standing a strenuous life, the details of the examination of tombs left on my mind an indelible impression that it is in those tombs and in the underground excavations that the most valuable matter will probably be found in the future. I have much pleasure in seconding the resolution.

The resolution was put to the Meeting and carried unanimously.

The proceedings then terminated.

WEIGHTS FOUND IN JERUSALEM.

CONSIDERATION OF THE ANCIENT SYSTEM OF WEIGHTS, SHOWING THE DERIVATION OF THE STONE WEIGHTS FOUND IN THE EXCAVATIONS AT JERUSALEM IN 1867–1870, AT OPHEL, ROBINSON'S ARCH., &c. (*P.E.F.Q.S.*, 1870, p. 336).

By General Sir CHARLES WARREN, G.C.M.G., K.C.B., F.R.S., R.E.

I have many times attempted to come to some conclusion as to these weights, but have always failed to do so until I tested them by Troy grains, and the later Egyptian Kat, weighing about 145·5 grains Troy. I am now able to show, that these weights are measured by grains Troy, and are to be referred to the Troy pound of 5,760 grains Troy (of 12 ounces), and to the old European Commercial pound of 7,200 grains Troy (of 16 Troy ounces), and that these pounds have been raised to their existing weights at some period (uncertain) from the ancient Tower pound (5,400 G.T.), and from the ancient Hon (6,750 G.T.), both of which weights are familiar to us, as they were our standard weights in England; the Hon having been suppressed in 1326 A.D., and the Tower pound in 1527 A.D. In order to show how this has come about, it is necessary to go somewhat into detailed considerations of the early weights and measures.

(1) Our Troy grain has lost about 1 per cent. in weight: so that originally there were 250 Troy grains to a cubic inch of water.

I propose, first, to show that our Troy grain has lost, in weight, about 1 per cent. since mediæval or earlier times, so that in comparing the values of existing weights I will use the original value of the Troy grains. This will save very much in calculations, as the Roman pound will come out 5,184 instead of 5,235 G.T., and the Attic pound as 6,480 instead of 6,544 G.T., as at present, and thus can be compared with the original weight of the Tower pound 5,400, as follows:—

		Ratio.
Tower pound	5,400	25
Roman pound	5,184	24
Attic pound	6,480	30

I shall call existing Troy grains simply G.T., and original Troy grains O.G.T. The present Tower pound in old Troy grains is really about 5,346 O.G.T., and the ancient Tower pound in present Troy grains is 5,454 G.T.

The first test which I make is that of dividing the weight of the ancient Tower pound (5,400 O.G.T.) into the number of cubic inches of water in a cubic foot (1,728), according to the old rule of 80 pounds to a cubic foot. This gives 21·6 cubic inches to 5,400 O.G.T. or 250 O.G.T. to the cubic inch.

Therefore, if the inch has remained constant, the grain Troy has lost the difference between 250 and 252·5 in every 250 grains, or about one per cent. of its weight. And as we may be certain that the inch has not varied perceptibly from the inch deduced from the Great Pyramid base (as will be shown), we may feel sure that it is the Troy grain that has deteriorated in weight.

The Troy grain may have lost weight either through a given portion having been cut off by authority or else through some inaccuracy in the keeping of the standard: but our standards have been kept with such extraordinary accuracy, through so many centuries, that it seems more probable that during the changes from the Tower pound to the Troy pound some portion may have been removed from the weight.

Mr. Donisthorpe in *Measures, Past, Present, and Future*, makes the following remark: "Our present Troy pound did not exist till 1527, when it was established by Henry VIII, upon what must be described as a disgraceful arithmetical blunder, or a piece of unworthy State dodging and sharp practice, deliberately planned, with a view to extracting a penny in the pound for the Treasury." It

weighed only 6,120 Tower grains ($\frac{1}{16}$ grain Troy) instead of 6,144 Tower grains, as the Troy pound should have weighed. We thus learn of the weight of one half of the loss being abstracted in one transaction, and if at any other time a penny and a half (36 Tower grains) were abstracted from the weight of the pound, we have the whole loss of 1 per cent. made up. There would be a slight difference in using well water in olden days instead of distilled water, but the difference only amounts to about one grain in a thousand, and is not worth consideration.

I will now give a number of instances, showing that by accepting the Troy grain as defective in weight by one per cent., the comparison of ancient weights and standards closely agrees with existing weights.

	Weight, G.T.	Reduced by 1 per cent. G.T.	Correct weight, O.G.T.
Kelly's "Cambist," 1824. Existing Roman pound	5,234	—	—
Kelly's "Cambist," 1824. Florence and Leghorn pound	5,240	—	—
Mean	5,237	5,182	5,184
Hussey's estimate of Roman pound	5,204	—	—
Clerk's „ „ „	5,240	—	—
Arbuthnot's „ „ „	5,249	—	—
Congius of Vespasian	5,204	—	—
Mean of 4 ..	5,230·6	5,178·6	5,184
Quiebo, 100 Attic drachmæ	6,557·7	6,492	6,480
„ „ Ptolemy „	5,460	5,406	5,400
„ „ Euboïc „	9,090	9,000	9,000
Hussey's shekel	218	216	216

The various ancient minas and pounds when transferred into cubic inches at 250 grains to cubic inch, come out as 2,592, 43·2, 32·4, 27·0, 30. It may then be assumed that the grain Troy has lost 1 per cent. of its weight and was originally estimated at 250 to the cubic inch.

(2)—The Ancient Cubit and the Inch.

There is but one ancient cubit. It was the fourth part of the height of a man, and was divided originally into 20 digits, and subsequently into 24 digits, and should naturally measure about 17 inches, allowing about 5′ 8″ for the average height of a man in early days.

The exact length for practical and commercial purposes had, however, to be fixed arbitrarily with reference to some standard. It was made a rule that a cubit cylinder (*i.e.*, a cylinder of height and radius equal to a cubit) full of water must weigh or balance a given number of standard weights of the period. The weight used for this purpose was a Hon of 6,750 grains Troy (4,000 Rati). 640 Hons were to balance a cubit cylinder of water, giving very closely a capacity of 8 bushels of our old Winchester measure; the half-cubit cylinder holding one bushel, and the quarter-cubit cylinder holding one gallon.

The cubit resulting from this weight of 640 Hons is very nearly[1] the length of the cubit of 24 digits, deduced from the measure of the base of the Great Pyramid, which we knew to contain 440 cubits of 28 digits, and to be 9,068·8̇ inches in length. This 24-digit cubit is then 17·6666 inches in length, while the cubit from the 640 Hons is 17·59 inches.

In process of time, probably before the era of the Ist Egyptian dynasty, it was found necessary for building purposes in Babylonia and Egypt to establish a ratio between the side of a cube and the height and radius of a cylinder of equal capacity.

Now the true ratio is $\sqrt[3]{\pi} : 1$ or 1·4646 : 1 so that they were involving themselves in all the intricacies of squaring the circle, and it must be admitted that they acquitted themselves admirably as I will explain.

Let us take a cylinder 28 inches in height and radius and a cube of equal capacity, and ascertain what is the double cubit resulting, and the height of a man to be deduced from it.

The side of this cube will be 28 × 1·4646 inches = 41·0088 inches or a cubit of 20·5044; if this be divided into 56 digits we have $\frac{1{\cdot}4646}{2} = {\cdot}7323$ inches, and the 24-digit cubit will be 17·58 inches,

[1] See further on.

and the height of a man 5′ 10″·32. That is to say, the British inch is bound up with a digit of ·7323 inch and the height of a man of 5′ 10″·32, and cannot be separated from these adjuncts. The inch,[1] therefore, is the natural result of taking the height of a man as the standard. Given the height of a man as somewhere about 5′ 10″, the digit or 96th part must be somewhere about ·7323, and the unit of measure (in similar terms to the side cube) must be either the inch or multiples or sub-multiples of it. Thus by taking this second measure (the inch) the ancients had no trouble in accommodating their cubes to their cylinders, a cube of 14 palms a side was equal to a cylinder (equal height and radius) of 28 inches a side.

The ancients, however, had no knowledge of the true value of the ratio that the circumference of the circle bears to the diameter, they could only get to it by degrees, and the nearest cube root of π they were able to get at first was $\frac{53}{36} = 1{\cdot}472$; subsequently they arrived at $\frac{22}{15} = 1{\cdot}466$ (which is very near the true value 1·4646) and this value they seem to have used with our 13·2 Belgic foot.

They found it necessary to increase the length of the cubit of 24 digits to 28 digits, because of the numbers they used in squaring the circle, and then they found that a cube on 56 digits a side (the double cubit cubed) was equal in capacity to four cubit cylinders of 24 digits, height and radius. This was the basis of all their measurements and calculations.

In consequence of their taking too high a value for the cube root of π, they have an inch somewhat greater or a palm somewhat shorter than it should have been; the length being (taking the inch as the standard) 20·5044, (cubit from the Great Pyramid 20·6109), but as the Euboïc system gives the cubit almost according to the exact ratio we may assume, I think, that the ancients knew the true value of the cubit, but could not manage to get it nearer than 20·6109 when using linear measure, on account of the necessity for taking a number of cubic inches as the standard which could be divided up readily, keeping to whole numbers.

No doubt the principal reason for keeping to the 20·6109 cubit was that the number of cubic inches in the double cubit cubed is 70,048, and 70,000 (discarding a very small fraction) gives a cubic

[1] The absolute length of the inch was subsequently fixed by the Babylonians as $\frac{1}{500000000}$ the diameter of the Earth.

foot of 2,592 cubic inches = 12 × 12 × 18. I give the various results in cubic inches obtained from the several systems, and it will be seen that they arrived at nearly the same number of 70,000 in a very skilful manner:—

Base.		O.G.T.	O.G.T.	C.I.
Cylinder	Original Binary system, $(8)^6$ × 67·5		17,694,720	70,778·8
Cylinder	Euboïc, 2,560 Hon of ..	6,750	17,280,000	69,120·0
Cube	Eginetan, 2,160 Log of ..	8,100	17,496,000	69,984·0
—	Gudean, 60,000 + 10,000		——	70,000·0
Cube	Double cubit cubed, 2 × *20″·6109*		17,512,000	70,048·0

In extracting the cube root of quantities the ancients had far less difficulty than may be supposed, though they could not attain accuracy unless they arrived at their object by repeated multiplications. They could, however, arrive closely at the results they wanted by means of a scale. It is quite an easy matter to construct a scale vertical and horizontal of different values, and by putting up a few cubed quantities, to trace out a curve through the points, from which the cube roots of other numbers may be obtained. Such a scale can be laid out and cube roots obtained with considerable exactitude in a few minutes at the present day. They were probably quite as expert in such manual work as we are now, and they knew a great deal more about the theory of numbers than we, as a rule, do. For example, to extract the root of 3,000 I get as a result $14\frac{5}{12} = 14{\cdot}416$, the root by logarithms being 14·423, difference = ·007 inch.

In all their calculations the inch must have been a factor constantly necessary, and no doubt they always carried about with them a note of the ratio which it bore to the cubit.

The inch as deduced from the Great Pyramid is identical with the British inch, and we have all reasons for supposing that there has been no change in its dimensions since the earliest times. F. Petrie says (in *Inductive Metrology*) of the buildings in England where the inch was used, "it seems that the inch now in use has not varied any appreciable amount on the average for centuries."

All that any person required for obtaining the value of the inch at any time was to know the number of digits on which the cubit was based and the fraction giving the ratio between the digit and the inch.

(3)—The Evolution of the Grain Troy.

Grain by weight: 64 ancient wheat = 32 Rati = 48 ancient barley = 54 old grain Troy = 54·54 Troy.

The earliest standards of weight, so far as we have any information as yet, were grains of wheat or barley, or seeds of Rati, in the ratio of 2 wheat grains to one Rati seed by weight. There is no clear indication as to which was first used, but at present the balance is rather in favour of the Rati. Wheat and barley grow over the districts of Babylonia and about Lake Van, and the Rati (the Abrus precatorius) grows in Arabia, Syria, India, and probably Babylonia.

The earliest method of counting numbers was the binary system of constantly doubling or halving the amount as: 1, 2, 4, 8, 16, 32, 64, &c. And the earliest standard weight, so far as we know, was 64 old grains wheat = 32 Rati seeds (equal to 54 old grains Troy).

This weight is found all over the world. In Europe it is the quarter shekel, the ducat. In India it is the Dharana, Purana, Tank, Pagoda, Varaha.

This method of doubling constantly from one grain was found to be too laborious, and we next find that they took ten fingers of grain, or ten Rati, and made a standard weight of 80 Rati. This weight is found all over Southern Asia, India, and the Levant. It is the Kat of Egypt (135 O.G.T.), the Indian Karsha-pana or pana (copper), the Suvana (gold), the Adalia, 2 Jitals or 2 kani amongst the Indian Moslems. This system of doubling was in primitive times a necessity with measures of capacity, as a cylinder of a cubit height and radius has eight times the capacity of a similar cylinder of half a cubit height and radius. It is generally supposed that cylinders were in use for measures of capacity before cubes.

It is probable that the first measures of capacity did not go by weight of water, but by the number of grains of wheat or Rati they would hold, but of this we have as yet but indistinct indications, in the information that has come down to us. It is possible that the cylinder which held $a \times 32$ Rati may have held an amount of water weighing $a \times 40$ Rati, giving a ratio of grain to water as 4 : 5; at the present day there are 80 pounds of water to a bushel, and about 64 pounds of wheat.

We start our consideration of the grain from the time when a cubit cylinder of 24 digits (17·6 inches), full of water, balanced or weighed a certain number of Rati, which we know from the average weight of the Rati to be *about* 2,560,000, and we find that by constantly dividing by eight, we arrive at 80 Rati (the Kat), and then to the base of 10 Rati: whilst by continually dividing the content of the double cubit (28 digits) cubed by eight, we arrive at 40 Rati, or a base of 5 Rati. We may then assume that the primitive base for the measurement of a cylinder of water was 10 Rati, and that the standard weight was the Kat: the older weight of 32 Rati being used for weights only: but this use of the Kat or the standard only holds good for those countries where the original binary system was adhered to.

The work of constantly doubling the amount of grain was so laborious that they very soon found a short cut by taking the pint as 5,000 Rati instead of 5,128 Rati, thus reducing their weights by nearly 2 per cent. This accounts for the difference of 2 per cent. between the primitive weights at the present day in India and Egypt.

Original computation: $80 \times 8 \times 8 \times 8 \times 8 = 327{,}680$ Rati.

Improved computation: $40 \times 10 \times 10 \times 80 = 320{,}000$ Rati.

Thus the multiple of 10 was introduced at the sacrifice of 2 per cent. of the weight of cylinder.

Process of arriving at the bushel or talent:

32 Rati, the weight standard.		40 the half Kat.	
100		100	
3,200 the Tower pound.		4,000	the Hon.
100		80	
The Euboïc talent, 320,000 or bushel.		320,000	

Thus from early times there were 100 divisions (drachmas) to the pound, and 80 pound to the bushel or talent.

We have thus arrived at the Euboïc talent or bushel, equal to a cylinder (24 digits) of half cubit height and radius. The most extensively used of all the world measures, and by all nations, all over the world, except in those parts where the still more primitive method is used of constantly doubling from 10 Rati, as in India.

We have then the following progression for the contents of the several cylinders:

	Multiple.	40 Rati =	½ Kat.	
	100	4,000 „ =	50 „	Hon.
⅛ cubit cylinder	125	5,000 „ =		pint.
¼ „ „	1,000	40,000 „ =	500 „	gallon.
½ „ „	8,000	320,000 „ =	4,000 „	bushel.
„ „	64,000	2,560,000 „ =	32,000 „	quarter.

(To be continued.)

THE IMMOVABLE EAST.

By PHILIP G. BALDENSPERGER, Esq.

(Continued from Q.S., 1906, p. 102.)

The Arab, at times so sober in words, and at times overflowing with voluble language, whether for praise or (more especially) for insult, indulges in much mimicry, and employs a language of signs with his hands, feet, and face.

Blushing is almost unknown, though I *have* seen a blush even through their dirty yellow-brown skin. They can tell fibs and lies without flinching, but *kadhdhâb* "liar" is an insult, and only hurled at liars of the most outrageous description. Denial can therefore be expressed by an action, viz., by shaking the index-finger of the right hand from left to right several times. "No!" would be, slightly throwing the head backwards. "Yes!" throwing the head forward, or shutting the eyes a few times in quick succession. "I have nothing at all, not an atom," can be indicated by putting the nail of the thumb to the teeth of the upper jaw and by releasing them by a violent movement of the hand forwards, thus producing a slight sound between nail and teeth. Beckoning with the hand palm downwards is "come"; throwing the fingers forward in the same position is "go." Holding the beard and gazing steadfastly means, "I swear by my beard." Holding the beard and inclining the head sidewards, "please have pity." Touching and twisting the moustache, with furious eyes, "I will avenge myself." To