniformity of measures. Paucton in his *Métrologie*, published in 1780, proposed that the unit of measure for all nations should be the 400,000th part of the degree of the meridian proper to each country; and he supported his proposition by the development of a theory with regard to ancient measures, which will be understood from what follows.

The measures of antiquity, according to Pythagoras, were derived from Egyptian standards, themselves copied from an invariable prototype taken from nature. Egypt alone preserved the authentic model of this universal measure, to which the Greeks compared their measures. Paucton states, that this prototype or natural standard was the measure of the earth, and that the pyramids were built to record the dimensions of the earth, and also to furnish an imperishable standard of linear measure. His conclusions were based upon the measurements of the pyramids and Nilometer, by John Greaves, Savilian Professor of Astronomy at Oxford, who left London in 1637, taking with him a 10-foot rule "accurately divided into 10,000 parts, besides some other instruments for the fuller discovery of the truth." He engraved the English foot, copied from the Guildhall standard, with his name, "J. Gravius," underneath, on the wall of the King's Chamber in the Great Pyramid. Paucton found that the Egyptian cubit, as resulted from Greaves's measurement, was 1·712 French foot; that 400 of these cubits gave a stadium of 684·8 French feet exactly, or 114·13 toises; and that 500 of these stadia gave 57,066 2-3ds toises as the length of a degree of the meridian. Whereat he exclaims, "*Ce qu'il falloit démontrer!*" Bailly adopted the same hypothesis; but Dr. Peacock, in his article on arithmetic in the *Encyclopedia Metropolitana*, treated it as absurd, and said that it was unfortunate for Paucton, that "the cubit of the Nilometer was found to be 20·54in. instead of 19·992, as it should have been," and the length of the side of the pyramid 716½ French feet instead of 684 1-5th. Professor de Morgan was equally incredulous with respect to the statement of those who seek "a mystical origin of weights and measures." But, in justice to Paucton, it should be stated that he gives the cubit at 20 27-50in., or 1·712 *pieds de Roi.* This *pied* is equal to 324·839 millimetres, so that the cubit would be 555 millimetre; and the latest measurement makes the cubit 525 millimetres, showing no very important error when we remember that he was careful to explain that he did not pretend to be strictly accurate, for he says, " Peutêtre ai-je trop rétranché de la mesure de M. de Chazelles." Jommard, who accompanied the French expedition to Egypt, imagined the side of the base of the pyramid to be the 480th part of a degree of the meridian proper to Egypt. Subsequent travellers made admeasurements; but it was not until the survey of Colonel Howard Vyse, in 1837, when what are called the casing stones were discovered, that the conjectures of Paucton, Jommard, and others were confirmed. According to Mr. Perring, the surveyor employed by Colonel Vyse, the former base, with the casing stones, was 764ft., and the present base, 746ft.; the former height, including the casing stones, 480ft. 9in., the present height, 450ft. 9in. This discovery, we are told, not only solved an important problem, but at the same time confirmed all previous measures.

It will be no great inconvenience to turn aside here for a little while to notice a most ingenious theory started by Mr. John Taylor in his work on the Great Pyramid, which has received the approbation of Sir John Herschel, and has every appearance of being correct, because it shows that our much abused English inch, which so mortified, annoyed, worried, wearied, and humiliated Mr. Cobden two years ago on account of his conceiving it to be incoherent and inconsistent, is an integral fraction of the earth's diameter which all mathematicians and metrologists agree in declaring, is the best standard or unit of lineal measure that could be attained, for it is almost exactly the five hundred millionth of the earth's polar axis. Professor H. Pope Hennessy, of the Dublin

Catholic University, suggested that a length of ten inches, should be adopted as our linear unit from philosophical considerations, and as being preferable to the metre and present foot of twelve inches, if the whole subject were to be reconsidered. Sir John Herschel subsequently proposed a similar unit. Where, then, is the wisdom of throwing away the duodecimal multiple — the foot — of the universally admitted best unit, the inch, to adopt a foreign standard, the metre, which is not exact, as will be presently explained, and which is inconveniently long for ordinary purposes? To do so would surely be to drop the substance in pursuit of the shadow.

In his work mentioned above, Mr. John Taylor states that:—

"In the vertical height or radius of the Great Pyramid, as deduced from the angle of the casing stones, 51 deg. 50 min., we have the number of 486 English feet, which, when doubled makes the diameter 972 feet. The base of 764 feet, multiplied by 4, gives a perimeter or circumference of 3,056 feet. Taking the diameter as unity we have 1,000 feet, of 0·972 feet of the English foot, equal to 11,664 inches; of which feet there are in the circumference 3,144. The true proportion in a sphere would be 3,141·5927, about two and a-half feet less than the actual measure. Is it possible that the founders of the Great Pyramid should come so near to the right proportion of the diameter of a circle to its circumference without intending to express it as nearly as they were able."

Without quoting further, it may be stated that the results of Mr. Taylor's analysis of the figures obtained by the measures of the pyramids are that the English foot is closely connected with the Egyptian foot, as recorded by Diodorus Siculus, for if one-twelfth be deducted from the foot of 1·0909 of the English foot, which is the measure of the Drusian foot, it leaves the English foot without any remainder. Mr. Taylor also concludes, that evidence is afforded that a measure, equal in length to the English inch, was made use of by the founders of the pyramids when they had ascertained the circumference of the earth and determined the proportion due to its diameter. That proportion is at present found by dividing the circumference—viz., 120,000,000 Egyptian feet of 1·0909 English feet by 3·1415927, which would allow for the diameter about 38,200,000 Egyptian feet; but this number seems incapable of furnishing any principle of unity as a measure of the diameter:—

"What was denied to the Egyptian foot was made attainable by the English inch. In 38,200,000 Egyptian feet of 1·0909 are contained 41,672,380 English feet, and this number of feet is equal to 500,068,560 English inches. The circumference of 120,000,000 of Egyptian feet of 1·0909 is equal in English feet to 130,908,000, and to 1,570,896,000 English inches. If we double this number we have 3,141,792,000, and if we divide 130,908,000 by the number 3·141792 (instead of by 3·141592) it will give us 41,667,000 English feet, or 500,000,000 inches for the diameter. Thus the proportion of the diameter to the circumference of a circle was considered by the founders of the pyramid as 1 to 3·141792."

Without wishing to detract in the slightest from Mr. Taylor's merit as the developer of a most ingenious theory, and as a careful analyst, it must be admitted that he has not been the first to notice the close approximation cf English to ancient measures. M. de Romé de l'Isle observes, in his *Tables pour servir à l'Intelligence des Mesures, Poids, et Monnoies des Anciens*, that the English foot more nearly resembles the Grecian than the Roman foot, for the Grecian foot is equal to 136·80 French lines, the English foot to 135·25, and the Roman to 130·60 French lines. Consequently, the English foot varies no more than 0·55 lines from the Grecian foot; and we know from Pythagoras that the Greeks were accustomed to compare their standards with the "Egyptian prototype." Stuart found the Grecian foot to equal 1·015 English foot, or 12·138 inches, and Mr. Penrose estimates it to equal 1·01336 English foot, or 12·16 inches. This remarkable approximation leads Mr. Taylor to conclude that "by these several minute and singular coincidences, the English nation appears to be more closely identified with the people who founded the Great Pyramid than those nations of antiquity who were brought into closer contact with Egypt in the earliest ages." After this, one is almost disposed to look with favour on the strange theory, that we are descended from, or have remote affinity with, one of the lost tribes of Israel, which during their captivity and wanderings preserved a knowledge of the wisdom of the Egyptians.

In the King's Chamber of the Great Pyramid is a porphyry vessel, called the pyramid-coffer. French *savans* and others have suggested that its sides were intended to serve as standards of linear measure; but Mr. Taylor insists that it was intended as a measure of capacity. According to the measurements of Colonel Vyse and Mr. Perring, it was 78 inches long, 26·5 inches wide, and 34·5 inches deep. Mr. Taylor shows that the capacity of the pyramid coffer is nearly equal to the Hebrew measure of 4 chomers; to the Grecian measure of 128 hecteis; to the Roman measure of 128 modii; and to the English measure of a chaldron—the difference being 14 quarts between the chaldron and the coffer.

"But no nation, ancient or modern, is so remarkable for having preserved a close agreement with the pyramid coffer as our own. First, our peck of wheat, like the hecteus and the modius, is contained 128 times in that coffer: secondly, 32 of our bushels of wheat, or four of our quarters of wheat, would fill a vessel of that same capacity if we had one still in use; but thirdly, though a vessel of this capacity is not in existence with us at present, we must have had such a measure in earlier times, since we daily make reference to it, for when we say eight bushels of wheat are a quarter, we affirm it to be the fourth part of some entire measure which is exactly equal in capacity to the Pyramid coffer."

The coffer is also found to contain 18,005,760 troy grains, and would hold 2,500 troy pounds of wheat, or 3,125 troy pounds of water or wine:—

"Hence any vessel of capacity which would hold 10lb. of 5,760 grains was considered to hold 8 lb. of 7,200 grains. This was the origin, in all probability, of our avoirdupois pound, for according to Fleta's explanation of the merchant's pound and its use, the dealer bought by the pound of 15 oz., and sold by the pound of 12 oz., the ounce being in each case the same, 480 troy grains—so that although he appeared to sell at the price he bought, he in reality obtained a profit of 20 per cent."

We will now return to the origin of the metric system. At the commencement of the French Revolution, when men were athirst for novelty and the great work of progress was initiated—afterwards neutralised by the Terror and the Empire—an agitation arose in the provinces for the establishment of uniformity in weights and measures. Numerous petitions to that effect were presented, and, in 1790, M. de Talleyrand made a proposition to the Assemblée Constituante relative to the adoption of uniform international weights and measures. On the 6th of May, M. de Bonnai made his report upon the proposition, and on the 8th, the Assemblée rendered a decree by which the King, Louis XVI,—"Was supplicated to write to His Britannic Majesty, and to pray him to engage the Parliament of England to concur with the National Assembly in the fixation of a natural unity of weights and measures, in order that, under the auspices of the two nations, the Commissioners of the Academy of Sciences might unite in equal numbers with the members chosen from the Royal Society of London, in the place which shall be respectively judged the most convenient, to determine—in the latitude of 45 deg., or any other latitude which may be preferred —the length of the pendulum, and to deduce therefrom an invariable model for all measures and weights."

The letter was written, but, in consequence of the disturbed state of Europe, no English Commissioners were appointed. Ill-informed persons make the Royal Society responsible for not attending. Even Mr. Cobden throws the blame on the British Government when the terms of the decree clearly prove, that it was a matter between the two monarchs—two of the most self-opinionated men of the age — and that neither the Royal Society nor the British Government had anything to do with it. If George III. did not please to ask the Parliament to what Louis XVI. had requested him to require it to do in obedience to the decree of the Assemblée, it is ridiculous to seek to cast the blame and responsibility of non-compliance either upon the nation, the Royal Society, or the Government. So far from the people of England and their rulers being averse from acting in concert with France, as has been insinuated by Mr. Cobden and his colleagues in the metrical system agitation, we have the best of all evidence that such was the very reverse of truth. According to M. Delambre, in his speech on the progress of mathematical sciences, delivered 6th of February, 1806, before the Emperor in Council, the metrical system arose out of the surveys made both in England and France towards the close of the last century (1787). After the completion of Cassini's great map of France, doubts were felt as to the respective positions of the Observatories of Greenwich, and of Paris, which rendered it desirable to verify points between Dunkirk and Boulogne. In England, it was determined to execute a new triangulation between London and Dover ; and the two Commissions united in concert to measure the triangles which crossed the Channel. As M. Delambre's speech rendered full justice to the scientific skill of the English Commissioners at a time when Trafalgar ill-disposed the minds of the Emperor and his subjects towards us, and as it affords the most complete contradiction to the systematic *denigrements* of this country by Messrs. Cobden, Ewart, and their friends, it will not be amiss to quote :—

"D'après les progrès des arts et des sciences, on devait s'attendre que les Anglais se piqueraient de surpasser tout ce qui avait été fait en ce genre ; ils *y réüssirent ;* le théodolite de Ramsden, les feux Indiens qui servaient de signaux, les appareils nouveaux employés à la mesure des bases donnèrent une exactitude jusqu'alors inouie. Les Français n'avaient à mesurer que des angles ; le cercle répétiteur que Borda venait d'inventer n'était pas d'une forme aussi imposante que le théodolite ; mais il renfermat dans sa construction même un principe qui lui assurait une précision au moins égale et plus indépendante du talent de l'artiste. Les commissaires Français, Cassini, Legendre, et Méchain, soutinrent la concurrence."

The successful issue of the enterprise suggested the idea of the operation on which shortly after was founded the new system of weights and measures. In 1790 only, the date of the French King's letter, was communicated to the public an account of the survey executed by the Commissioners of the Royal Society and the Academy of Sciences for the trigonometrical junction of the Paris and Greenwich Observatories.

It will be remarked, that the original idea of the Assemblée was to adopt the English standard, by taking for base the length of the pendulum vibrating seconds in 45 deg. latitude, and that taking a fraction of the earth's meridian was not thought of. Huygens first proved that the times of vibrations of pendulums depended on their length only; and whatever their structure, that a certain point may be found, which, in pendulums that vibrate in the same time, is constantly at the same distance from the point of suspension. Hence he conceived that the pendulum might afford a standard or unit for measures of length; and, though gravitation was not the same in all latitudes, he believed science furnished the means of determining this correction with sufficient accuracy. The increase of the pendulum is more regular than that of the degrees of the meridian, and differs less from the proportion of the squares of the sines to the height of the pole, either because its measurement is easier than that of the degrees, is less liable to error, or because the perturbating causes of the regularity of the earth produce less effect upon gravitation.

Richer, who was sent, in 1672, by the Academy to make astronomical observations at Cayenne, remarked that his timepiece, which had been regulated at Paris, mean time, lost regularly at Cayenne; and he was thereby enabled to obtain the first direct proof of the diminution of gravitation at the equator. Fresh operations were made at the equator and in Lapland, and more especially by Borda in the Paris Observatory, and by Biot, Arago, and Mathieu, at Formentera, Bordeaux, and Dunkirk, which established the now well-known fact—the regular increase of the lengths of the pendulum going from the equator to the poles. M. le Marquis de Laplace, after alluding in his *Exposition du Système du Monde* to this discovery, says,—"The observations of the pendulum, by furnishing a length invariable and facile to be found at all times, has suggested the idea of employing it as a universal measure." The length of the pendulum and that of the meridian are the two chief means to be found in nature for determining the unit of lineal measure. The French chose the meridian; our predecessors preferred the pendulum. The reason for the preference given by the French is set forth in a report to the Academy from Condorcet, Borda, Lagrange, Laplace, and Mongès, dated the 19th of March, 1791. There were three different fundamental units to select from, they say —a quadrant of the equator, or a quadrant of the meridian, or the length of the pendulum marking seconds. The Commissioners reported that if the length of pendulum were employed to furnish the standard, as proposed in the address to George III., the degree of latitude should be the 45th, because it is the arithmetical mean between all pendulums unequal, one to another, beating seconds in different latitudes. But they objected that the pendulum standard contained a heterogeneous element—time, and an arbitrary element—the division of the day into 86,400 seconds, while they deemed it was possible to have a unit of length taken upon the earth itself which would depend upon no other quantity. The Commissioners believed it much more natural to compare the distance between two places with one of the terrestrial circles than with the length of the pendulum. As for the quadrant of the equator, they observed that its regularity was not more certain than regularity or similarity of the meridians, that the celestial arc corresponding to the space measured is less capable of being determined with precision; and that every nation lays claim to an arc of the meridian, while but very few are placed under the equator. Consequently there remained the quadrant of the terrestrial meridian only. The Commissioners recommended that it should be immediately measured, and its ten-millionth part adopted as the unit of lineal measurement; that the meridian should be divided decimally into degrees, minutes, and seconds; and that the base for weights and measures of capacity should be distilled water, weighed *in vacuo* at the temperature of melting ice. The arc to be measured should be that of the meridian passing from Dunkirk to Barcelona, which is rather more than 9½ deg., is 6 deg. to the north, and 3½ deg. to the south of the mean parallel, and has its extreme points at the level of the sea. Already Lacaille had measured a degree at the Cape, and Boscovich the distance from Rome to Rimini. In 1762 Beccaria measured a degree in Piedmont, Liesganig commenced to measure three degrees in Austria, a fourth in Hungary, and six years later Mason and Dixon measured two degrees in the plains of Pennsylvania.

Circulars were sent from Paris to foreign States, inviting to take part and to send *savans* to form a commission with members of the Institute. The commission was subsequently formed, and consisted of Ænea (Holland), Balbo (Sardinia), afterwards replaced by Vassalli, Berthollet (as member of the Egyptian Institute), Borda, Delambre, Méchain, Bresson, Buggé (Denmark), Ciscar (Spain), Darcet, Coulomb, Fabbrione (Tuscany), Franchini (Rome), Haüy, Lagrange, Laplace (president), Legendre, Mascheroni (Cisalpine Republic), Lefèvre-Gineau, Mongès (as member of the Egyptian Institute), Mulledo (Portugal), Pedrones (Spain), Prony, Tralles (Swiss), Vendermonde, and Van Swinden (Holland), who took as active and important a part as any.

It would be tedious to follow the progress of the work and describe in detail the labours, sufferings, and scientific blunders of the commissioners. But it may be briefly stated that the ten millionth part of the meridan measured in Peru toises $\frac{5,130,740}{10,000,000}$, was adopted as a standard and base for the new French weights and measures, and called a metre. It was equal to 443·295936 lines of the Paris foot; but its legal value and standard were established by law on the 10th of December, 1799, at 443·296, thus suppressing three places of decimals. Since the adoption of the metric system, several subsequent admeasurements have proved that its base, or the metre, is incorrect. The real length of the quadrant of the meridian is 5,131,800, not 5,130,740 toises, and therefore 1,060 toises more than the French *savans* calculated it at. Consequently, the true length of the metre is 443·39 lines—not 443,296 lines—and about one-tenth of a line longer than it is fixed at by law. The commission committed two mistakes—one in the reduction of the bases, and the other in comparing the platina rules,—standards of the metre,—with the toise. The errors were afterwards nearly compensated. Further, and in spite of the advice of Delambre, they omitted to recalculate the arc of the Peru meridian in which Delambre subsequently made a correction of 16 toises by degree. "Lastly," says M. Saigey,—

"If even the operations had been made with mathematical precision, there would always remain the uncertainty of the deviation of the verticals due to the attraction of continents or plumb-lines. Wherefore the commissioners greatly deceived themselves when they defined the length of the metre by means of six decimals. Delambre alone saw, in all probability, this species of ridiculousness, and *niaiserie de géométre*, when he endeavoured to have the length of the metre fixed at 443·3 lines."

Delambre did his utmost to extenuate the errors of the Metrical Commission; and the writer just quoted pointedly observes, that it was singular to behold the *savant* charged with editing the descriptions of the works executed for the metric system, correct results reputed irrevocable, and substitute other numbers for those which ought for ever to represent the dimensions of our globe. Delambre declared that if the standard were allowed to remain as it then was, it would be necessary to measure it, not at the temperature of melting ice—the centigrade zero—as legally must be done, but at a much higher temperature, which he proposed should be 8·5 degrees centigrade.

The great argument in favour of the introduction of the metric system here has been its extreme mathematical accuracy and the presumed ease with which the standard could be recovered and verified in case of the original being destroyed. Instead of such being the case, the unit is founded in error, which, according to the arguments of Sir William Armstrong, is sufficient reason for its abandonment. For we have been told that instead of the quadrant of the arc of the meridian being, as the metric system supposes it to be, 10,000,000 metres, it is 856 metres more. This fundamental error necessarily vitiates the whole series of weights and measures, and the kilogramme should be augmented by 257 milligrammes. Whether it is of importance or not, it certainly destroys all pretensions of the metric system to strict mathematical accuracy. Besides the error in the kilogramme, resulting from that of the metre, there are others of great moment. Bessel, in his *Populäre Verlesungen*, published 1848, shortly after his death, observes that the kilogramme is not exactly the weight of a cubic decimetre, for " many of the late weighings show that water at its *maximum* density has a different density from that which was assumed by the French philosophers who prepared the original standard of the kilogramme." M. Babinet, of the Institute, admits the existence of both these errors, and gives the following curious explanation :—M. Lefèvre-Gineau, to whom, with M. Fortin, was confided the task of determining the kilogramme, pierced a hole in the hollow cylinder that was to contain a cubic decimetre and furnish the unit of weight, " in order that the air in the interior should be in equilibrium with the external atmosphere !" M. Babinet does not hesitate to express the gravest doubts respecting the accuracy of the model kilogramme, which is deposited in the Paris archives, and is the standard of reference for all the States that have adopted the metric system. As for the original papers and tables of calculations which Delambre was so anxious should be preserved, and which he induced the Institute to appoint a committee to examine and receive as a sacred deposit, M. Babinet declares that he has examined them previous to their sale as waste paper, and that he was unable to discover the slightest trace or indication of that careful elaboration which was to be expected in documents of such a nature. The great pretended merit of the metric system is that the base—the metre—is intimately connected with the earth, and can always be recovered in every part of the globe in case of the original in Paris being destroyed. But, before the French Commission terminated their labours, they became aware that all their proceedings were based on error, and that no future measure of the quadrant of a meridan would give their length of the metre as its ten millionth part, and consequently, should the standard be destroyed, the most deplorable confusion would ensue. Accordingly Borda was employed to compare the length of the metre with the length of the pendulum, vibrating seconds in 45 deg. latitude, in order to enable it to be recovered without measuring an arc; so that, notwithstanding all the outcry and all the pretensions set up to the strict mathematical accuracy and the highest scientific character, as compared with our imperfect system, which Mr. Cobden termed "illogical, utterly dislocated and inconsistent," the French metrical system draws its base, the metre, from the same source that we obtain the length of our yard, which is the base of our lengths and measures. The reader will doubtless be led to enquire why the French refused to have recourse at first to the pendulum, which would have given to both countries the same unit of linear measure—preparatory, in all probability, to the establishment of international uniformity—and why they preferred to run the risk of creating a system based on error, that must sooner or later lead to confusion. The "reason why" will be found curious, but quite French. On the 4th Messidore, year 7, M. Delambre appeared at the bar before the two councils of the legislative body—the Cinq Cents and the Anciens—to present in the name of the Institute the standards of the metre and kilogramme, and he then stated that the object of the metric system was to entitle a Frenchman to say—"*Le champ qui fait subsister mes enfans est une telle proportion du globe. Je suis dans cette proportion co-propriétaire du monde.*" Elsewhere we read, "The earth is the Lord's.

There is no lack of evidence of the inconvenience of the metric system, furnished by practical experience during many years past, which fully justifies the apprehension entertained when it was first started. Even Laplace, the last few years before his death, was seriously disquieted by the anticipated discordance between the kilogramme and the metre, and in defence of the system elaborated under his presidency, he urged the facility it affords for arithmetical calculation, as compared with the vulgar system, but he admitted that "our arithmetical scale (the decimal one) is not divisible by three and by four—two divisors whose simplicity renders them very usual," and he declared that the addition of two cyphers or new figures would have sufficed to procure that advantage. But he feared the duodecimal system would neutralize the advantage of having ten digits to count upon. To Laplace we may oppose Professor Playfair, who reviewed, in the first number of the *Edinburgh Review* for 1807, the first volume of Delambre's work on the Base du Système Metrique, and whom Mr. James Yates, Secretary of the International Association, with a recklessness rarely surpassed, quotes as being the author of a "most beautifully written article," in which he expressed "a decided wish that the system should be adopted in this country." Professor Playfair was an admirer of the labours of the French Commission, but he was anything but a thorough partisan of the metric system. He objected to several of its features, to which objections Delambre replied in the third volume of his work, that appeared in 1810. This is what the Edinburgh Reviewer did say more than half a century ago, and his opinions deserve the most careful attention now:—

"Ten has indeed no advantage as the radix of numerical computation, and has been raised to the dignity which it now holds merely by the circumstance of its expressing the number of a man's fingers. They who regard science as the creature of pure reason must feel somewhat indignant, that a consideration so foreign and mechanical should have determined the form and order of one of the most intellectual and abstract of all the sciences. The duodecimal scale would nowhere have been found of greater use than when applied to the circle, the case in which the decimal division is liable to the strongest objections. The number by which the circumference of the circle is expressed ought not only to be divisible into four integer parts—as in the French system [which divided the circle into 400 grades, subdivided into 100 minutes, and these into 100 seconds], but also into six; for the sixth part of the circumference, having its chord equal to the radius, naturally falls, in the construction of instruments and in the computations of trigonometry, to be expressed by an integer number. According to the decimal division of the quadrant, the sixth part of the circumference not only is without an integer expression, but the decimal fraction by which it is measured is one that runs on continually without any termination. This is at least a deformity that arises from a rigid adherence to the decimal division; and it is probably the main cause why that division has been found so difficult to introduce into trigonometrical and astronomical calculation. In astronomical tables we believe it has never been adopted."

Following the same side, Mr. John Quincy Adams, who was the commissioner appointed by the United States' Government to inquire into the desirability of adopting a decimal system, reported,—

"The decimal system can be applied only, with many qualifications, to any general system of metrology; its natural application is only to numbers; and time, space, gravity, and extension inflexibly reject its sway. It is a contrivance of man for computing numbers, and not a property of time, space, or matter. Nature has no partialities for number ten, and the attempt to shackle her freedom with it will for ever prove abortive."

Yet Mr. Yates did not scruple to say, in his evidence before Mr. Ewart's Committee, that Mr. Adams " passes the highest eulogy, quite enthusiastically, on the philosophers who were employed in making the measurement and devising the system." How just and accurate is this representation of Mr. Adams's opinions may be judged from the quotation of Mr. Adams's own words:—

" The metrology of France is a new and complicated machine formed from principles of mathematical precision, the adaptation of which to the uses for which it was devised is yet problematical, abiding with questionable success the test of experiments."

And he further observes, as to the comparative practical advantages of the two systems:—

" The habits of every individual inure him to the comparison of the definite portion of his person with the existing standard measures to which he is accustomed. There are few English men or women but could give a yard, foot, or inch measure from their own arms, hands, or fingers with great accuracy. But they could not give the metre or decimetre, although they should know their dimensions as well as those of the yard or foot."

Although Professor Playfair said, it is an indignity to make an intellectual science depend upon so foreign and mechanical a consideration as a man having ten fingers to aid his calculations, yet, as it is held to be a recommendation of the metrical system, it should be a recommendation of our system that a *digit* is a finger's breadth; an *inch*, the length of the thumb; a *nail*, from the tip to the middle joint of the longest finger; a *palm*, the breadth of four fingers; a *hand*, the fist with the thumb uppermost; a *span*, the space between the tips of thumb and fingers extended to the utmost; a *foot*, that of a man; a *cubit*, from the elbow to the end of the longest finger; a *yard*, girth of a man's body; a *step*, when each foot advances alternately; a *pace*, two steps; a *fathom*, width to which a man's arms and hands can extend, and 32 grains of average wheat equal to a pennyweight or 24 grains troy.

Having alluded to Mr. Ewart's Committee, it may be permitted to express the surprise which every one who peruses it must feel that, in face of the overwhelming balance of scientific evidence taken against the metric system, a Bill pretending to be based upon it should have been presented to Parliament. The Astronomer Royal declared, that the anomalies complained of in the existing scales of weights and measures had arisen from a general feeling of convenience, which prompted the introduction of various kinds, great and small, such as the yard for one purpose, the inch for another, and the mile for another; but these do not, he believed, produce such inconvenience in practice. He did not think the advantage to be derived from the establishment of international weights and measures worth mentioning in comparison with the extreme difficulty of introducing them. The number of persons is so small. and the daily transactions in foreign trade are very small in comparison with our domestic transactions. Could the change be made, even *per saltum*, from the present to the decimal system, he did not believe it would be advantageous; or that the decimal system would scarcely at all facilitate calculations, except in the coinage. Few working men ever use the tenth; they employ the half-quarter, eighth, and sixteenth, and, comparing the persons interested in foreign measures with the mass of the people, the former will be found to be so inconsiderable in number as to render the establishment of international uniformity in weights and measures not of the least consequence. There is no utility in having a system based on a common unit like the French. All should be done by practice. The merit of the decimal scale is strictly limited to its application to long sums of addition, and to troublesome sums of multiplication or division. The French system would not suit the habits of the people of this country at all; it would not be a convenient system, but the inconvenience of its introduction would be very much felt by the common people. Uniformity would be bought at the price of such enormous inconvenience, and the trouble would be so great, that people would see no advantage in it at all. If he had a new nation to create, said the Astronomer Royal, with a new system of weights and measures, he would give them the binary scale throughout, That, he conceived, would be the nearest to perfection—the binary scale with means to enable us to use decimal multiples and submultiples. During the cross-examination of this witness by Mr. Cobden, a curious episode occurred, which is interesting as proving that, for a practical man of business, the hon. member for Rochdale is not at all quick at figures, and anything but a ready reckoner or an arithmetical authority. He asked if a cargo of 27 tons of tea had to pay 1s. duty a lb., would it not be necessary to multiply 27 tons by 20 cwt., then by 112lb., which would be "a pretty long calculation." Should these remarks fall under the eye of "a little boy" in a merchant's office—one of those who, Mr. Cobden told the House of Commons, intended to petition for free trade in arithmetic, and who are advertised for, to serve without salary for the first six months, writing a good hand, and quick at figures—he would be able to show the hon. member for Rochdale that by the aid of what the little boy will call "gumption," the pretty long calculation may be made a remarkably short one. Inasmuch as 20s, make a pound sterling, and there are 20cwts. of 112lb. each in a ton, the duty being 1s a lb , the little boy will be able to tell on the instant, without pause or putting pen, to paper, that the duty per ton will be £112, and the duty on the cargo will be £112, multiplied by 27, which will be the only calculation he will have to effect to arrive at the required result.

Professor de Morgan insisted on the necessity of keeping distinct decimalization and metricalization, two things often confounded. He was as much for. decimal division as any person could be, which he believed might be easily introduced and would co-exist perfectly well with the binary division which he was satisfied must always be used by the common people. He objected to the introduction of French units into this country upon the balance of convenience and inconvenience. It would create such an immense amount of confusion throughout the country, that the inconvenience would far more than counterbalance the advanatge we should derive in our foreign commercial relations. The metre was objectionable. It arose from a mere fanciful connection with the quadrant of the meridian, and is of no practical importance to any man alive. "You might just as well," said the Professor with polished sarcasm, "try to subdivide the distance from the earth tlo the moon." The metre is too long to be the common measure, and the next decimal division—the decimetre—would be too short to take the place of our foot. The litre—about a pint and three-quarters—is either too large or too small. Half a litre would not do, because that would destroy the decimal character.

Mr. William Fairbairn was not prepared to say what would be the best standard or the best unit, but he believed the foot or the inch would be the best.

Mr. C. H. Gregory, C.E., freely admitted, that there may be difficulties in the way of the adoption in England of the French standards for money, weights and measures, which, when considered by those who devote themselves deeply to the subject, may be judged to outweigh the advantages of an identity of our weights and measures, and money with the French system. All he desired was the decimal division of our scales.

Mr. J. A. Franklin, a professional auditor, did not believe it would be just as easy to induce Englishmen to measure length and capacity by the metre as it would be by the decimal multiples of the foot. A change is not universally or generally desired. The differences which exist between the scales of various localities are rather modes of expressing weights and measures than a difference in the weights and measures themselves. The pound avoirdupois is recognized universally, and the witness objected to anything else but 7,000 grains being called a pound in Great Britain.

The evidence as to the metrical system being evaded in countries, on the inhabitants of which the use has been imposed by law, is remarkable, all the more so as it is supplied by witnesses who desire to force it upon this country. M. Michel Chevalier admitted that in the two great staples of trade—wine and corn—it was not used. "No care has been taken to have the cask of any regular number of hectolitres. Wine is sold in what we call *la barrique*, generally of that kind of barrique which we call *la Bordelaise*. It is two hectolitres and 18 or 20 litres generally on an average. It would have been better to have made it of two hectolitres." The eminent political economist might have added that elsewhere in France wine is sold by the *pièce* and *demi-pièce*, *feuillette* and *demi-feuillette*. M. Michel Chevalier further said, that not only were bottles by which wine is sold not metrical, but they were not alike. For Burgundy they are nearly a litre; for champagne they are smaller, and for Bordeaux smaller still. "First-rate wine is too dear to have in all cases a full litre in a bottle." He stated also that "at Marseilles, where there is a very large trade in grain, grain is sold by the *charge*. But what is a *charge*? It is not a certain number of hectolitres, as it ought to be." Mr. Bass, perhaps the largest purchaser of grain in England, said the French have adopted a decimal and metrical system, yet there is an entire absence of uniformity They affect to sell by the hectolitre, a measure of capacity it is referred back to the kilogramme, a measure of weight. "In point of fact, so far as I can see, in the French system they have no measure of capacity." The buyer for Mr. Bass's house reported, that in Champagne he bought barley by the quintal of 100 French lbs. (50 kilogrammes), and in Paris by the metrical quintal (100 kilogrammes); on the Loire by the hectolitre of 65 kilogrammes; on the Saale corn is bought by the last of 11 quarters, not of 10 quarters as is customary elsewhere. In the price current, wheat is quoted by the 120 kilogrammes, barley by the 100 kilogrammes, rye by the 115 kilogrammes, and flour by the 6 marks of 159 kilogrammes. If the reader will refer to *The Times*' correspondent's letter of last Tuesday from Paris, he will perceive that, in addition, flour is sold by the sack of 157 kilogrammes, and at Lyons by the sack of 125 kilogrammes, which quite justifies Mr. Bass's conclusion, that the metrical system is merely a nominal system, and that it does not exist so far as the sale of corn goes. Mr. Dickson, a manufacturer, who opined that the metrical system was the greatest blessing ever bestowed on France, admitted that the people were scarcely yet brought round to use the blessing. Instead of calculating their produce, or letting their land by the hectare, they let by the *mesure*, which in one parish consists of 35 *ares*, and in another of 44.

To present a Bill to Parliament, and assert that it is based upon such evidence in favour of the introduction of the metric system here, is to be almost sublime in audacity. It looks much like a breach of good faith and like an attempt to palm off an imposture on the public, for the metrical system is not what it is said to be. It is not accurate; it is not symmetrical; it is not logical; it is not consistent; and it is not logically sequential, as Mr. Cobden declared it to be, and yet we are asked to adopt it instead of the English system, which, as Mr. Taylor truly says, "has for its foundation all the scientific accuracy attributed to the French, with the further recommendation that it has stood the test of actual experiment for above 4,000 years."

INDEX TO THE GREAT PYRAMID.

ADDED HERE FOR THE CONVENIENCE OF THOSE WHO POSSESS THE FIRST EDITION OF THE BOOK, IN WHICH IT WAS NOT INSERTED.

A.

B.

D.

F.

G.

H.

NAMES OF EMINENT PERSONS, WHOSE WORKS AND OPINIONS ARE CITED.

*** The figures refer to the *pages* of the "Great Pyramid," where direct *quotations* are introduced.