Notes on Egyptian weights and measures

F. L. Griffith

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NOTES ON EGYPTIAN WEIGHTS AND MEASURES.

BY F. L. GRIFFITH, F.S.A.

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A paragraph intended to rectify a few points in regard to measures of capacity, has rapidly expanded into what I fear is hardly less than a bulky conspectus of Egyptian metrology, as derivable at the present moment from hieroglyphic and hieratic sources down to the Ptolemaic period.* In presenting it to the benevolent criticism of Egyptologists and others, I must not fail to acknowledge my enormous indebtedness to the writings of others who have collected together materials and have often discussed them with success: Brugsch, Chabas, Dümichen, Eisenlohr, Lepsius, Petrie, and Revillout are names that will especially be remembered in connection with important discoveries and publications in the province of Egyptian weights and measures. Firm ground is now being reached at many points: the great official systems are yielding up their secrets; but side by side with them one seems to discern here and there vestiges of popular and perhaps foreign systems, which have left few traces in written records, and yet were abundantly used by the mixed peoples of ancient Egypt according to their various crafts and at various periods of the country's history.

It will be seen that the XVIIIth dynasty forms as marked an epoch in metrology as in palæography and in the still unwritten history of titles.

SECTION I.—MEASURES OF LENGTH.

The royal cubit of about 20·6 inches with its subdivisions into 7 palms and 28 digits is the ordinary measure of length. For land, a measure of 100 cubits named *khet* or *khet n nuh* "reel of cord," and for itinerary measures the *ater* or schoenus, of varying length in different localities, formed the units.

The cubit. The royal cubit *meh suten* is well known from inscribed examples, the earliest of which date from the XVIIIth

* A few illustrations are taken, chiefly at second-hand, from demotic and Greek documents.

dynasty. Many of them are divided in a most elaborate way, and the divisions are generally accompanied by names, but the only division that can as yet be recognised in other inscriptions are the *shep* or "palm" , $\frac{1}{7}$ of the cubit, and the *téba* , "finger" or "digit," $\frac{1}{28}$. The others were probably in practical use, but records of length less than the royal cubit were kept, so far as can be ascertained, in terms of the palm and digit. These cubit rods, the evidence of which has to be received with caution, for they are often very carelessly inscribed, have been published and discussed by Lepsius in his memoir entitled *Ueber die Altaegyptische Elle und ihre Eintheilung* (Berlin, 1865), to which I beg to refer the reader for fuller information. According to Lepsius, the chief divisions marked upon them are: —

"royal cubit"	= 7 palms	= 28 digits.
meh net's, "short cubit"	= 6 ,,	= 24 ,,
remen, "upper arm"	= 5 ,,	= 20 ,,
t'eser	= 4 ,,	= 16 ,,
peṭ aa, "great span"	= $3\frac{1}{2}$,,	= 14 ,,
peṭ net's, "small span"	= 3 ,,	= 12 ,,
	= 2 ,,	= 8 ,,
	= $1\frac{1}{2}$,,	= 6 ,,
"handsbreadth"	= $1\frac{1}{4}$,,	= 5 ,,
, *, *šp*, "palm"	= 1 ,,	= 4 ,,
, *t'bā*, digit (subdivided $\frac{1}{2}$, $\frac{1}{3}$, etc., to $\frac{1}{16}$)	= $\frac{1}{4}$,,	= 1 ,,

but when the details are closely examined, it is found that the progression is not quite so uniform, and that probably several more or less incommensurable units have been pressed into the scheme, partly indeed by the Egyptians themselves.†

Subdivisions of the cubit are not common in the early periods, and it is fortunate that Mr. Newberry has found an early hieroglyphic sign for *shep* in revising the well known inscription of Chnemhotep at Beni Hasan (XIIth dynasty). In l. 202 we now have , 5 cubits two palms; where may be an abbreviation of the *

* is only approximately correct. The sign is practically with the thumb omitted.

† Flinders Petrie, article on *Weights and Measures* in *Encyclopædia Britannica*, IXth edition.

(=), which is found on some cubit rods. The later form of *shep* is taken from the hieratic. The Rhind Mathematical Papyrus (XVIth dynasty) sometimes writes the word in full, and marks a finger (quarter of the palm) in the hieratic by a dash / (Pl. XV).

Measurements of small objects. There are but few records of the measurements of small objects. On the shrine of Saft el Henneh, XXXth dynasty (edited by Naville, Pl. V–VII), for the dimensions of small images we find the digit used as the unit up to a total length of 10 digits, *e.g.*, , for 6 and 10, while 14 digits are expressed as , 3 palms 2 digits. The cubit here is .

In the Westcar Papyrus (II 23), of the XVIth dynasty(?) a wax crocodile of 7 *khet(?)* is made, which when thrown into pond turns into a monster 7 cubits long. The (?) is evidently to be taken in the sense of some very small measure, possibly some decimal division of the cubit. As to the reading of the word, the first sign is nearly identical with that for in the Rhind Mathematical Papyrus, although is formed quite differently elsewhere in the Westcar; in common-sense matters there would never be a risk of confusing a of 100 cubits (*see* below) with one of (say) $\frac{1}{100}$ cubit, while the existence of two such homonyms would help to explain the nonsensical variants of Chapter 108, l. 1, 2 of the Book of the Dead.*

For ordinary measures above 2 palms the cubit, palm, and digit were used. In the Bulaq Papyrus of accounts (XIIIth dynasty) we find sticks of incense, one cubit, or one cubit five palms in length (adopting the above hieroglyph for the palm). For , *see* the Postscript.

Architectural, etc.—Mr. Petrie's researches have shown, in agreement with the results of other enquirers, that the royal cubit was the principal building-unit from the earliest times. As howevei he has noted a 25-inch cubit in Egypt, and the cubit-rods name a of 17·1 inch, it is worth while to point out that the cubit of the Rhind Mathematical Papyrus is the "royal cubit."

* See below, p. 5.

It follows from the equations given by that document, namely:—

(1.) *henu* $= \frac{1}{10}$ *hekt*
(2.) 100 quadruple *hekt* = 20 *khar*
(3.) *khar* $= \frac{2}{3}$ cubit cubed

that the *henu* $= \frac{1}{4000}$ of 20 *khar*
$= \frac{1}{200} \times \frac{2}{3}$ cubit cubed $= \frac{1}{300}$ cubit cubed.

According to Mr. Petrie,* the cubit shown in the marvellously accurate work of the Great Pyramid is 20·62 inches, and the average of the royal cubit on the rods is 20·65. Taken at 20·6 inches the cubit when cubed gives 8742 cubic inches, of which $\frac{1}{300}$ is 29·1. $20{\cdot}65^3$ would give 8805 cubic inches, of which $\frac{1}{300}$ is 29·35. The average capacity of the *henu* is known from several inscribed examples (which however vary considerably amongst themselves), to be 29·2 ± ·6 inch,† so the equation with the cubit cubed is extraordinarily accurate.‡ The cubits of 17 and 25 inches would give totally wrong results.

In all probability any cubits other than the royal cubit would be distinguished by some name or epithet in the inscriptions. The , , whenever it occurs, is presumably that of about 20·6 inches. The is found as an architectural unit on the earliest monuments of the time of Senefru, at Mêdûm,§ and at Abûsîr,‖ and the arm is the determinative of the words , , meaning "measured length, breadth," in the inscription of Una, of the VIth dynasty, where a barge of 60 by 30 cubits is mentioned. In the quarry of Hammamât the sizes of blocks are recorded in cubits.

The MSS. of the Book of the Dead, in cursive hieroglyphs, as edited by M. Naville, give an interesting example of the cubit notation in the chapter 108, l. 1, 2: namely, (con-

* *Weights and Measures.* † Flinders Petrie, *l.c.*

‡ That the *henu* was intended to be $\frac{1}{320}$ of the cubit cubed can hardly be admitted: 1, the equation goes against the working equations of the Rhind Papyrus, which are no rough approximations, but (in practice at least) are the bases of minute calculations down to fractions of the ; 2, it leads to a *henu* of only 27·3 to 27·8 cubic inches, and is therefore apparently inaccurate; 3, there is no direct evidence in the texts for such a relation with the cubed cubit.

§ Petrie, *Medum*, pl. VIII.

‖ L.D., II, 7, tomb of Amten.

firmed by a fragment of another copy ( ), which can only be translated "½ of the cubit of 7 palms." This seems to indicate, (1) that the Egyptians really recognised a cubit other than that of 7 palms, (2) that they occasionally wrote "½ cubit" instead of "3 palms 2 fingers." Once also in the Rhind Papyrus (No. 46) we find 3⅓ (cubits) where the unit is not written.

Inscriptions of every period might be quoted to show that, for architectural purposes, the only recorded unit of linear measurement was the cubit , without special multiples. Amten, in the IVth dynasty, tells of a house 200 cubits × 200 cubits. In the plan of the grave of Rameses IV (XXth dynasty, *Br. Thes.*, p. 1441) the entries are all 135 cubits 2 palms down to 1 cubit 3 palms 2 fingers, and the like. So also the dimensions of the temple of Edfu are all in cubits, palms, and fingers.

The khet. The main land measure was the *khet*, which is shown by its relation to the ἀρούρα to be 100 cubits in length. It occurs in the Book of the Dead: in Chapter 108, l. 1, 2, of the Turin text, the mount of Bekhat is said to be 370 *khet* in length and 140 cubits in breadth. (The variants in M. Naville's edition give for the *length !* (1) "½ of a cubit of 7 palms" (*see* above), (2) "4 cubits 4 palms and 2 fingers," (3) "300 cubits," each with breadth of 200 or 300 cubits.) In Chapter 149 *d* the Turin text describes a mountain 300 long and the same broad. The earlier variants for this are 300 or for the length, and 10 , 10 or 10 *ater* ( ) for the width.

At Edfu and at Denderah (Brugsch, *Wtb.*, *Suppl.*, p. 963) the as the side of the ἀρούρα appears also as , , , a word of which the true form is given by a stela of the time of Thothmes I, at Kum el Ahmar, opposite El Kab. A certain Tehuti says there (sic) "I have cleared a road for my offerings, of 21 *khet.*"* The tomb in which the stela is engraved is a long distance behind the ancient town, which itself lies on level desert, so that this road of about 1,200 yards or 1 kilometre was a very suitable encouragement to visitors.

The name , determined by , evidently means something like "a reel of cord," the measuring line of 100 cubits being no doubt wound round a stick or reel. It is remarkable that no text recording simply linear measurement gives fractions or special multiples of the .

The schoenus. As an itinerary measure for very long distances there is the *ater*, which apparently corresponds to the σχοῖνος of Herodotus and other Greek authors (who value it at 60, 40, 32, or 30 stades). On a stela of Amenhotep III from Semneh, the distance between two garrisons in Ethiopia, (near Dakkeh) and (*cf.*) is given as "52 *ater* of sailing."† Rameses III at Medinet Habu states that "the slaughter of the enemy continued from to the city (?) of Rameses III which is on the hill of . . . . . ., making "8 *ater*." In the picture of he fields of Hotep, Chapter 110 of the Book of the Dead, the Ani Papyrus gives the length of the as an *ater*, , while the Turin text gives 1,000 *aters* .

In a papyrus of the Louvre (Pierret, *Insc. du Louvre*, I, pp. 104 and 107) we have the forms , , the last leading to the Ptolemaic , *ar.*

* *Proceedings*, X, plate opposite p. 74, bottom line. My extract is taken from an excellent copy made by Mr. Petrie in 1887 : most of the readings were incorporated in the published copy, *l.c.*, but some seem to have been omitted from the plate.

† Birch, *On an Historical Tablet of Ramese II*, in *Archæologia*, Vol. XXXIV, p. 389.

The connection with the σχοῖνος is furnished by the name δωδεκασχοινος given to the country between Syene and the island of Takompso: the inscriptions of Philæ and Dakkeh record the renewed grant of the 12 *ar* to Isis of Philae, stating that from Syene to Takompso it measures 12 *ar* on the east and 12 *ar* on the west, in all 24 *ar*. Strabo and others state that the *schoenus* varied in different parts of Egypt, and it is interesting to note that one of these inscriptions specifies the measure in question as the *ar* "of Isis," that is no doubt the local *schoenus* of Philæ, which if Takompso is placed at Maharraka, would be no less than 8½ miles or over 70 stadia.*

A very interesting inscription published by Brugsch from the temple of Edfu, raises hopes (that are hardly realised) by giving an estimate of the length, breadth, and area of the Egyptian Nile valley : the first, from Elephantine, is 106 *aur* (=*ater*), the breadth , "in level land from the western barrier of Kemt to the eastern barrier likewise is 14 *aur*," "comprising (?) 270 *aruras*" (=27,000,000 *aruras*).† Now 14 × 106 = 1484, so here we may have an equation between 27,000,000 *aruras* and 1484 *ater* squared, giving about 18,200 *aruras* to the square *ater*; the *arura* contained 10,000 square cubits, so that the *ater* squared would have contained 182,000,000 square cubits, and the *ater* of Edfu would thus be 14,000 cubits = 4·2 miles, about 40 stadia.‡ According to this, the Egyptians reckoned Egypt as an area extending 4·2 × 106 = 445 miles from south to north, and (on an average (?)) 59 miles between the barrier hills. My interpretation, however, is merely a tentative one. The Edfu text is intended to display the extent of country below Elephantine that

* The above examples are mostly taken from Brugsch's two Dictionaries and *Geographische Inschriften*: for Takompso, *see* the *Dict. Geog.*, p. 841, and for the measurement, Baedeker's *Upper Egypt*, p. 300.

† *Thesaurus*, p. 604. = 100,000 is the highest power of 10 used in Egyptian arithmetic.

‡ Assuming that the "royal cubit" forms the basis of the field measures.

was irrigated by the Nile: the measures in *ater* are probably not intended to represent the actual length and breadth of the land, but are rough *average* estimates from which to judge the area. From the round numbers of *ater*, the area is deduced likewise in round numbers of (100,000) of *aruras*. This is the only explanation I can offer until further evidence is found; the priests seem to have over-estimated the area of the Egyptian Nile valley even when taken in its broadest sense, for 27,000,000 *arouras* mean about 73,918 square kilometres or 28,430 square miles, while Schweinfurth, who gives the length of Egypt proper as 550 miles, makes the cultivable area only 11,342 square miles:* this, it may be observed, implies an average breadth of only 20 miles: exaggeration on the part of a college of native priests, anxious to magnify the importance of the Nile, may be excused, but it must be confessed that the statements do not increase our respect for Græco-Egyptian geographical science.

Section II.—Measures of Area.

The areas of fields and countries were reckoned in squares of the *khet*, 100 royal cubits: such a square was called in Egyptian *set* and in Greek *arura*, and it was considered to be composed of 100 strips, each one cubit in breadth. The half arura was named *remen*, being the square of 100 of the linear *remen* of 5 palms in length. The square cubit, used in measuring small areas, is very rarely found.

Superficial field measure. The Rhind Papyrus includes a page† devoted to the art of reckoning field areas. The only measure of length used in this section is the *khet*, which, in the plural, seems to be written (No. 52, l. 12). The notation of the square measures is:—

| (| |, etc.)	= 10 square
(, etc., to 9)	= 1 ,, ,,
	= $\frac{1}{2}$,, ,,
× (hieratic)	= $\frac{1}{4}$,, ,,
(hieratic)	= $\frac{1}{8}$,, ,,

* Baedeker, *Lower Egypt*, 1st edition, p. 30.

† Pl. XVII with No. 48 on pl. XVI.

EGYPTIAN I

TABLE OF MULTIPLES AND SU

Sq. Metres.	Sq. Cubits.	or πήχεις	ἀρούρα	Dynasty IV. 1.	Dynasty IV. 2.	Dyn. XII. Asyût.	Dyn. XII–X Kah
27,287·	100,000	1,000	10				
2,728·7	10,000	100	1	...			
...	5,000	50	$\frac{1}{2}$	...	...	...	
...	2,500	25	$\frac{1}{4}$	...	...	...	
...	1,250	$12\frac{1}{2}$	$\frac{1}{8}$	...	...	...	
...	625	$6\frac{1}{4}$	$\frac{1}{16}$	...	...	...	..
85·27	$312\frac{1}{2}$	$3\frac{1}{8}$	$\frac{1}{32}$	...	...	...	..
42·63	$156\frac{1}{4}$	$1\frac{9}{16}$	$\frac{1}{64}$	...	...	...	..
...	1,000	10	$\frac{10}{100}$	...	...	...	
27·287	100	1	$\frac{1}{100}$	...	...	...	
13·643	50	$\frac{1}{2}$	$\frac{1}{200}$	...	...	...	(ar =25 sq

LD MEASURES.

VISIONS OF THE *SET* OR *ARURA*.

Dyn. XIII. El Kab.	Dyn. XVI. Rhind.	Dyn. XIX. Berlin Pap.	Dyn. XX. Harris Pap.	Demotic.	Greek.	Edfu, *c.* 100 B.C.
	|			...	early ...	∩
...					ἀρούρα	|
...				/	β́	
...	×	...	×		δ́	
...			...		ή	
...	...	...	...	($= \frac{2}{16}$)	later also ιϛ́	
...	...	...	...	...	λβ́	
...	...	...	...	...	ξδ́	...
...	*false?*	?	...	...	...	...
...		?	...		πῆχυς	...
...	in	?	...	...	...	...

* (hieratic) $= \frac{10}{100} = \frac{1}{10}$ square .

 (, etc., to 10) $= \frac{1}{100}$ " "

/ , † (hieratic) $= \frac{1}{200}$ " "

The names of the $\frac{1}{2}$ and $\frac{1}{100}$ are denoted by one sign (=) in hieratic, but the comparative table given below shows that $\frac{1}{2}$ is at Edfu, whereas $\frac{1}{100}$ is "cubit of land," in a Ramesside Papyrus, and is therefore to be written "cubit." The hieratic for admits of many transcriptions.

The (for the square) is in the hieratic: the transcription is obtained thus:—In No. 50 of the Rhind Papyrus, where the area of a circular field with a diameter 9 is obtained by squaring $\frac{8}{9}$ of the diameter, the result of the multiplication is given as 8×8 = 6 4: but in some cases one of the factors is first multiplied by 100 (producing instead of square), and in the final result the *thousands* are entered as units, while the *hundreds* are placed under the curved line . In a previous volume (XII, pp. 85–87) I have pointed out a measure of area (apparently with rounded ends) having a 10-multiple "a thousand": these measures and must thus be hieroglyphic equivalents for the and the | (= 1,000 , 10) of the Rhind Papyrus; only instead of I prefer to use , which has still better authority. The remaining signs cannot yet be transcribed.

It is clear that this complicated notation is rather clumsily made up from several units, namely: (1) the or square ; (2) the , of which 1,000 make the , or "thousand," and 100 the ; (3) the , comprising 50 of the , and equal to $\frac{1}{2}$ of the , and $\frac{1}{20}$ of the .

* The two passages (No. 54) in which this occurs are so much blundered, that one suspects it to be simply a scribe's error for : it exactly resembles the numeral ∩∩∩ "30," and actually occurs in No. 55.

† is the usual sign for $\frac{1}{4}$, and probably is incorrectly substituted for / by the careless scribe, just as he seems to have written the familiar 30 for .

In the primæval tomb of Amten (early IVth dynasty) there are records of land granted or inherited, as follows :—

L.D., II, 3. , ,

L.D., II, 6. , .

L.D., II, 7. .

The last shows that the and were already in use, and as the in this text has straight ends, we need not hesitate to identify it with the large , of the other examples in which , is the sole unit. It will eventually become clear that the , is the full name of the land-measure , which in the unsettled orthography of the period could be inserted or omitted at pleasure.

Thus in four of the above instances the system was that of the without a special multiple, in a fifth it is doubtful, as the number of does not reach 10, but in the sixth the 10-multiple is admitted.

At Asyût, Tomb I (XIIth dynasty) I, 313 ff, there is a total gift of made up of , , . Here the determinative replaces the of the early inscription, and the has rounded instead of straight ends.

At El Kab in the tomb of Sebek-nekht (XIIIth dynasty, L.D., III, 13*b*) we have "lands, low-lying, 20 'thousands,' that which is on the high ground 120 of 'thousand of land,' total 140." Here = .

A Kahun papyrus (XII–XIII dynasty) uses the 1 (=), the and the : like the Rhind, for it uses the correct form .* As an example of the Rhind notation we may take from No. 55 the "duplication."

. *i.e.* $1 = \frac{1}{2}\ \frac{10}{100}\ (\frac{60}{100})$

.. *i.e.* $2 = 1\ \frac{1}{8}\ \frac{7}{100}\ \frac{1}{100}\ (1\frac{12\frac{1}{2}+7+\frac{1}{2}}{100} = 1\frac{20}{100})$

.... *i.e.* $4 = 2\ \frac{1}{4}\ \frac{1}{8}\ \frac{2}{100}\ \frac{4}{100}\ (2\frac{25+12\frac{1}{2}+2+\frac{1}{2}}{100} = 2\frac{40}{100})$

In the notation of the New Kingdom the disappears, and the name , is revived for the . In a Berlin papyrus we have entries such as and ,† *i.e.*, 70 $\frac{1}{2}\ \frac{1}{8}\ \frac{10\frac{1}{4}}{100}$, corresponding to the Rhind . , also , is to be read *set*, *setet*, and it is the same as the *sata* (for *set*) of the Edfu texts, which is the square , just as the of the Rhind Papyrus is the square . In some late texts for we find and in the new "Rosetta" text of the Naucratis tablet corresponds to the Greek ἀρούρα. The ἀρούρα was a square of 100 cubits, and contained 100 πήχεις or cubits of land, *i.e.*, cubit-strips (of 100 cubits length) taken down the width of the ἀρούρα. Thus the ancient notation of the containing 100 "cubits" or (?) "cubits of land," is fully explained.

The essential identity of the system of land measurement throughout Egyptian history down to the end of the Greek period, will be made still clearer by the following table. Only it will be observed that the was abandoned at the beginning of the New Kingdom, and the is replaced at Edfu by an extension of the

* See the Table for the Kahun series. † *A.Z.*, 1879, p. 75.

binary division of the ἀρούρα to $\frac{1}{32}$. The Greeks carried this a point further to $\frac{1}{64}$ during the Roman period.* For the demotic notation, compare Eisenlohr, p. 341 of the present volume.†

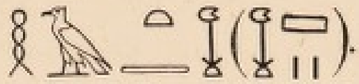
* Tessera Berlin, P. 158, *Rev. Ég.* VI, p. 11.

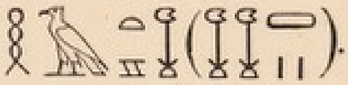
† Being obliged to quote this paper, I cannot pass over the hostile remarks upon p. 342. As to the Kahun papyri, I hope to publish them soon *in extenso:* meanwhile, if the Professor will take the trouble to refer to the story of Sanehat, L.D. VI, 104, l. 123, he will see the sign  (in the word  "bull") resembling in essential points the  of the Ebers cartouche. What is more distressing is that the Professor should have thought it necessary to defend his "priority" against my "pretensions," and to call attention to it more than once. This "priority" which is so highly valued is, on p. 597 of vol. xiii, shown to lie in the comparison of certain symbols in the Ebers papyrus with those of the *hekt* in the Rhind Mathematical Papyrus. It would have been an unparalleled feat in the annals of decipherment if a Professor, who spent so many years in preparing an edition of the Rhind Mathematical Papyrus, had failed to see a resemblance between the symbols of measurement contained in it and the *identical* symbols in the magnificent Ebers papyrus, the publication of which took place while he was in the midst of these studies, and caused such a sensation in the world of Egyptology. I did not notice his printed remark on the subject, otherwise I might certainly have mentioned it for the sake of completeness. This little "ewe lamb" of the Professor is, however, so minute that no one but himself could have detected its presence in the alien fold. My object in writing on the Metrology of the Ebers papyrus was to explain the whole system: Eisenlohr's remarks show how little he understands the metrology which he is supposed to have studied so long, but which he must have almost forgotten in the midst of other occupations. If any scholar had addressed himself for a month or so to the serious study of the texts, he might surely have explained almost the whole system of Egyptian metrology, which has so long stood in need of interpretation: when once the grammar and writing is understood, the greater part of the work consists in merely putting 2 and 2 together in simple arithmetic. I am as much astounded at the subject having been left so long in obscurity, as at the Professor's insisting upon his claim to priority in a mere comparison of forms, which was perfectly obvious and might or might not mean something. He was not and is not aware that there were double and quadruple *hekt* having the *same series of symbols* (and *besha*(!) is still his reading for *hekt*), although they occur so conspicuously in the Rhind Papyrus. Professor Eisenlohr's labours have undoubtedly thrown much light on Egyptian metrology and arithmetic: if some remark of mine as to improving the commentary on the Rhind Papyrus (of which his edition was excellent for the time, 1877) hurt his feelings, I am sorry for it, and I beg to assure him that it was quite unintentional.

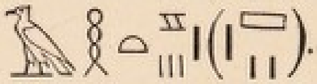
I hope that this defence will not have the effect of preventing the Professor from criticising the present paper, for I am sure that if his interest in metrology should revive, the result would be a gain to science. The subject is in fact still capable of almost daily development.

In the absence of any direct evidence on the point, I have assumed the cubit in question to be the royal cubit of about 20·6 inches, and have thence calculated the areas in metres. All that follow the subject closely will agree that the correctness of this assumption is almost beyond doubt.

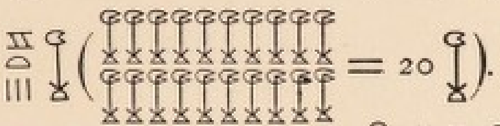
The "1000 of land" is written as the largest unit in various texts thus:—

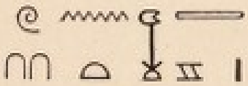
Dynasty IV. Amten, L.D. II 7. 

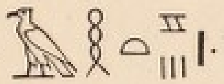
Dynasty XII. Asyût tomb I, l. 313 ff. 

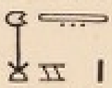
Dynasty XII—XIII. Kahûn Papyrus 

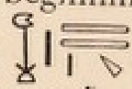
Dynasty XIII. El Kab, L.D., III, 136.

(1) 

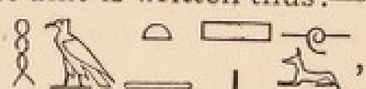
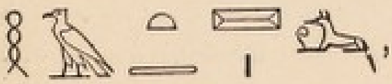
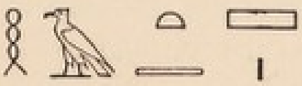
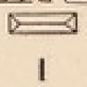
(2) for high numbers, , or with numeral only .

Dynasty XVI. Rhind Math. Pap. 

The diagram of this measure would be , 10 *aruras;* but each arura being subdivided into 100 cubits of land makes it also "1000 (cubits) of land  . It would comprise about 6¾ English acres, and that area of rich Egyptian soil would be a valuable possession.

The unit seems to have disappeared at the beginning of the New Kingdom, but the name was preserved in the  "farm" of the papyri of the XIXth—XXth dynasties; just as ἄρουραι lived on to "Byzantine" times* in the sense of "fields."

The arura *set* when it occurs as the largest unit is written thus:—

Dynasty IV. Amten, L.D. II, 3 and 6 , ,  or  (*see* examples above).

* Revillout, in this volume, p. 65.

Dynasty XVIII. Thothmes I, El Kab, L.D., III, 12. *c.* , do. 12 *d.*, l. 21 .

Dynasty XVIII. Thothmes III, Karnak. *Br. Thes.*, 1288 = Mariette, Karnak, Pl. XV, ll. 38, 39. , ... *

Dynasty XVIII, Thothmes III, Mêdûm, hieratic graffito .†

Dynasty XIX. Seti I. Destr. des Hommes ‡ (for ?). The hieratic form of has here been retained in the hieroglyphs, thus offering a parallel to the , for the "palm."

Dynasty XIX. Rameses II. Berlin Papyrus .

Dynasty XX. Harris Papyrus and .

Dynasty XXV. Louvre Stela ().

Dynasty XXVI. Louvre Stela () in a formal record.

Ditto „ Statue A 93. in an archaistic inscription.

Ptolemy V. Naucratis Stela .

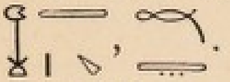
Ptolemy XI Alexander I, Edfû Temple () , , or numerals only.

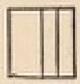
The name is *set*, usually written , in which the sign of land is combined with the measuring rope. I cannot explain why the jackal appears in , , . *sata* is probably

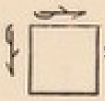
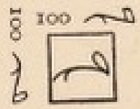
* There can be no doubt of the correctness in the main of Prof. Brugsch's restoration here. The use of the and in this fine inscription is a link connecting the old style with the new.

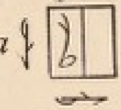
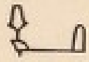
† No. VIII, l. 7, in Mr. Petrie's *Medum*, Pl. XXXIV.

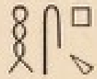
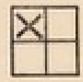
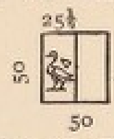
‡ Lefebure, tombeau de Se'i I, Pl. XV, XVI.

only a false *basse-epoque* spelling of *set*, formed on the analogy of   means "land," or "fields;" it is not a part of the name, but is usually specified before the field measure for the sake of clearness.

The divisions are binary, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, after which the  or  becomes the unit, but the Edfu text substitutes for the last a continuation of the binary divisions down to $\frac{1}{32}$. In discussing the linear field measures, I shall show that these divisions were, in practice, taken right across the *arura* , but the names are sometimes more easily explained by other diagrams.

The sign  *remen*,  at Edfu, for the half arura is remarkable. We must connect it with the  *remen*, "upper arm (?)" of the cubit rods, this being of 5 palms, while the royal cubit is 7 palms, so that sq. : sq. :: 25 : 49, practically $\frac{1}{2}$: 1. While the *arura* was a square of 100 cubits , the *remen* was a square of 100  

treated as a rectangle forming half (50 cubits length) of the *arura* . The presence of the sign  therefore increases the probability of the basal cubit being the *royal* cubit of 20·6 inches; an allied sign  appears on the rods at $\frac{2}{3}$ of the *short* cubit; but $(\frac{2}{3})^2$ or $\frac{4}{9}$ is too far from $\frac{1}{2}$ to cause any uneasiness on that head.

The $\frac{1}{4}$, named  *hesep* at Edfu, in hieratic is represented by ×, the usual symbol for $\frac{1}{4}$. The diagram would be  for the *set* divided into four *hesep*. The sign  for $\frac{1}{8}$ *arura*,  at Edfu, indicates the *half* of some measure, superficial or linear, probably the superficial *hesep*, so that the *hesep* would be 

.

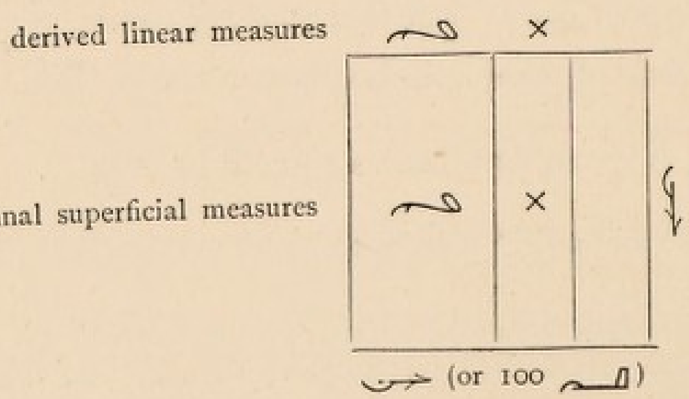
*Linear field measures.** In a tomb at Anîbe (L.D., III, 229 *c*,

* These linear measures are so intimately connected with the measures of area from which they are derived, that to group them with the latter needs no apology.

XXth dynasty) the extent of certain estates is represented by notched rectangles , , while others , , and , collectively amount to . Thus each space between the notches denotes 1 , and the second picture, in which the sides are divided, probably indicates *i.e.*, 10 units. Although the tomb is not in Egypt proper but in Ethiopia, without doubt the unit is the *set* or *ἀρούρα*. The linear and superficial field-measures were so closely connected and so far interchangeable that finding for (the square) is not at all surprising.

Amongst the subdivisions of the *arura* we have seen that $\frac{1}{100}$ is named "cubit" after the length of its base in the side of the *arura:* the *set* being denoted by at Anîbe stands on precisely the same footing. By a reverse process binary subdivisions of the in land-measuring are designated by the names of the rectangles of area which would be described upon them in the side of the *arura*, so that for instance at Edfu can mean either $\frac{1}{4}$ or $\frac{1}{4}$. It is clear that the three names of these linear subdivisions are derived from the superficial and not the superficial from the linear, for how else is the for $\frac{1}{2}$ linear and $\frac{1}{2}$ superficial to be explained?

For the Rhind Papyrus (Pl. XVII, Nos. 53, 54) in which the use of these linear subdivisions of the is very scanty, we can draw the following diagram of the *ἀρούρα* as the type used in practice. No doubt the side, like the square itself, should be further subdivided to $\frac{1}{8}$, and the subdivision of the into 100 cubit lengths is amply vouched for by calculations in which the number of *on one side only* is first multiplied by 100.



For Edfu we might construct a similar diagram showing the divisions, linear and superficial, down to $\frac{1}{32}$. Instances of their use are extremely plentiful: I need only give the names—

of the *arura* and *khet*.

In the Edfu system the *set* would be theoretically by quartering the *ḥesep*, making 16 *su*, and of the 25 the half was named *rema*, meaning perhaps "the new fraction." Later still in a Greek document the quartered quarter is again quartered, reaching the $\frac{1}{64}$ of the arura.

The "cubit of land" *meh*, *meh-ta*, is written:

Dynasty XVI. Rhind Math. Pap. ; $\frac{1}{2}$ = /, /.

Dynasty XIX. Berlin Pap. ; $\frac{1}{2}$ = .

In the Greek papyri it is simply πῆχυς (explained in 1828 by Amadeo Peyron), in the demotic *meḥ aten*, "cubit of land."* Its type form is 1 × 100 = 100 square cubits, its half being 50 square cubits. It was probably also treated as the square of 10 cubits 10, but for this we have no definite evidence.

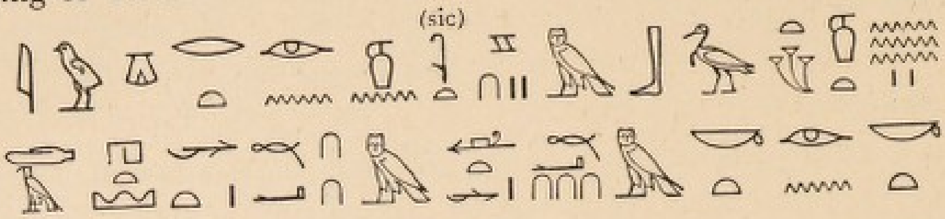
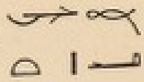
The ἀρούρα being made up of 100 of these cubit strips, the contained 50, the × 25, and the 12½. No lower subdivision than the ½ cubit was recognised,† so that the binary subdivision of the arura could not be carried further than $\frac{1}{8}$, except by abandoning the cubit system as was done at Edfu and by the later Greeks.

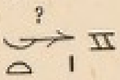
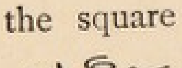
The square cubit. Areas not being field measures are usually denoted by two linear dimensions, or by the diameter in the case of a circular space. At Hammamât the well known inscription of Henu, dating from the reign of Sankhkara (XIth dynasty) records among other things

Diagram of the cubit of land.

* Revillout, in this volume, pp. 66 and 237, note 35.

† *i.e.*, in land measuring [but see "Kahun" in the table with ½].

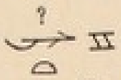
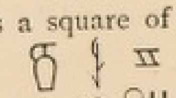
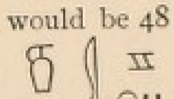
the digging of certain reservoirs or wells on the desert road. Henu states:  : * "Moreover I made a well of 12  in 'The Bush' and two wells in Adahet 22  in the one, 30  in the other: I made another in Aahebt 10 cubits by 10 on each side."

The last of these wells is given as a square of 10 cubits: in another graffito † king Nebtaui-ra is said to have discovered a natural (?) well or pool  likewise "10 × 10 cubits and full of water," one, too, that "kings and armies had passed in former times without seeing it." In both of these cases two dimensions are given, but for each of the first three there is only one numeral. Obviously then the measures in the first three cases are measures of area. I see no better way than to make the  and both of these = square cubit, so obtaining an ascending series; the first well will be 12 square cubits, the second 20, the third 30, and the fourth 100. Thus ,‡ or  *khet meh*, the square cubit, would be the ancient form of the demotic  *meh khet*, which Professor Revillout long ago recognised in the papyri, and has mentioned again on p. 66 of this volume.

The square cubit was too insignificant to be utilised in field measures, and there was little risk of confusing it with the linear 100-cubit *khet*, or with the "cubit of land," despite similarities of name.

* L.D., II, 150 *a*, Golénischeff, *Hammamat*, Pl. XVI, ll. 12, 13.

† L.D., II, 149 *f*, Golénischeff, Pl. XIV.

‡ This , however, might be some other measure such as a square of two cubits, 12 of which would be 48 square cubits; or instead of  we might perhaps read  "12 wells," only the number 12 seems excessive.

Section III.—Measures of Capacity.

The principal measure was the *hekt* (equal to $\frac{1}{30}$ of the cubit cubed), on which a most elaborate system of multiples and subdivisions was built. For corn the *khar*, "sack," of 20 *hekt* was superseded at or before the XVIIIth dynasty by the "sack" of 16 *hekt*, called by the Greeks *medimnus*. The medimnus, probably after the Macedonian conquest, was halved to form the *artabe*, which was thenceforth the principal corn measure in Egypt. For liquids and solids alike, the *henu*, $\frac{1}{16}$ of the *hekt*, was commonly used. Many other measures existed.

a. The *khar*.

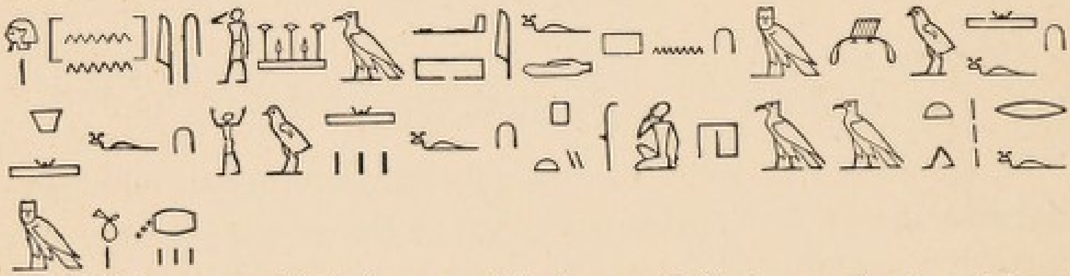
This measure, hitherto unnoticed, is likely to prove an important one. The word first* appears in the Westcar Papyrus XII, 4, as , and in the Rhind Mathematical Papyrus several times on Pl. XV, XVI, (namely, No. 41, 3 ; No. 43, 3, 4 ; No. 44, 3) as (plural) : the last-named document makes it $\frac{2}{3}$ of the cubit cubed, which at 20·6 inches to the cubit would give 5827·88 cubic inches or about 21 gallons ($2\frac{1}{2}$ bushels, 97 litres) as the modern equivalent of the *khar:* the determinative would imply that it was sometimes made of hide, and therefore sack-shaped. In the Westcar Papyrus XI, 1, Ra-user offers the disguised deities in return for their good services "one (measure) of corn,"† "let me give this one (measure) of corn to your baggage carrier," and in the sequel we find this measure of corn once specified as a *khar*, as follows: the gods having put some magical instruments "into the measure of corn," request Ra-user to keep it for them until they come northward again: afterwards, a servant is sent to take some of the corn, but on opening the door of the sealed

* The Asyût Tomb I l. 292, "caldron (?)," must not be confused with the *khar; cf.* Le Page Renouf, *Proc.*, VII, p. 102, 104, for the reading : (for the fish, see Mr. Petrie's *Medum*, Pl. XII, and p. 38, in which certainty is at length arrived at).

† This group must be carefully distinguished from , *i.e.*, 10 *hekt*, see below.

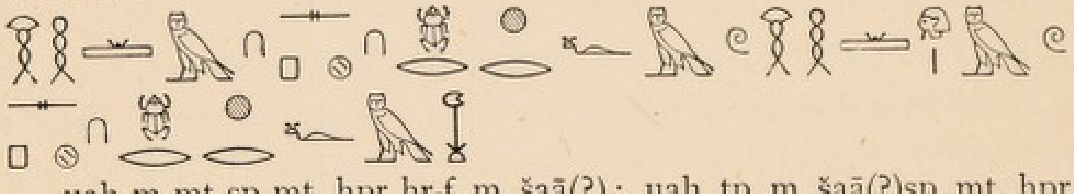
chamber in which it lies, hears music and dancing. Her mistress then comes into the room and hunts about without discovering where the sound comes from until she puts "her forehead to the *khar;*" then, finding that the music, etc., was going on inside it she puts it in a box, etc., etc. The *khar* is thus evidently identical with the "corn, one (measure)" or with a sack or other receptacle containing it. That "corn, one" should denote the *khar*, shows the great importance of the latter in practical life. The determinative seems to be appropriate to sacks, baskets, etc.

I find no trace of this measure after the Middle Kingdom: its latest appearance is in the calculations of the contents of granaries in the Rhind Papyrus: to take an instance, the example No. 44 on Pl. XVI is as follows:—



ṭp [n] nȧs šaā(?)ȧfṭ (n mt m) fu-f mt, usḫ-f mt, qau-f mt: pti haat rf m šs?

Chapter (?) of reckoning a granary square (of 10, in*) its length 10, its breadth 10, its height 10: what is the amount that is put into it in corn?



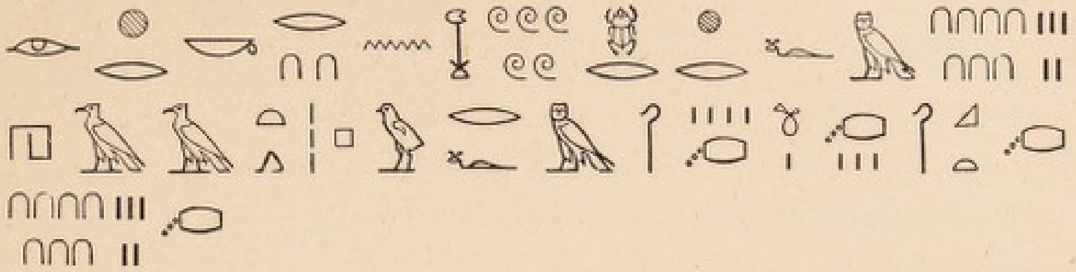
uaḥ m mt sp mt, ḫpr ḫr-f m šaā(?): uaḥ ṭp m šaā(?)sp mt, ḫpr ḫr-f m ḫa.

Count (?) 10 ten times, it becomes 100: count (?) 100 ten times, it becomes 1000.

ȧr ḫr-k ḳs n ḫa m ṭuȧ-n-šaā(?), ḫpr ḫr-f m ḫa ṭuȧ-n-šaā(?): rḫ·f pu m ḫaru.

* These three words are superfluous and should be omitted.

Make thou the half of 1000, *i.e.*, 500, it becomes [by addition] 1500 : that is its amount in *khar*.



ȧr ḫr-k r-t'aut n ḫa ṭuȧ-n-šaā, ḫpr ḫr-f m sfḫu ṭuȧ : haat pu rf m ḥqt ȧfṭ (?) : šs [?] ḥqt sfḫu ṭuȧ.

Make thou $\frac{1}{16}$ of 1500, it becomes 75 : that is the amount that is put into it in quadruple *hekt* measures, namely 75 hundreds of *hekt*.

The implied measure of length is the cubit : this is the general view, and is proved, *e.g.*, by No. 46, where cubits are specified, it being shown that a bulk of 25 hundreds of *hekt* ($\frac{1}{3}$ of 75) is contained in a granary of 10 cubits × 10 cubits × $3\frac{1}{3}$ (= $\frac{1}{3}$ of 10).

In order to find the contents, the scribe has first multiplied together the three dimensions, thus obtaining a result in cubic cubits : the next step, adding the half, gave the contents in *khar*, which measure was therefore $\frac{2}{3}$ of the cubed cubit : the final conversion into quadruple *hekt* will be dealt with below.

b. The *hekt* (and *apt*) measures.

In this section I shall endeavour to give a sketch of the elaborate system of the .

The sign , the groups , and , and the monogram in the inscriptions all denote one measure : corresponding to them in the papyri are , , , , but early hieratic offers two distinct forms of , one of them being undistinguishable from . In transcribing from the papyri I have preserved these two forms as in order to give the evidence for their identity more fairly : this in fact was adopted into hieroglyphics ; in a tomb of the XVIIIth dynasty we find for , and in another inscription stands for the double *hekt.* The word *hekt* seems to be masculine, *cf.* (Rhind Math. Pap., Pl. XX, No. 69).

The Rhind Mathematical Papyrus states that the *hekt* contained 10 *henu* ( ) = about 292 cubic inches. The *henu* as being $\frac{1}{10}$ of the *hekt* might have been expected to form part of the series, but it is never so used, and appears only as an independent unit.

The above signs and groups generally appear as headings to long series of multiples and fractions, so that it is not easy to obtain clear evidence as to which unit or units in the series they represent. I have several times been led to think that the *hekt* , might be the 10 multiple or even 100 multiple of . There are, however, two decisive arguments on the other side.

(1) The Naucratis stela, see below p. 32, makes 8 [sic] = ἀρτάβη (=39·39 litres), so that the *hekt* must be 300 cubic inches, or about 10 *henu*, which is the value of the . being only a base variant for , it follows that = .

(2) The exchange value of bread, beer, etc., depended entirely on the amount of corn used in making it: the number of cakes of bread or jars of beer per measure of corn was called the *pefsu*, "baking" or "cooking." According to the evidence of the *pefsu*, the strength of the ordinary beer was slightly diminished in the course of centuries. In the Rhind Papyrus (Nos. 71–78) of the XVIth dynasty the *pefsu* of beer is 2, 2¾, and 5 to the : in the earlier Bulak papyrus of accounts (Mar., *Pap. de Boulaq*, II, Pl. 25, 30, 35, 36), XIIIth dynasty, it is constantly 2, evidently to the same measure. At Karnak, in an inscription of Thothmes IV (Dum., *Kal.*, XXXIX = Mar., *Karnak*, Pl. 33), XVIIIth dynasty, the only entry of beer-pefsu is IIII, "Beer, *tesi*, *pefsu* (in the) 4." There is here no sign of the being the 10 or 100 multiple of . On the other hand, the calendar of Medinet Habu (XXth dynasty) gives the *pefsu* of *tes*-beer as 5, 10, and most commonly 20, for the *quadruple* (written ,) = 1¼, 2½, and 5 for the single . Similar results could be obtained from

the far more complicated *pefsu* of bread. Thus = in the *pefsu*-entries.

Dynasty I—VIII. I do not recollect any mention of the on the monuments of the Old Memphite Kingdom.

Dynasty IX—XIII. In the inscriptions I can only point to , mentioned at Asyût, Tomb V, l. 9 (Xth dynasty) and Asyût Tomb I, l. 279, possibly = l. 281, 309 (XIIth dynasty).

In the papyri we have, as headings for the figures and symbols of the series, from Kahun (XII—XIIIth dynasty) , and perhaps other forms : in the Theban papyrus of accounts (Boulaq, No. 18, XIIIth dynasty) .

The papyri of this period display a special notation in connection with the *hekt:* thus , , etc., stand for 100, 200, etc., up to any number (*e.g.*, = 5,000 *hekt:* fractions of this 100-multiple $\frac{1}{2}$ (= 50), $\frac{1}{4}$ (= 25), and perhaps rarely $\frac{1}{3}$* (= $33\frac{1}{3}$) are placed after the if that is expressed, otherwise they can stand alone. (× = 25 *hekt*, × = 125 *hekt*): 10 and 20 *hekt* are ( ) ı, ıı : and 1, 2, 3, etc., up to 9 are ·, ··, ∵, etc.

These multiples are ignored in hieroglyphics, *e.g.*, in Thothmes III's record of Usertesen III's gifts at Semneh, *L.D.*, III, 55, *a*, which no doubt reproduces the figures of the XIIth dynasty. The hieratic notation must in fact be due to the method of counting. Each would be represented by a spot •, the spots being arranged in vertical columns of 10 each, and the columns cut in half by a dividing line, making 5 and 5, . If 10 such columns were completed the result would be a square of 100 spots . Each square completed would be denoted by ; if 5 columns only were made up the entry was , as being half of the square; if $2\frac{1}{2}$ columns ×, $\frac{1}{4}$ of the square.† Also, one column would be ı, two columns ıı, while the superfluous units remained as spots. That count-

* $\frac{1}{3}$ occurs once in the Rhind Mathematical Papyrus.

† The rare $\frac{1}{8}$, usually avoided, would be a later refinement of arithmetic.

ing was sometimes performed by means of vertical bisected columns of 10 spots each, arranged in squares like the above figure, can be seen from an instance in the Sallier Papyrus IV, 14 *verso*, of the XIXth dynasty.

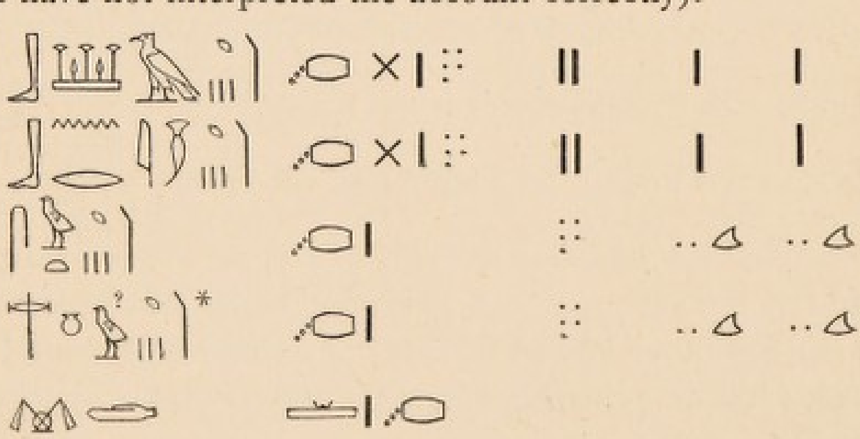
Fractions of the *hekt* happen to be rare in these early documents, but none the less the principle of the notation of the fractions must be stated. They form a dimidiated series down to $\frac{1}{64}$, and are denoted by special symbols which in an inscription of the XIXth dynasty are rendered thus into hieroglyphs:—

$\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, > or $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$.

The hieratic sign + for $\frac{1}{64}$ is a symbol of quartering, and shows that the Egyptians looked upon that fraction as $(\frac{1}{4})^3$.

10 was a very useful division, and $\frac{1}{10}$ of the *hekt* produced the important measure named *henu:* the Egyptians therefore found it convenient to break up the *hekt* into fractions which united their cubic-quarter series with the *henu.* This fraction $\frac{1}{320}$, the G.C.M. of $\frac{1}{10}$ and $\frac{1}{64}$, they named *re*, or "the fraction" *par excellence.* In the Kahun papyri, besides the special multiples, there are the symbols for the dimidiated fractions of the *hekt*, and indications of this series, which, according to the fuller evidence of the Mathematical Papyrus (see below) is , , , for 1, 2, 3, and 4 (5 being the cubic quarter $\frac{1}{64}$), the admitting also of subdivision, $\frac{2}{3}$, $\frac{1}{2}$, etc., etc., so as to express fractional quantities with the utmost accuracy.

For the Bulak Papyrus we have a good example of the notation of multiples in Pl. 29, day 3, entry No. 4 (*A.Z.*, XXIX, p. 112, where I have not interpreted the account correctly).



* For followed by *cf.* Brugsch, *Thes.*, V, 1170.

	a.	*b.*	*c.*	*d.*
*Besha**-corn	¼, I, 5 (=40)	II	I	I (together=40).
Dates	¼, I, 5 (=40)	II	I	I (together=40).
Grain	I, (=10)	5	2½	2½ (together=10).
Meal	I, (=10)	5	2½	2½ (together=10).
Total	I =100 *hekt.*			

The column *a* gives the whole amount to which three different *uart* or offices contribute *b*, *c*, *d*.

Dynasty XVI. The Rhind Mathematical Papyrus is the only document, and a very valuable one. It makes the , and , equal to 10 *henu* in Pl. XXII, Nos. 81, 82; Pl. XXIII, No. 83. Eisenlohr succeeded in discovering the values of the multiples and divisions of the from the evidence contained in its pages.

At this period we find developed a double *hekt*, a quadruple *hekt*, and possibly a triple *hekt*, with precisely the same elaborate system of notation as that used for the single *hekt*, and distinguished from that only by the different heading.

1. The double *hekt*, written , is used in No. 82 in reckoning the cost (?) or the food (?) of domestic birds.

E.g., No. 82, ll. 10, 11,

l. 10 ȧr m šs (?) m ḥqt. $\frac{1}{2}$ $1\frac{1}{4}$ 8 $\frac{1}{4}$ $\frac{1}{16}$ $\frac{1}{64}$ 1 *r* $\frac{1}{1\frac{1}{2}}$

* The word *besha* has often been wrongly taken as the name of one or more of the measures: if I did not mention this, the metrological reader might be puzzled to know whether the measures dealt with in this section had ever been discussed before.

(a certain quantity) makes in corn in *hekt* $50+10+25+8+\frac{80+20+5+1\frac{2}{3}}{320}$

$=93+\frac{106\frac{2}{3}}{320}=93\frac{1}{3}$

l. 11, ár m ḥqt sn ? $20\ \frac{1}{4}\ 2\ \frac{1}{2}\ \frac{1}{4}\ \frac{1}{64}\ 3r\ \frac{1}{3}$

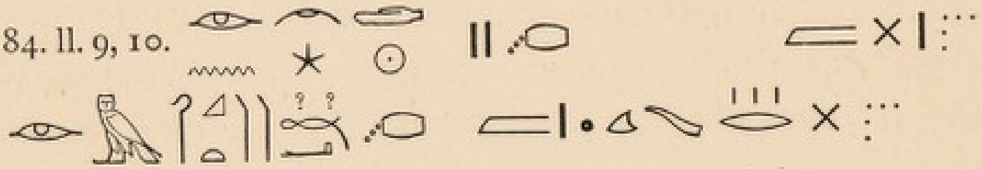
making in double *hekt* $20+25+2+\frac{160+80+5+3\frac{1}{3}}{320}$

$=47+\frac{248\frac{1}{3}}{320}=$ about $47\frac{2}{3}$ (instead of $46\frac{2}{3}$ as it should be).

It occurs again in l. 15.*

2. The treble *hekt* is extremely doubtful. The calculation No. 84 is so excessively inaccurate that any deduction made from it should be received with extreme caution. It deals with the food of domestic animals.

No. 84. ll. 9, 10.



l. 9. ár n ábṭ — 2 — $\frac{1}{2}\ \frac{1}{4}\ \bar{\ }\ 5$

makes per month (in *hekt*) — 200 *hekt* — $50+25+10+5(=90)$ *hekt*

l. 10. ár m ḥqt · · · · (?) — $\frac{1}{2}, 1, 1, \frac{1}{2}, \frac{1}{8}, 3\ r$ — $\frac{1}{4}, 5$

makes in triple (?) *hekt* — $50+10+1+\frac{160+40+3}{320}$ — $25+5$

$61+\frac{203}{320}$ *hekt* — 30 *hekt.*

In making this extract from No. 84, I am aware of passing by difficulties which would require a long commentary to explain them, and of ignoring some steps which ought probably to be interposed between l. 9 and l. 10, and which seem to have confounded the ancient calculator as much as they do modern students. If the reader will agree that $61\frac{203}{320}$ and 30 are approximately $\frac{1}{3}$ of 200 and of 90, I beg to assure him that that is sufficient, on the analogy of cases in No. 82, to strongly *suggest* a translation "triple *hekt*" for the . Unfortunately there are no other traces of a triple *hekt.*

* I hope to explain most of the difficult sections 82—84 in a later paper.

3. About the quadruple *hekt* there can be no such doubt. It is written , "quadruple *hekt*" (Pl. XV, XVI, Nos. 41–47), , "great quadruple *hekt*" (Pl. XX, No. 69).* It is used especially in the computation of granaries, in which , or the square of 100 of these, is made equal to 20 *khar*.† The notation is of course the same as for the but once by accident the 100-multiple is written instead of (No. 68, 2).

There is no difficulty in ascertaining whether the single, double, or quadruple unit is intended in any series, for the unit is always written conspicuously before the figures and symbols, unless the meaning is implied by the context: the single unit of course has the preference.

The wording of the Rhind Mathematical Papyrus, Pl. XV, XVI, of which an example is given above, "75, that is the number of quadruple *hekt*, namely 7,500 quadruple ," would imply that the *hekt* is the 100-multiple of the . If a distinction is to be drawn it must be between the and the on the one hand, and the on the other: for the is certainly not a 100-multiple in the *pefsu* (p. 22). On the other hand it is impossible to distinguish the from the , as they are interchangeable as "headings" in the hieratic of dynasty XII–XIII, and the is the unit in the inscription of Thothmes III, when recording in ancient style the large amounts of corn given by Usertesen III. The largest ordinary unit would of course be chosen for this purpose.

* Perhaps should be substituted for in all the above.

† On calculation it can easily be ascertained from the four equations, (1) *henu* = about 29·2 cubic inches, (2) 40 *henu* = quadruple *hekt*, (3) 100 quadruple *hekt* = 20 *khar*, (4) *khar* = ⅔ cubit cubed, that the cubit referred to is the ordinary royal cubit of about 20·6 inches, and cannot be either of the others of which traces are found in Egypt, viz., the small cubit of 17 inches and the 25-inch cubit, for which see Flinders Petrie's article on *Weights and Measures*, in the *Encyclopædia Britannica*, 9th edition. See above, p. 4.

I conclude, therefore, that the scribe uses a rather inaccurate, but perfectly intelligible abbreviation of language, in saying that "75 is the number of quadruple *hekt*," when the truth is that 75 is the number of complete squares (of 100 each) of the quadruple *hekt*, an amount which would be written on papyrus , but in monumental hieroglyphics .

Dynasty XVIII. The inscriptions now come to our aid. On her obelisk at Karnak, Prisse, *Mon.*, Pl. XVIII, *L. D.*, III, 24, the Queen Hat-shepset records that she "measured gold in , like corn, ." In a tomb we find a picture of weighing gold, , "that (had been measured) according to (making) 36, 692 *uten*." At the temple of Semneh, *L. D.*, III, 55 *a*, Thothmes III records that Usertesen III had made endowments of corn (, with small quantities of ,* *i.e.*,) for certain purposes, the amounts being given in ; but this, as we shall see, was an obsolete method at the time, and is therefore interesting as giving what is probably the notation of the inscriptions of the XIIth dynasty; no special multiples are used, though the numbers of rise over hundreds; fractions unfortunately do not occur.

The statistical inscriptions of Thothmes III at Karnak (*L. D.*, III, 30–32) make use of the , , for incense (and) without special multiples (30 *b*, l. 33, 31 *a*, l. 9), but for corn the *quadruple* unit, written with a new multiple of it by *four* written (32, l. 31) which is of course equal to 16 . In the inscriptions of about the same period published by

* The proportion of *bti* to *àt rs* in each case is very small, and where the amount of *àt rs* is not large there is no *bti*. It has been thought that in this passage was the name of a measure. Chabas started the idea in 1867, when scarcely a single fact about the corn measures was known or *could* be ascertained. Unfortunately in the general confusion this opinion still holds its ground.

Dümichen, *Kalender-Inschriften*, Pl. XXXIX, we find the double written for corn (?), and for the notation of *pfsu* (proportion of loaves to a measure of corn), the .

Turning to the Louvre Papyrus No. 3326 (Brugsch, *Thesaurus*, V, pp. 1079–1106), of the same reign, we see dates, , measured in the with its multiple and subdivisions as before. The only change from the system of the in the Mathematical Papyrus is the very important one of substituting the or multiple by four, for the multiples by 10 and 100 (columns and squares, | and |); in other respects the notation is the same.*

The Medical Papyri deserve a separate paragraph, which may be inserted here, as the principal document dates from the beginning of the XVIIIth dynasty. All of them make use of the symbols of subdivision of the single *hekt* (without specifying the unit), but the does not occur. The cubic quarter is the most usual amount to prescribe, and forms an important unit by itself; when in a mixture of several ingredients a cubic quarter is prescribed of each, the Ebers (XVIIIth dynasty) and Berlin (XIX) indicate the amount simply by the numeral 1, but the early Kahun Papyrus (dynasty XII–XIII) retains the hieratic symbol + (=). The Ebers and Berlin Papyri use multiples of the +, the former sometimes giving numerals only, while the Berlin always writes + with the numerals; they also subdivide it to the quarter. For the details see *Proceedings*, XIII, pp. 392–406, 526–530 and the table on pp. 536–538.†

* But 2 (quadruple) *hekt* are denoted by : instead of ··. The which occurs sometimes is only the determinative of the word repeated instead of the whole word; the unit is the .

† On p. 537 for $\frac{1}{32}$ $\frac{1}{128}$ $\frac{1}{28}$ (?) read ($\frac{1}{32}$ $\frac{1}{128}$). I am now sure that the fractions of the *henu* would not be combined with those of the *hekt* in one group, so × } must mean $1\frac{1}{4}$ ($=\frac{1}{32}+\frac{1}{128}$ *hekt* $= 12\frac{1}{2}$ *r*), not $+\frac{1}{4}$ *henu*; l. 8 of p. 537 can therefore be omitted.

Dynasty XIX. Fragments of a calendrical list of offerings of Rameses II at Medinet Habu have been discovered by Dümichen, who has published his copies in the *Opferfestliste*, Pl. I–III. The parallel text of Rameses III shows that the unit of measurement is of 40 *henu*, *i.e.*, quadruple. The copy gives sometimes , sometimes ; possibly both these forms are correct. There is the 4-multiple , and for almost every detail the remarks below on the calendar of Rameses III can be applied to that of Rameses II. The Rollin Papyri of the Bibliothèque Nationale (published by Pleyte), which date from the reign of Seti I, give a unit written (unless be a separate word), its quarter (presumably the , not the) denoted by dots, and the symbols of the fractions. In the well-known D'Orbiney Papyrus the younger brother carries the enormous load of 5 of corn.

Dynasty XX. The elaborately recorded list of offerings of Rameses III at Medinet Habu contains a quantity of valuable material for the metrologist, but the copies hitherto published leave much to be desired as to correctness. The *pefsu* entries (see above p. 22) and the occurrence of the imply the quadruple as the basis throughout, and on Pl. II o Dümichen's *Kalender-Inschriften* from the same text we have the (?) = 40 *hnu*. It seems probable that *ȧpt* is a new name invented for the quadruple unit, instead of the "4-*hekt*" or "great *hekt*," which had served in earlier days: until a more minutely precise copy sets doubt at rest, we may assume that this *ȧpt* or quadruple *ḥekt* (written (?)) is the unit all through. We find the 4-multiple , and the divisions down to $\frac{1}{64}$ supplemented in some places by the and its fractions, in others (Pl. XIX, XX) by a decimal division $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{40}$, probably equal to 8, 4, 2, 1 *hnu* respectively; or if the unit is the , 2, 1, $\frac{1}{2}$, $\frac{1}{4}$ *hnu*. The details will be found in a previous paper, *Proceedings*, XIII, pp. 530–534. I need only add that instead of the special symbol for $\frac{1}{2}$, is sometimes used in the list where there are no other fractions to follow *e.g.*, Pl. XI, .(?)

The Harris Papyrus I, for incense, etc., uses the without multiples, (with the subdivision = $\frac{1}{2}$, *e.g.*, 70, *b*, 6), but for corn and salt the , with the multiple and the subdivision , *e.g.*, 54, *a*, II. The unit must be the quadruple - *hekt*, or *àpt*.

We have now traced the history of the measures as exemplified in numerous documents from the XIIth to the XXth dynasty, a period embracing perhaps 1500 years. At first we find the *hekt* system of notation, already elaborately developed, used as a general measure for solids and even for liquids, but more especially for corn and other common vegetable foods. In the Hyksos period we find the unit doubled and quadrupled, yet for general purposes the single *hekt* still holds its ground. With the New Kingdom, however, the peculiar notation for multiples is dropped, the single *hekt* gives way to the quadruple *hekt* (now called the *àpt*) for bulky food-products, and the , a further multiple by four, forming part of the series, seems to drive out the *khar*, an independent unit of nearly the same value (5 quadruple *hekt*). It is perhaps not too fanciful to see derivatives from the words , "rule," and , part of the capital city of Thebes, in the names of the first and second leading measures *hekt*, , and *àpt*, ; the reading of the third is quite unknown.

A text of Shashank I at Karnak (Brugsch, *Thes.*, V, p. 1229) possibly indicates a reversion from the quadruple to the single *hekt* for corn measures in the XXIInd dynasty. The fractional symbols and the dimidiated tenths, $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{40}$, (1, $\frac{1}{2}$, $\frac{1}{4}$ *henu* ?) are used.

In Ptolemaic times the system of measures was most completely changed, while preserving a few relics of Pharaonic usage. According to well-known data,* the "Ptolemaic medimnus" of Didymus = about 78·78 litres; this makes about 160 to 165 *henu*, or 1 . It seems as if the Græco-Egyptians had borrowed a Greek name and applied it to an ancient Egyptian measure of different value from the Attic *medimnus*. Didymus also gives the

* Hultsch, *Griech. und Rom. Metrologie*, 2nd ed., p. 284.

old (*i.e.*, Ptolemaic) *artabe* as half of this medimnus,* so = 80 *henu* or 8 *hekt*. This equation we actually find in the new text of the Rosetta inscription which was dug up at Kûm Ga'êf, in the great temenos of Naucratis (*Rec. de Trav.*, VI, 1 ff., *Naucratis*, II, p. 83). Here, in l. 30, corresponds to the Greek τῆς ἀρτάβης. The cutting of the text is very bad: the mason should have written instead of , but the number remains correct. The *artabe* was probably an importation from Persia,† modified to suit the .

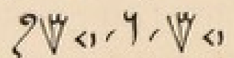
The chief measures dealt with above are:

ancient *khar* ($\frac{2}{3}$ cubit cubed)	= 5 quadruple *hekt* or *apt*	= 20 *hekt* = 200 *henu*,
later	= 4 *àpt*	= 16 *hekt* = 160 *henu*,
later	*àpt*	= 4 *hekt* = 40 *henu*,
ancient and later		*hekt* = 10 *henu*.

It has been the custom of metrologists to derive measures of capacity from the cubit cubed. There have not hitherto been materials available for applying the theory to Egyptian measures with any prospect of *true* results; Mr. Petrie ‡ alone saw through the prodigious fallacy of making the 20 cubits cubed = 100 quadruple *hekt*, or 100 *besha*, as the measure was formerly termed: this fallacy, drawn from a misinterpretation of the Rhind Papyrus, has been a leading *datum* in three considerable treatises.

The ancients would not necessarily make the cubit cubed, or any other cube, the standard of quantity; if standard measures were required, they might have been cylindrical like the ordinary measuring vessels depicted in the granary scenes, but of a fixed diameter and depth: on the other hand, the occurrence of a cubic quarter (denoted in hieratic by a special sign ╋, which clearly indicates the quartering process) as the termination of a dimidiated

* Possibly the ancient = *medimnus* is to be seen in the common formula of repetition which ensured the accuracy of important amounts in demotic documents.



4 *artabae*, making 2 (*medimni?*) making 4 *artabae* again; compare this volume, p. 235. (The proper demotic sign for 4 is not in the fount.)

† Petrie, *Weights and Measures*, p. 485, in the *Encyclopædia Britannica*, 9th edition.

‡ *l.c.*, p. 485.

series of fractions of the , is a most important piece of evidence in favour of a cubic standard. Yet the would represent a cube of about 6·7 inches, which cannot, so far as I can see, be connected with the divisions of the cubit.

The double, treble (?), and quadruple *hekt* merely retained as derivatives the system of the single *hekt*, but the division of the *henu*, down to the $\frac{1}{64}$ (in the Ebers Papyrus), may have been independent. The *henu* as a cube would have a side of nearly 3·1 inch. Probably the cubic idea was introduced long after the measures had become fixed by custom.

Besides the vases which are marked as containing multiples of the *henu*, the capacity of that measure can be checked by several working equivalents given in the Egyptian texts, which may or may not be intended as exact. Ptolemaic texts,* as Chabas pointed out, give the weight of a *henu* of wine or water as 5 *utens*, of honey as $7\frac{1}{2}$ *utens*, and the Rhind Papyrus, making the *khar* $\frac{2}{3}$ of the cubit cubed, leads to the equation, 300 *henu* = cubit cubed. It is noteworthy that the *henu* was often divided by 3, 6, etc., as well as by 2, 4. In the Ebers papyrus there is the dimidiated series of fractions to $\frac{1}{64}$: a vase with the name of Thothmes III is marked $7\frac{1}{4}$ *henu*, but another is $8\frac{1}{6}$, and in the Calendar of Rameses III (Düm., *Kal.*, Pl. II) we find $\frac{2}{3}$, $\frac{1}{6}$, as well as $\frac{1}{2}$; and in the Edfu texts there is a measure $= \frac{1}{3}$ of the *henu*. This makes it all the more probable that the fractions $\frac{2}{3}$, $\frac{1}{3}$ which occur rarely in the Ebers papyrus, also refer to the *henu*. (See *Proc.* XIII, p. 401.)

Section IV.—Weights.

In early times there were probably several units of weight for various metals: later, probably in the XVIIIth Dynasty, the *uten* of 1400–1500 grains with the *kiti* of 140–150 grains became the only unit recognised in documents. The *value* of objects was often reckoned in a certain weight of metal, gold, silver, or copper.

The texts which have given so much information on the measures of Ancient Egypt are disappointingly silent on the subject of weights. That the art of weighing was known in Egypt from the earliest historic times, is proved incontestibly by the ancient stone weight,† now in the collection of Mr. Hilton Price, upon which is

* Dümichen, *Geog. Insch.*, II (Brugsch, *Recueil*, IV), Pl. LXXXIII.

† No. 1 below.

engraved the cartouche of Chufu. Balances are figured in the tombs of the Vth, XIth, XIIth and XVIIIth dynasties; there is the well known vignette of weighing the soul in the *Book of the Dead*, and some Middle Kingdom texts are full of references to justice as typified by the equipoise of the balance. Yet when we search through the inscriptions and papyri, we find only one reference to *weights* before the XVIIIth dynasty.

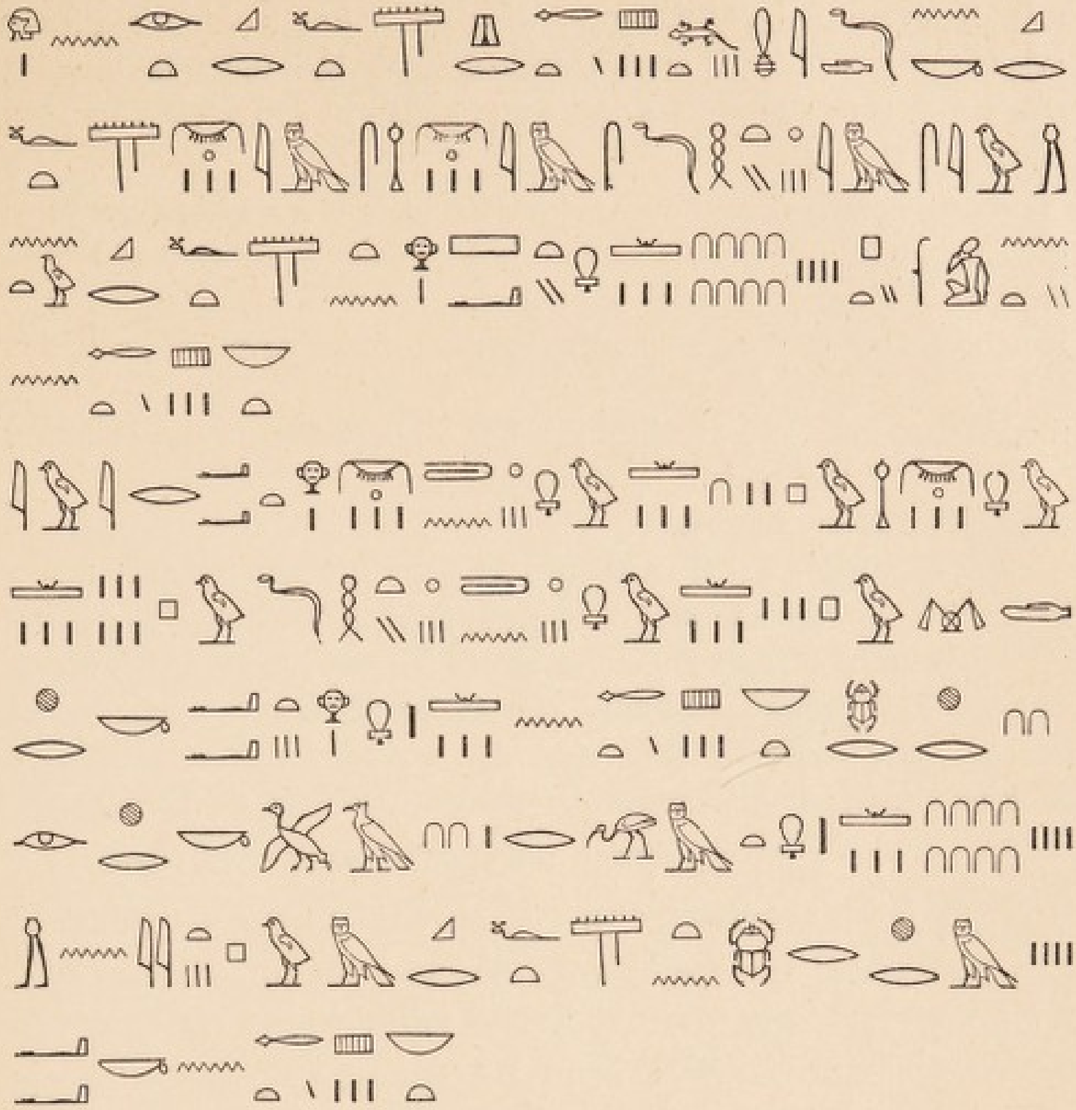
This silence however is not without its teaching: the Medical Papyri show no signs of the use of weights in Pharmacy, and even in the XVIIIth dynasty it appears that the only substances ordinarily weighed are minerals—gold, silver, copper, and lapis lazuli. In later times, incense, and in Ptolemaic times honey and drugs may be safely added to the list. Bartering gold and silver must have led to the invention of the scales, and it was only by slow degrees that weighing was applied to an ever widening range of practical and scientific uses.

The subject of weights is invested with a special interest, owing to its connection with coinage, and in Ancient Egypt to its connection with the use of metals as a medium of exchange long before the invention of stamped money. It is not known how far back into antiquity true money, *i.e.*, pieces of metal of definite weight and value for use in exchange, can be traced. About the time of the XVIIIth dynasty we know that the precious metals were kept in dust, in ingots, and in ornamental forms, but more especially in *rings*, and it is almost certain that the important weight-name *uten* has the root-meaning of a ring or coiled wire. It is well known not only that the metals were bought and sold by weight, but further, that goods of all kinds might be valued at a certain weight of metal in order to be exchanged against each other.*

The Rhind Mathematical Papyrus, dating from the Hyksos period,† offers the earliest example of the metals as a medium of exchange. On Pl. XIX, No. 62, we read :—

* Erman, *Aegypten*, p. 657. Chabas, *Recherches sur les Poids, Mésures et Monnaies*.

† The use of the double and quadruple *hekt* in the measures of capacity makes it almost certain that a large portion of the Rhind Mathematical Papyrus dates originally from the Hyksos period, and was not copied from writings of the XIIth dynasty. I must note with regret that my attempt to transpose the two halves of the papyrus is no improvement; the original arrangement of Dr. Birch and Eisenlohr must be reverted to. The study printed on p. 328 of Vol. XIII was in several respects premature.



ṭp ? n árt qrft ḥr āat āšat. Má t'ṭ-nk ; qrft nb ám-s ḥt'ám-s t'ḥti ám-s, áu án-tu qrft tn ḥr šāti ḫtm 84, pti nti n āat nbt.

áu ár ṭṭt ḥr nb uṭn ḫtmu 12 pu, ḥt' ḫtmu 6 pu, t'ḥti uṭn ḫtmu 3 pu : ṭmṭ ḫr-k ṭṭt ḥr ḫtm n āat nbt, ḫpr ḫr 21 : ár ḫr-k pa 21 r ḳmt ḫtm 84, ánīt pu m qrft tn, ḫpr ḫr m 4 ṭṭ-k n āat nbt.

This example is so full of uncertainties that I am obliged to write out three versions, but its importance is such that one cannot afford to neglect it.

Chapter (?) of buying (?) a carpet (?) with various minerals (*i.e.*,
Example of making a bag ? of various minerals
Example of making up a purse ? with various minerals

metals), as is said to thee a carpet gold for it, silver for it, lead for it,
as is said to thee a bag gold in it, silver in it, lead in it,
as is said to thee a purse gold in it, silver in it, lead in it,

this carpet is to-be-sold for 84 pieces of *shati*, how much is (required)
this bag is valued at 84 pieces of *shati*, how much is there
this purse is to buy 84 pieces of goods, how much is (required)
of each metal?

As to what is given for an *uten* of gold it is 12 pieces, an (*uten* of) silver it is 6 pieces, an *uten* of lead it is 3 pieces: add thou together that which is given for a piece (*i.e.*, an *uten*) of each metal, it becomes 21 (pieces): count thou 21 to make 84 pieces, which is the amount to { pay for this carpet / be worked into this bag / be bought by this purse } it becomes 4* pieces which thou givest of each metal.

A prime difficulty is to decide whether *ȧrt qrft* means "buy a kerfet," "construct a kerfet" of various precious materials, or "make up a money-bag," *i.e.*, a sum of money to buy goods of a certain value. The second difficulty lies in *shati*, which may denote generally the goods to be bought, or may be a real or imaginary substance used as a *common measure* for the *utens* of all the metals.

The word (plural used *with singular* (?) *numerals*†) is an important one. at Edfu means a "parcel of land" of any size or shape as a separate piece of property, and , if I am not mistaken, occurs at Kahun with the same meaning. In the Rhind Mathematical Papyrus No. 67, means "heads of oxen," and here in No. 62 is a unit of value for *shati*, and stands once for the *uten* of the metals gold, silver, and lead. Beyond this I need only draw attention to the fact that the values of the utens of gold, silver, and lead respectively and of the piece of *shati* are in the proportion 12 : 6 : 3 : 1.

We next meet with valuations in metal units in papyri of the time of Amenhotep III (XVIIIth dynasty). The Bulak Papyrus No. 11 (Mariette, *Papyrus de Boulaq*, Tome II, Pl. 3) gives a long list of provisions, supplied with values in "pieces," , "pieces of gold," and , "pieces of silver," and half

* 21 is counted 4 times in 84.

† Plural with 12, 6 and 3; singular with 84. Compare the Hebrew usage. The reason is no doubt the same as for the Hebrew, that the numeral 80 had itself a *plural form*.

pieces frequently occur. The first of these is shown by various remarks to stand for "piece of silver," and in the fifth line of the first column we are given the valuable equation 5 silver pieces = 3 gold pieces. These "pieces" are presumably the *utens* of the Rhind Papyrus. Thus since the Hyksos period gold had become less valuable in comparison to silver, and if *shati* was a common measure in the Hyksos period, it was now useless from that point of view. From Kahun there are two papyri,* dating from the reign of Amenhotep III, which value articles in "pieces," presumably of silver. In one of these an ox is valued at one "piece."

We hear nothing of these gold and silver "pieces" in later papyri: the *uten* of copper, with its half and quarter, is traceable as the unit of value in papyri of the XIXth dynasty, and abounds as "*uten*" or "copper *uten*" in the accounts of the XXth dynasty: from these we learn that the of corn was worth 2 *uten*, an ox 119 *uten*, an ass 40 *uten*. In the XXIInd dynasty land at Abydos was leased or sold at the rate of 10 *arouras* to an *uten* of silver, and 360 *henu* of honey were paid for by $3\frac{2}{3}$ *uten* of silver,† while an earlier ostracon values 5 *henu* of honey at 4 *utens* (of copper). A thorough investigation of this subject would be very desirable: for the present I will only say that the *uten* of copper in the New Kingdom was most probably the weight of 1400–1500 grains, and that this became the standard for all the metals; but the "piece of gold" in the papyri of the XVIIIth dynasty, and the *uten* = "piece of gold" of the Hyksos period, should be the ancient royal gold weight of 196–207 grains.

Returning now to the subject of weights as weights: in a tomb of the XVIIIth dynasty at Abd el Qurneh (L.D., III, 39, *d*) a scene of

* Here again I must be permitted to make a correction: in writing my note, Vol. XIV, p. 43, on the cartouche of the Ebers Papyrus, I have stated that it resembled in style those of the papyri of the Middle Kingdom from Kahun. This was a slip of the memory; the fact is that it bears a strong likeness to the cartouches of Amenhotep III in these two later papyri from the same collection.

† Mar., *Abydos*, II, pl. 37. In this inscription $\frac{2}{3}$ of the silver *kiti* is frequently mentioned. The division of the *kiti* by 3 is very common at Edfu, and is found at all periods. In the demotic papyri of the Greek period the equivalent for the drachma is $\frac{1}{2}$ *kiti*, the *tetradrachm* is *sttr* (not to be read shekel), *στάτηρ*, and the *uten* occurs commonly: *see* Revillout, in this volume, p. 82 ff.; the reading *sttr* = stater, which is a perfectly correct name for the tetradrachm, is due to Brugsch. (A. Z., XXVII, p. 9, etc.)

weighing is accompanied by the inscription "[weighing (?)] this great mass of electrum which had been measured in (?) *hekt* (or, which amounted to (?) a *hekt*) making 36,692 *uten*." It seems clear enough that in is only a semi-hieratic form of , and , Dum., *Kal.*, Pl. XL, A, is double the , of Pl. XL, B, so the meaning *hekt* for is certain.

If we have here an equation between a *hekt* of electrum (in small ingots (?)) and 36692 *utens*, we can roughly calculate the *uten* from it. The *hekt* contains 10 *henu* or about 292 cubic inches, and this amount of water would weigh 7,811 grains. The specific gravity of pure gold being 19·26, by substituting a *hekt* of solid gold for a *hekt* of electrum ingots in the equation, we should obtain an *uten* not much exceeding 40 grains, and the actual equation would reduce this to 25 or 30 grains. I do not find any other evidence for such an *uten*, and therefore conclude that the first of the two translations must be accepted as the true one, namely, "which had been measured in hekt."

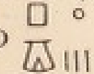
The statistical inscription of Thothmes III at Karnak reckons gold, silver, lapis-lazuli and bronze in *uten* without special multiples, but with its $\frac{1}{10}$ subdivision *ketet* (Coptic ΚΙΤΕ) of which fractions occur. $\frac{1}{9}$ of the *ketet* or *kiti* is found in this inscription in connection with gold (Leps. *Aus.*, Pl. X = Mar. *Karn.*, XIII, 22).*

The Rollin papyri of the age of Seti I (XIXth dynasty) appear to reckon large amounts of corn, bread, etc., by weight in *uten*.

In the great Harris Papyrus of Rameses III (XXth dynasty), besides metals and minerals, we find sparingly incense and drugs of various kinds and even linen (?) reckoned by weight in *uten* and *kiti*; minerals in the same document, and especially figures of the Nile, are also sometimes reckoned in *nusa*. The word *nusa* occurs in he form in the statistical in-

* A curious attempt recently made to show that , , , denote certain foreign units of weight is quite hopeless.

scription of Thothmes III (1200 *nus* of lead, Leps. *Auws.*, XII, 35); if it was a unit of weight it was evidently considerably less than the *uten.**

In the inscription of the Ethiopian king Horsiatef (Mar., *Mon. Div.*, Pl. XI, l. 26), gold given in *uten* is reduced to  *pek* in the proportion of 1 : 128. The fraction $\frac{1}{128}$ is probably reached by successive halvings, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, $\frac{1}{128}$, as Bortolotti suggested.

The Ptolemaic texts of Edfu (Dümichen, *Geogr. Inschr.*, II, Pl. LXXXIII–IV) equate the *henu* of wine or water with 5 *uten* weight, that of honey with $7\frac{1}{2}$ *uten*. The *henu* at 29·2 cubic inches gives an *uten* of 1474 grains, the *kiti* of which, 147·4 grains, lies between the Heliopolite *kiti* 140 grains, and the royal (*kiti*(?)) weight of Aahmes II, 150 grains. This is a fixed point of great value. As I have indicated above, the *uten* and *kiti* from the beginning of the New Kingdom onwards are probably the same for all materials, and denote the 1400–1500-grain *uten*, 140–150-grain *kiti*, while the *khetem* of the papyri of Amenhotep III, and the *khetem-uten* of the Hyksos Mathematical Papyrus may have varied in weight for different metals: in all probability the early royal gold unit of 196–207 grains is the gold piece in question.

The scarcity of written information on the monuments and papyri, is to a great extent made up for by the immense collections of weights which M. Petrie has amassed, weighed, and classified according to certain standards, some of which were suggested by the ancient coinage standards, while others were deduced entirely from the evidence of the weights themselves. Such a classification is of great value, as making the long series of several thousand specimens easy to refer to. Marked weights are very rare, and the inscriptions upon them being much abbreviated, are often difficult to interpret: even now, when the inscribed specimens are 30 in number as against 6 ten years ago, it would be a hopeless task to classify the unmarked weights upon the basis of the marked ones: yet it is obvious that as material increases we must rely mainly upon the inscriptions, which often have a many sided value, to settle the units, and upon careful excavations to show the ages and

* A note in *Records of the Past*, VI, p. 68 (*nusa* = 2 *uten*) which has been relied on by Mr. Petrie for a unit, *Season in Egypt*, p. 41, is contradicted by a second note, VIII, p. 20. The *nusa* in the Harris Papyrus, according to the numbers, must have weighed much less than the *uten*, but the meaning of the word is altogether doubtful.

localities of fine and unaltered specimens, while the evidence of damaged and ill formed weights need not be taken into account except for special reasons.

Whereas the monuments and papyri seem to indicate hardly any unit beyond the *uten* and *kiti*, the weights themselves show embarrassing variety: at one time or another during the three or four thousand years that elapsed between Chufu and the Roman occupation, a multitude of native and foreign standards for various metals, each having local, trade, or other variations, must have left their abundant traces in the country. The following list of inscribed weights is sufficient to give an idea of the complexity of the subject. Amongst these the examples that bear cartouches or inscriptions specifying the exact standard may rank higher for accuracy than those with mere numerals or numbers of ○ units, which seem often to have been adjusted as exchange weights for two standards.

(A.) Early royal gold series, extending from the earliest times to the beginning of the XVIIIth dynasty. An example of this was noticed by Mr. Petrie in 1883, but in the last two years no less than three more royal specimens have come to light.

1. IVth dynasty, Chufu,  ○∩; "10 units;" oblong, rectangular, the top rounded; 2060 grains.

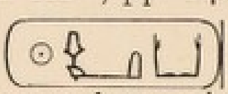
   Unit 206 grains = 13·348 grammes.

   Collection F. G. Hilton Price, F.S.A. Bought in Cairo, 1891. See W. M. F. Petrie, *Academy*, January, 1891, No. 977, p. 95.

2. XIIth dynasty, Amenemhat III,  ||||; "4 gold (units);" 50·835 grammes = 784·5 grains.

   Unit 196·5 grains = 12·7 grammes.

   Louvre, Revillout, *Proceedings*, Vol. XIV, pp. 246, 247.

3. XVIIIth dynasty, Amenhotep I,  ; "5 gold (units);" oblong, rectangular, curved top, injured. 1022·7 grains, originally 1038.

   Unit 207·6 grains = 13·452 grammes.

   British Museum; from Gebelên. W. M. F. Petrie, *Archæological Journal*, 1883, p. 419.

4. XVIIIth dynasty, Thothmes I, "beloved of Ptah,"  |||||| ○; "6 gold units;" 76·645 grammes = 1182·7 grains.

   Unit 197·7 grains = 12·774 grammes.

   Louvre, Revillout, *Proceedings*, Vol. XIV, p. 247.

We here see two varieties of an unit of about 200 grains showing a constant difference of about 10 grains. The Chufu specimen (from Memphis (?)), and that from Gebelên (south of Thebes) are of the heavy standard, while the two specimens recently acquired by the Louvre, one of which is dedicated to the Memphite deity, are light. With the lower variety we may connect the following :—

5. Oblong rectangular weight, | | | | | | cut in the edge, weight 1177·2 grains, originally 1178·4.

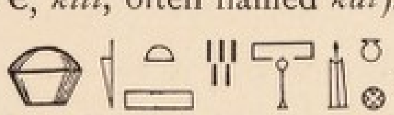
Unit 196·4 grains.

From Memphis. Petrie, *Season in Egypt*, p. 40, No. 4407, Pl. XXVIII, fig. 161. "12 Aeginetan drachmas of 98·2."

It would seem as if 196 grains was the Memphite standard, the Chufu value of 207 grains being preserved in Upper Egypt.

This unit of about 200 grains, the same as the Aeginetan *stater*, must now be considered as the representative gold standard in Ancient Egypt. Mr. Petrie's heading for the unit or half unit is *Aeginetan stater* or *drachma*.

(B.) It is very instructive to find the same phenomenon of two closely allied standards or varieties of the same standard in connection with the *kiti* (properly transcribed , Coptic ⲕⲓϯ, ⲕⲓⲧⲉ, *kiti*, often named *kat*).

6. Form ; "5 *kiti* of the silver-house of Heliopolis;" 698 grains, originally 700.

Unit 140 grains.

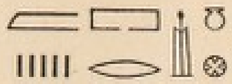
Harris Collection, from Thebes. Chabas, *Rev. Arch.*, Nouv. Sér., III, 1861, p. 14.

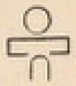
6*a*. Identical with 6 in form, inscription, and weight, but on the top marked

Basalt.

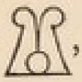
The first sign (?) may be only a flaw in the stone. The seated deity may be Thoth or Chonsu; behind the figure is a sign in outline resembling an inverted egg .

British Museum; marked 75.8–10.58. Probably the same specimen as 6.

7. Weight, ; "half (*uten*), 5 (*kiti*), house of (?) Heliopolis," or "coming out (from) Heliopolis." 45, 48 grammes.
Units, *uten* = 1404 grains, *kiti* = 140·4 grains = 9·096 grammes.
Louvre. Revillout, *Rev. Ég.*, II, p. 178.

8. Weight, ; "10 (*uten*) of the house of Ra (Heliopolis)."
Much injured; 12510 grains, originally 14000.
Unit, about 1400 grains.
From Defeneh (XXVIth dynasty (?)). Petrie, *Nebesheh*, p. 85, No. 946, and Pl. XLVII, fig. 118.

These are all Heliopolitan; Nos. 6, 6*a*, furnish the name *kiti*, which is known from the inscriptions to be $\frac{1}{10}$ of the *uten;* the unit of No. 8 is therefore the *uten.*

9. Granite , very fine  beneath plumes , Aahmes II.
Weight 150 grains.

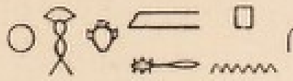
There being no indication of multiple upon it, we have no alternative but to consider this as the royal standard *kiti* of Aahmes II, XXVIth dynasty, 564–526 B.C. The *uten* and *kiti* were infinitely the commonest weights at that period, and had long formed the standard in official documents.*

British Museum. *Cf.* Petrie, *Naucratis*, I, p. 80.

The unmarked weights in Mr. Petrie's lists under the heading *kat*, show every shade of gradation between these two varieties of the *kiti*, with a large preponderance in favour of the higher value; there appears to be no coinage on the *kiti* system. It is very interesting to see how closely the marked weights adhere to their special variety of standard, keeping well within 1 per cent., while the existence of well marked varieties with 10 or 11 grains difference between them in the gold and *kiti*, prepares us for the intricacies of the unidentified standards which we have to deal with next, and may help others in considering the marked measures of length and capacity that have come down to us.

* For another example of the *uten*, see No. 30.

(C.) Uncertain standards. Amongst the weights here enumerated, Nos. 13 and 20 are of great importance; the arrangement is roughly according to the value of the marked unit.

10. Domed weight,  "Uah-ab-ra, in this mass 10 (units)." 570·7 grains.

Has been much altered since the inscription was engraved, but can hardly have lost less than a fifth, or more than half of its bulk, so originally not more than 800 grains.

Unit, between 65 and 80 grains.

Compare the Attic drachma 65, Euboic 67, and the "80-grain" standard.*

Naucratis (XXVIth dynasty); Petrie, *Naucratis*, I, pp. 76, 79, and Pl. XXII, fig. 100, "apparently adjusted to 4 *kats* of 142·7.'

11. Flattened barrel form, |||, "3 (units)." 363·9 grains.

Unit 121·3 grains.

Compare No. 19, which may be the 100-multiple assimilated to another unit.

Gurob, XVIIIth–XIXth dynasty (?). Petrie, *Kahun*, p. 41, No. 4905.

12. Lead flattened barrel, |||, "3 (units)." 415·6 grains, with accretions; originally 408 grains.

Unit 136·0 grains.

Double of the Attic drachma, or a very light kiti.

Gurob, XVIIIth–XIXth dynasty (?). Petrie, *Kahun*, p. 41, No. 4911. "6 'Attic drachmas' of 68·0 grains."

13. Name of a priest Ampi,  "with $\frac{1}{10}$ (?), 10 *uten*." 141·8 grammes = 2188· grains.

Unit 218·8 grains = 14·18 grammes.

This weight is exceedingly ancient, probably of about the Xth dynasty. The inscription is difficult, but certainly indicates 10 units, perhaps named *uten*. This unit is plentifully illustrated in Mr. Petrie's lists amongst the light varieties of the "Phœnician shekel," and it was the standard of the Ptolemaic coinage, but it

* Petrie, *Weights and Measures*, p. 487.

is astounding to find it at so early a date: possibly it is the old silver standard or a heavy third variety of the gold standard.  may mean $\frac{1}{10}$, if so we have the statement that the weight is $\frac{1}{10}$ of a unit of 21880 grains, containing 100 of the smaller unit: in No. 4352,* from Memphis (not marked), of 22,080 grains, there may be an example of the large unit.

Berlin Museum. Stern, *Rev. Égypt.*, II, p. 173. Brugsch, *Thes.*, VI, p. 1452. Revillout, *Proceedings*, Vol. XIV, p. 245.

14. Oblong, rectangular, ○||||||, "6 units." 1380·2 grains, originally 1381 grains.

Unit 230·2 grains.

This may be a 10-multiple of the last unit (and so a light *uten* (?)) adjusted to 6 "Phœnician shekels" of a heavy type.

Gurob, XVIIIth–XIXth dynasty (?). Petrie, *Illahun*, p. 21, No. 4973. "6 Phœnician shekels."

15. Oblong, rectangular, ||, "2 (units)." 480·6 grains.

Unit 240·3 grains.

Kahun, XIIth–XIIIth dynasty (?). Petrie, *Illahun*, p. 14, No. 4954. "2 Phœnician shekels."

16. Oblong, rectangular, ||||||, "6 (units)." 1473·3 grains.

Unit 245·5 grains.

Probably an *uten* assimilated to 6 "Phœnician shekels" of the heaviest type.

Gebelên (now in the British Museum (?)). Petrie, *Illahun*, p. 21.

17. Oblong, rectangular, ∩∩∩∩∩∩, "60 (units)." 14700 grains.

Unit 245·0 grains.

Probably 10 *utens* assimilated to 60 "Phœnician shekels" of he heaviest type.

Gebelên. Petrie, *Illahun*, p. 21.

18. Oblong, rectangular, ○ |||| ||||, "8 units," injured. 127·7 grammes, probably original 131·24 = 2025 grains.

Unit about 253 grains = 16·4 grammes.

Perhaps 10 of the gold units assimilated to 8 of the heavy Assyrian shekels."

Colln. Golénischeff, *Rev. Égypt.*, II, 177; *cf. A.Z.*, XXVII, p. 85.

* *Season in Egypt*, p. 40.

19. Oblong, rectangular, rounded top, ∩∩∩, "30 (units)." 12,040 grains.

Unit 401·4 grains.

This may be 100 of the unit of No. 11 (121·3 grains) assimilated to 30 of the next unit (423 grains).

Kahun, XII–XIIIth dynasty (?). Petrie, *Kahun*, No. 4920, p. 42. "60 'Aeginetan staters' of 200·7 grains."

20. Rectangular, rounded top, ∩ |||||, "15 copper (?) units;" injured. 409·6 grammes, originally about 411 = 6,343 grains.

unit 423 grains = 27·4 grammes.

The weight seems to be 100 of the "Attic drachma" unit. The first sign in the inscription is generally believed to be = copper or bronze; and as several marked specimens exist, such a view is all the more probable. *Cf.* Nos. 21, 22 (?) and 23.

Berlin Museum. Brugsch, *A.Z.*, XXVII, p. 90; Revillout, *Proceedings*, Vol. XIV, p. 243.

21. Shape with square sides |||||||||, "9 (units)." 3798·2 grains, originally 3799·5 grains.

Unit 423·6 grains.

Probably an Assyrian half-mina, *i.e.*, 30 × 126·6, assimilated to 9 of the above units.

Kahun, XII–XIII dynasty (?). Petrie, *Illahun*, p. 14, No. 4924.

22. Square. ∩ |||||||||, "10 (units) 9 (?)" or "19 units." 3,822·6 grains, originally 3,835 grains.

Units 42·6 with 426·1

or 201·8 grains.

201·8 would be the gold unit, 426·1 the copper (?) unit of No. 20, and 42·6 the $\frac{1}{10}$ of the copper (?).

Memphis. Petrie, *Season*, p. 40, No. 4420, Pl. XXVIII, fig. 170.

23. Oblong, rectangular, curved top, ∩∩, "20 (units)." 8536 grains, originally 8550 grains.

Unit 427·4 grains.

Kahun, XII–XIII dynasty (?) Petrie, *Illahun*, p. 14, No. 4942.

24. Oblong, rectangular, curved top, ∩∩, "20 (units)." 8735 grains, originally 9030 grains.

Unit 451·4 grains.

Kahun, XII–XIII dynasty (?) Petrie, *Illahun*, p. 14, No. 4948.

25. Domed "Aata son of Hor-ut'a," 676·9 grains.

Unit 676·9 grains (?)

This may be a weight certified by an inspector: it bears no mark of multiple, but can be a light half *uten*, or 10 drachmæ of 67·7. XXVIth dynasty or later.

Memphis. Petrie, *Season*, pp. 36, 39, 42, and Pl. XXVIII.

26. Oblong, rectangular, rounded edges, | | | |, "4 (units)." 2951·3 grains.

Unit 737·8 grains.

The unit may be the half *uten*, making an *uten* of 1476 grains.

Kahun, XII–XIIIth dynasty (?). Petrie, *Kahun*, p. 42, No. 4914.

27. Oblong, rectangular, rounded top, ∩∩∩, "30 (units)," 22235, originally 22860 grains.

Unit 761 grains.

The unit may be the half *uten*, making a heavy *uten* of 1524 grains.

Kahun, XII–XIII dynasty (?). Petrie, *Kahun*, p. 42, No. 4916.

28. Domed. Demotic inscription, "weight of the house of Thoth, the twice great, lord of Hermopolis Magna;" apparently much injured, 1908 grammes = 29445 grains.

I have adopted Maspero's version, which seems the best available. Probably a large allowance has to be made for injury to the weight: it may be 20 *uten* of about 1,500 grains. Compare the royal *kiti* of Aahmes, No. 9.

In the Khedivial Museum. *Mon. Div.*, Pl. 97, No. 2; text by Maspero, p. 29. Revillout, *Rev. Égypt.* II, p. 183.

29. A weight (?), rectangular, with rounded top,  (?), "gold $\frac{1}{4}$ (?)." 4,732 grammes = 73 grains.

Unit (?) 292 grains.

Doubtful, but might be a double *kiti* used perhaps as a unit by jewellers.

In the Khedivial Museum. *Mon. Div.*, Pl. 100, No. 45.

30.  inscription "the superintendent of the scribe of the accounts of King Psammetichus Nefer-Psemtek." 93 grammes = 1435·2 grains.

Clearly a *uten* of 1435·2 grains.

Compare Nos. 6–9. It is disappointing to find that this *uten*-weight, which seems to be at least semi-royal, does not agree with the standard *kiti* of Aahmes II, No. 9.

In the St. Petersburgh Museum (Ermitage Impérial) Golénischeff Inventaire, p. 349, No. 2396.

POSTSCRIPT.

Since this paper was completed Mr. Petrie has given me an extract from a stela of Khuenaten at Tell el Amarna, which is of the greatest importance for measures of distance, using the *atru* as a multiple of the . The hieroglyphic subdivisions of the mentioned in it are , × and : the transcriptions arrived at above, p. 9, are therefore confirmed, being a common variant for whenever the meaning is unmistakable. A squeeze of the complete text will soon be available, and it is not too much to hope that the value of the ancient *atru* (in the XVIIIth dynasty) will be deduced from it (above, p. 6).*

I should have stated that the cubit (p. 2) is written: (1) from the earliest times (Dynasty IV, VI, etc.): on the naos of Saft (XXXth dynasty) : (2) usual, for distinctness, in hieratic (Bulaq XVIII, Westcar, Rhind, etc.), and in graffiti; in monumental hieroglyphs at Asyût, Tomb III, l. 13, V, l. 21. In some passages of the Westcar and some variants of the Book of the Dead (sic) is indicated but is perhaps hardly correct. In the Rhind Papyrus the cubit is often an *implied* unit with figures.

As to the measures of capacity, I find that the double *hekt* (p. 25) is regularly used at Kahun. Thus the *hekt* was doubled in the early Middle Kingdom, and this double *hekt*, as we have seen, continued in use as late as the XVIIIth dynasty, although a second doubling towards the end of the Middle Kingdom produced a quadruple *hekt*, relegating the double *hekt* to an inferior place and gradually extinguishing it. The triple *hekt* (p. 26) should probably be struck out. The *khar* appears to be rare at

* Some additional information derived from a newly catalogued Kahun fragment (XIX, 1) is embodied in the table. It extends the subdivisions of the arura to the quarter cubit.

Kahun, but I have found it four or five times in connection with boat-loads of corn; in the prevailing uncertainty as to the phonetic value of the later , the possibility of that being the *khar* itself, with the metrical value altered from 20 to 16 *hekt*, is worth consideration.

A quantity of new material put at my disposal by Mr. Petrie and a variety of considerations arising out of the preceding study necessitate the preparation of an appendix in the immediate future.

It would be a great advantage to be able to add to it descriptions of any still *uncatalogued weights bearing inscriptions* that may exist in continental and other collections. Notes of inscribed cubit-rods measures of capacity, etc., would be equally acceptable.

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