The Pyramids and Temples of Gizeh ... 1883.

SIR W.M.FlINDERS PETRIE. source

Notes ... a short introduction to the site.
Measure ... summary of the Great Pyramid's more important measures.

CHAPTERS 6 and 7.

20. The materials available for a discussion of the original size of the base of the Great pyramid are:--

(1) the casing in situ upon the pavement, in the middle of each face;
(2) the rock cut sockets at each corner;
(3) the levels of the pavement and sockets;
(4) the mean planes of the present core masonary.

Since the time of the first discovery of some of the sockets in 1801, it has always been supposed that they defined the original extent of the Pyramid, and various observers have measured from corner to corner of them, and thereby obtained a dimension which was---without further inquiry---put down as the length of the base of the Pyramid. But, inasmuch as the sockets are on different levels, it was assumed that the faces of the stones placed in them rose up vertically from the edge of the bottom, until they reached the pavement (what-ever level that might be) from which the sloping face started upwards. Hence it was concluded that the distances of the socket corners were equal to the lengths of the Pyramid sides upon the pavement

Therefore, when reducing my observations, after the first winter, I found that the casing on the North side (the only site of it then known) lay about 30 inches inside the line joining the sockets, I searched again and again for any flaw in the calculations. But there were certain check measures, beside the regular checked triangulation, which agreed in the same story; another clue, however, explained it, as we shall see.

The form of the present rough core masonry of the Pyramid is capable of being very closely estimated. By looking across a face of the Pyramid, either up an edge, across the middle of the face, or even along near the base, the mean optical plane which would touch the most prominent points of all the stones, may be found with an average variation at different times of only 1.0 inch. I therefore carefully fixed, by nine observations at each corner of each face, where the mean plane of each face would fall on the socket floors; using a straight rod as a guide to the eye in estimating. On reducing these observations to give the mean form of the core planes at the pavement level, it came out thus :---

	Case Plane Sides.	Azimuths.	Socket Sides.	Azimuths.
N.	9002.3	– 4' 35"	9129.8	– 3' 20"
E.	8999.4	– 5' 26"	9130.8	– 5' 21"
S.	9001.7	– 5' 23"	9123.9	+ 1' 15"
W.	9002.5	– 5' 39"	9119.2	– 7' 33"
Mean	9001.5	– 5' 16"	9125.9	– 3' 45"
Mean Difference	1.0	20"	4.4	2' 42"

Here, then, was another apparently unaccountable fact, namely, that the core masonry was far more accurate in its form than the socket square. It is, in fact, four times as accurate in length, and eight times as accurate in angle. This forced me to the conclusion that the socket lines cannot show the finished base of the Pyramid.

The clue which explains all these difficulties is ---that the socket corners vary from a true square in proportion to their depth below the pavement, the sockets nearer the centre being higher.

This means that the sockets were cut to receive the foot of the sloping face, which was continued right down to their floors, beneath the pavement. (See Pl. xi.)

Hence the sockets only show the size of the Pyramid, where it was started from varying levels, which were all under the pavement; and its true base upon the pavement is therefore 20 or 30 inches inside the lines of the sockets.

This exactly explains the position of the casing found on the N. side, as it was found to be inside the line of the sockets.

The test, then, of this explanation, was to find the casing on the other sides, fix its position, and see if it was likewise within the lines of the sockets. The shafts were accordingly sunk through the rubbish, two or three feet inside the socket lines; and the casing was found on each side, just in the expected alignment. Without this clue, the narrow shafts might easily have missed the casing altogether, by being sunk too far out from the Pyramid.

Now having found the casing foot on each side of the Pyramid, it is settled that the faces must have passed through these fixed points, and when the casing was duly projected down at its angle of slope to the socket floors, it was found to fall on an average 4 inches inside the edges of the socket corners. This is what might be expected, as the socket sides are neither straight nor square; so that this margin would be much less at a minimum than it is at their corners; and it would be natural to allow some free space, in which to adjust the stone.

21. Having, then, four lines passing through the middles of the sides, what is to define the junctions of those lines at the corners ? Or, in other words, what defines their azimuth? Was each side made equidistant (1) from its socket's sides ? or, (2) from the core side at each of its ends ? Or was a corner made equidistant (3) from the sides of its socket corner? or, (4) from the sides of its core corner? The core may be put out of the question ; for if the sides followed it exactly in any way, they would run outside of the sockets in some parts. Which, then, is most likely: that the sockets were placed with an equal amount of margin allowed on the two ends of one side, or with an equal margin allowed at both sides of one corner? The latter, certainly, is most likely; it would be too strange to allow, say, 6 inches margin on one side of a socket, and only 2 inches on its adjacent side. It seems, then, that we are shut up to the idea that the socket corners lie in the diagonals of the Pyramid casing.

But there is another test of this arrangement, which it ought to satisfy. Given four diagonals, as defined by the socket corners; and given four points near the middles of the sides of the Pyramid, as defined by the existing casing: if we start from one diagonal, say N.E.; draw a line through the E. casing to S.E. diagonal; from that through the S. casing, to the S.W. diagonal; and so on, round to the N.E. diagonal again ; there is no necessity that the line should on its return fall on the same point as that from which we started : it might as easily, apart from special design, fall by chance anywhere else. The chances are greatly against its exactly completing its circuit thus, unless it was so planned before by the diagonals of the socket corners being identical with those of the square of the casing.

On applying this test to the diagonals of the sockets, we find that the circuit unites, on being carried round through these points, to within 1 inch far closer, in fact, than the diagonals of the sockets and the line of the casing can be estimated.

This is, then, a conclusive test; and we only need to compute a square that shall pass through the points of the casing found on each side, and having also its corners lying on the diagonals of the sockets. This square, of the original base of the Great Pyramid casing on the platform, is of these dimensions :---

	Length.	Difference from Mean.	Azimuth.	Difference from Mean.
N	9069.4	+ .6	– 3' 20"	+ 23"
E	9067.7	– 1.1	– 3' 57"	– 14"
S	9069.5	+ .7	– 3' 41"	+ 2"
W	9068.6	– .2	– 3' 54"	– 11"
Mean	9068.8	.65	– 3' 43"	12"

Thus the finished base of the Pyramid had only two-thirds of the irregularity of the core masonry, the mean difference of which was 1.0 inch and 20" ; this is what would be expected from a final adjustment of the work, after the rougher part was finished.

But it must always be remembered that this very small mean error of .65 inch and I2" is that of the sockets, and not that of the casing stones; these latter we can hardly doubt would be adjusted more carefully than the cutting of the sockets with their free margin.

Also it must be remembered that this result includes the errors of survey. Now the probable errors of fixing the plumb-lines in the triangulation were about .2 on E. side, .2 on S. side, .1 on W. side, and the casing .1 on N. side; the probable errors of the triangulation of the points of reference is in general much less than this; we may then say ±.3 for the absolute places of the plumb-lines. The exact amount of this is not of so much ccontinuequence, because the errors of estimating the original points of construction are larger. They are, on the N., ±.04; on the E., ±.02 ; but another less satisfactory estimate differed 1.1 on the S., ±.02; on the W., ±.05, taking the mean of two points that differed 1.1 inches. Besides this, the estimation of the socket diagonals cannot be put under ±.5 by the bad definition of the edges and want of straightness and orientation of the sides. If we then allow that the probable errors from all sources of our knowledge, of each of the original sides of the Pyramid amount to ±.6, we shall not over-estimate them. Hence it is scarcely to be expected that our determinations of the sides should agree closer than .65 inch, as they do on an average.

So we must say that the mean errors of the base of the Great Pyramid were somewhat less than .6 inch, and 12" of angle.

22. In computing the above quantities, I have used my final determination of the socket levels below the pavement; these, with the first approximate results, and Inglis's figures, stand thus ;--

	Accurate in 1882	Approx in 1881	Inglis in 1865
N.E.	– 28.5	– 28.7	– 28.6
S.E.	– 39.9	– 39.9	– 42.4
S.W.	– 23.0	– 22.9	– 23.0
N.W.	– 32.8	– 32.6	– 32.8

the level of the pavement being zero. The approximation was very roughly done, and it is strange that it should agree as well with the accurate determination as it does. From Inglis's measures I have subtracted 28.6, in order to reckon them from the pavement level; by the exact agreement of my two levellings at the S.E. (which was taken second in the series each time, and hence is checked by others), I conclude that Inglis is there in error by a couple of inches; and his other work, in measuring the steps, contains much larger errors than this.

The relations, then, of the core masonry, the base of the casing on the pavement, the edge of the casing in the sockets, and the socket edges, are shown in Pl. x., to a scale of 1/50. The position of the station marks is also entered. The inclinations of the various sides of sockets and casing are stated; and it is noticeable that the core masonry has a twist in the same direction on each side, showing that the orientation of the Pyramid was slightly altered between fixing the sockets and the core. The mean skew of the core to the base is 1' 33", and its mean azimuth -- 5' 16" to true North. The diagram also shows graphically how much deformed is the square of the socket lines ; and how the highest socket (S.W.) is nearest to the centre of the Pyramid ; and the lowest socket (S.E.) is furthest out from the centre of the socket diagonals, and also from the mean planes of the core.

23. For ascertaining the height of the Pyramid, we have accurate levels of the courses up the N.E. and S.W. corners; and also hand measurements up all four corners. The levels were all read to 1/100 inch, to avoid cumulative errors; but in stating them in Pl. viii., I have not entered more than tenths of an inch, having due regard to the irregularities of the surfaces.* The discrepancy of .2 inch in the chain of levels (carried from the N.E. to S.E., to S.W., on the ground, thence to the top, across top, and down to N.E. again), I have put all together at the junction of levelling at the 2nd course of the S.W., as I considered that the least certain point. It may very likely, however, be distributed throughout the whole chain, as it only amounts to I.8" on the whole run.

* Owing to mistaking (in a photograph) the rock bed of the pavement for the pavement itself, Prof. Smyth has entered all the levels in his works (both of his own measures and those of others) from a datum 20 inches below the true pavement level. This has led him to reckon the first course as two; hence all his course numbers must have one subtracted, and all his levels about 20 inches subtracted, to reduce them to a true start from the pavement surface.

These levels, though important for the heights of particular courses, have scarcely any bearing on the question of the total height of the original peak of the casing of the pyramid; because we have no certain knowledge of the thickness of the casing on the upper parts.

The zero of levels that I have adopted, is a considerable flat-dressed surface of rock at the N.E. corner, which is evidently intended to be at the level of the pavement; it has the advantage of being always accessible, and almost indestructible. From

this the levels around the Pyramid stand thus :---

	N.E.	E.	S.E.	S.	S.W	W.	W.N.W.	N.W.	N.
2nd Course	+ 107.7		+ 105.5		+111.2			+106.6	+107.4
1st Course	+ 58.6				+ 57.6			+ 58.0	+ 58.9
Levelled rock	0	E.N.E. .15 N.N.E.							
Pavement	–	– .6?		– 5.5?		+ 1.1?	– 1.2?		+.
Socket	– 28.5		– 39.9		– 23.0			– 32.8	

The pavement levels, excepting that on the N. side below the entrance, are not of the same accuracy as the other quantities; they were taken without an assistant, merely for the purpose of showing that it really was the pavement on which the casing was found to rest on each side. The differences of the 1st course levels, probably show most truly the real errors of level of the base of the Pyramid.

24. To obtain the original height of the Pyramid, we must depend on the observations of its angle. For this there are several data, as follows; the method by which the passage and air channels determine it being explained in detail further on, when the internal parts are discussed :--

Casing stones, in situ, N. side, by theodolite	**51º 46' 45"**	**± 2' 7"**	**weight 7**
(To 3 points on top and 3 on base.) by goniometer and level	51º 49'	1'	2
(To 3 points on top and 3 on base.) by steel square and level	51º 44' 11"	23"	0
(To 3 points on top and 3 on base.) 5 overthrown by goniometer	51º 52'	2'	0
(To 3 points on top and 3 on base.) 18 fragments, all sides, goniometer (All above 2 inches in shortest length)	51º 53'	4'	0
N. face, by entrance passage mouth	51º 53' 20"	1'	10
N. face, by air channel mouth	51º 51' 30"	20"	5
N. face, weighted mean	51º 50' 40"	1' 5"	
S. face by air channel mouth	51º 57' 30"	20"	

In assigning the weights to these different data, the reason that no weight is given to the angles of shifted casing stones is that there is no proof that the courses did not dip inwards somewhat; on the contrary, I continually observed that the courses of the core had dips of as much as ½º to 1º so that it is not at all certain that the courses of the casing were truly level to 5' or 10', and occasional specimens showed angles up to 54º. The angle by means of the large steel square was vitiated by the concretion on the faces of the stones being thicker below than above, .1 inch of difference making an error of 6'. The small goniometer was applied to the clear patches of the stone, selected in nine different parts. These three casing stones in situ have not as much weight assigned to them as they would otherwise have, owing to their irregularities. One of them is 0.9 in front of the other at the top, though flush at the base ---a difference of 4'. The datum from the air channel, though far more accurate than that by the passage mouth (being on a longer length), is not so certainly intentional, and is therefore not worth as much. (See sections 32 and 33 for details.) From all these considerations the above weighting was adopted. It is clear that the South face should not be included with the North, in taking the mean, as we have no guarantee that the Pyramid was equiangular, and vertical in its axis.

25. The staff which was set up by the Transit of Venus party in 1874 on the top of the Pyramid, was included in my triangulation; and its place is known within ± ½ inch. From this staff, the distances to the mean planes of the core masonry of the Pyramid sides, were determined by sighting over their prominent edges, just as the positions of the mean planes were fixed at the lower corners of the faces. Hence we know the relation of the present top of the core masonry to the base of the Pyramid. The top is, rather strangely, not square, although it is so near to the original apex. This was verified carefully by an entire measurement as follows :--

			Mean of four readings, 1881.	Mean of three readings, 1882.	Mean of all.
Center of Pyramid base horizontal to the :	[	N. side E. side S. side W. side	226.0 ± .5 214.4 ± .4 215.0 ± .6 216.4 ± .5	223.7 ± .2 213.8 ± .6 215.0 ± .4 218.7 ± .5	224.5 ± .7 214.1 ± .3 215.0 ± .4 217.6 ± 1.0

Now, at the level of these measurements, 5407.9 at N.E., or 5409.2 at S.W., above the base, the edges of the casing (by the angles of the N. and S. side found above) will be 285.3 ± 2.7 on the North, and 30I.6 on the South side, from the vertical axis of the centre. Thus there would remain for the casing thickness 60.8 ± 3 on the N., and 86.6 on the S.; with 77.6 for the mean of E. and W. Or, if the angle on the S. side were the same as on the N., the casing thickness would be 69.2 on the S. This, therefore, seems to make it more likely that the South side had about the same angle as the North.

On the whole, we probably cannot do better than take **51° 52' ± 2'** as the nearest approximation to the mean angle of the Pyramid, allowing some weight to the South side.

The mean base being **9068.8 ± .5 inches**, this yields a height of **5776.0 ± 7.0 inches.**

26. With regard to the casing, at the top it must---by the above data---average about 71 ± 5 inches in thickness from the back to the top edge of each stone. Now the remaining casing stones on the N. base are of an unusual height, and therefore we may expect that their thickness on the top would be rather less, and on the bottom rather more, than the mean of all. Their top thickness averages 62 ± 8 (the bottom being 108 ± 8), and it thus agrees very fairly with 71 ± 5 inches. At the corners, however, the casing was thinner, averaging but 33.7 (difference of core plane and casing on pavement); and this is explained by the faces of the core masonry being very distinctly hollowed.

This hollowing is a striking feature; and beside the general curve of the face, each side has a sort of groove specially down the middle of the face, showing that there must have been a sudden increase of the casing thickness down the mid-line. The whole of the hollowing was estimated at 37 on the N. face; and adding this to the casing thickness at the corners, we have 70.7, which just agrees with the result from the top (71 ± 5), and the remaining stones (62 ± 8). The object of such an extra thickness down the mid-line of each face might be to put a specially fine line of casing, carefully adjusted to the required angle on each side ; and then afterwards setting all the remainder by reference to that line and the base.

Several measures were taken of the thickness of the joints of the casing stones. The eastern joint of the northern casing stones is on the top .020, .002, .045 wide; and on the face .012, .022, .013, and .040 wide. The next joint is on the face .011 and .014 wide. Hence the mean thickness of the joints there is .020; and, therefore, the mean variation of the cutting of the stone from a straight line and from a true square, is but .01 on length of 75 inches up the face, an amount of accuracy equal to most modern opticians' straight-edges of such a length. These joints, with an area of some 35 square feet each, were not only worked as finely as this, but cemented throughout. Though the stones were brought as close as 1/500 inch, or, in fact, into contact, and the mean opening of the joint was but 1/50 inch, yet the builders managed to fill the joint with cement, despite the great area of it, and the weight of the stone to be moved-some 16 tons. To merely place such stones in exact contact at the sides would be careful work; but to do so with cement in the joint seems almost impossible

The casing is remarkably well levelled at the base ; the readings on the stones of the North side, and the pavement by them being thus :--

	W.End.	Middle.	E.End.	Pavement by casing.	Core 40ft.E. of casing.
Casing Front	+ 58.83	+ 58.84	+ 58.90	– .01	
Casing Back	+ 58.84		+ 58.85	– .03	
Core				+ .02	+ 58.87
Pavement	(–.56)	(–.30)	(–.05)	.00	

The pavement levels in brackets are on decidedly worn parts, and hence below the normal level, as shown in the fourth column. The average variation of the casing from a level plane of + 58.85 is but .02; and the difference to the core level, at the farthest part accessible in that excavation, does not exceed this. The difference of pavement level out to the rock at the N.E. corner is but .17 on a distance of 4,200 inches, or 8" of angle.

27. The works around the Pyramid, that are connected with it, are :--
(1) The limestone pavement surrounding it; (2) the basalt pavement on the E. side and (3) the rock trenches and cuttings on the E. side, and at the N.E. corner.

The limestone pavement was found on the N. side first by Howard Vyse, having a maximum remaining width of 402 inches; but the edge of this part is broken and irregular, and there is mortar on the rock beyond it, showing that it has extended further. On examination I found the edge of the rock-cut bed in which it was laid, and was able to trace it in many parts. At no part has the paving been found complete up to the edge of its bed or socket, and it is not certain, therefore, how closely it fitted into it ; perhaps there was a margin, as around the casing stones in the corner sockets. The distances of the edge of this rock-cut bed, from the edge of the finished casing on the pavement (square of 9068.8) were fixed by triangulation as follows :--

N.N.W.	616.9 near the corner; corner itself not found, nor any W.N.W. side.
	615.9 at 570 E. of probable N.W. corner of pavement.
	618.7 at 670 E.
	616.2 at 890 E.
N.side	564 to 568 very rough and irregular, opposite entrance.
N.N.E.	529.0 at N.E. corner, N. side of it.
E.N.E.	538.8 at N.E. corner, E. side of it.
	533.9 at 586 from N.E. corner.
	No cutting found at S.E. corner.
	536.5 at 846 from S.W. corner.
	533.0 at 520 from S.W. corner.
	534.6 at 206 from S.W. corner.
S.S.W.	529.6 at S.W. corner, S. side of it.
W.S.W.	536.0 at S.W. corner, W. side of it.
	627.9 at 751 from S.W. corner.

From these measures it appears that there is no regularity in the width of the cutting; the distance from the casing varying 99 inches, and altering rapidly even on a single side. The fine paving may possibly have been regular, with a filling of rougher stone beyond it in parts; but if so, it cannot have exceeded 529 in width.

The levels of the various works around the Pyramid are as follow, taken from the pavement as zero :--

Flat rock-bed of pavement W. of N.W. socket	– 23.7
Flat rock-bed of pavement beside N.W. socket	– 21.6
Flat rock-bed of pavement N. of N.W. socket	– 17.0
Flat rock-bed of pavement N.E. of N.W. socket	– 15.9
Flat rock-bed of pavement before entrance	– 27.1
Flat rock-bed of pavement inner end of E.N.E. trench	– 26.9
Basalt pavement, E. side of it	+ 2.0
Basalt pavement, W. side, in excavation	+ 2.0

The Pyramid pavement must then have varied from 17 to 27 inches in thickness; it was measured as 21 inches where found by Vyse.

28. The basalt pavement is a magnificent work, which covered more than a third of an acre. The blocks of basalt are all sawn and fitted together; they are laid upon a bed of limestone, which is of such a fine quality that the Arabs lately destroyed a large part of the work to extract the limestone for burning. I was assured that the limestone invariably occurs under every block, even though in only a thin layer. Only about a quarter of this pavement remains in situ, and none of it around the edges the position of it can therefore only be settled by the edge of the rock-cut bed of it. This bed was traced by excavating around its N., E., and S. sides; but on the inner side, next to the Pyramid, no edge could be found ; and considering how near it approached to the normal edge of the limestone pavement, and that it is within two inches of the same level as that, it seems most probable that it joined it, and hence the lack of any termination of its bed.

Referring, then, to the E. side of the Pyramid, and a central line at right angles to that (see Pl. ii.), the dimensions of the rock bed of the basalt paving are thus :--

NORTH TO SOUTH.

From mid-line of Pyramid	1046.0 to N.E.	1061.9 to N.W.
	1077.7 to S.E.	1062.8 to S.W.
Total length	2123.7 E. side.	2124.7 W. side.
S. corner of opening on E. side	321.0 to mid.	756.7 to S.E.
N. corner of opening on E. side	693.3 to mid.	352.7 to N.E.

EAST TO WEST.

Width traced.	1006.6 + ×.
E. side, from Pyramid base.	2153.0 N. end.
	2148.0 S. end.
S. corner of opening on E. side of the base.	2169.0
N. corner of opening on E. side of the base.	2160.0

Next, referring this pavement to the trench lines :--

NORTH TO SOUTH.

N. trench, inner end from basalt	318.1
S. trench, inner end from basalt	327.9

EAST TO WEST.

N.E. corner to N. trench axis	1073.2
N. trench axis there, to Pyramid	1079.8
S.E. corner to S. trench axis	1022.6
S. trench axis there, to Pyramid	1125.8
S.E. corner to N. trench axis, continued	1075.0
N. trench axis there, to Pyramid	1073.0

Hence the plan of the basalt pavement seems to be two adjacent squares of about 1,060 inches in the side; the N. trench axis being the boundary of them, and there being a similar distance between that and the Pyramid. The outer side of the paving was laid off tolerably parallel to the Pyramid base ; but the angles are bad, running 15 inches skew.*

* The broken blocks of basalt, which border a track down the hill side E. of them Pyramid, are almost certainly from this pavement; they are of exactly the same stone, and have many worked faces remaining like those of the pavement. Their placing is quite rude, and looks as if done by some barbarian destroyers.

29. Next, referring to the rock-hewn trenches alone, the dimensions of the three deep ones are as follow :--

NORTH TO SOUTH.

N. trench, outer end, to central line	3510.2
N. trench, axial length	2130.2
N. trench, inner end, to central line	1380.0
S. trench, inner end, to central line	1390.7
S. trench, axial length	2093.7
S. trench, outer end, to central line	3430.4
E.N.E. trench, outer end of axis N. of central line	848.3
E.N.E. trench, axis cuts N. trench axis N. of central line	68.5

EAST TO WEST.

N. trench axis, outer end to base	1085.5
N. trench axis, inner end to base	1080.6
S. trench axis, inner end to base	1125.5
S. trench axis, outer end to base	1122.9
S. trench axis, E. of N. trench axis, at centre	497
E.N.E. trench, outer end of axis to base	4213.2
E.N.E. trench, axial length from N. trench axis	3231.1
E.N.E. trench, axial length from actual bed of basalt	2112.6
E.N.E. trench, axial length from straight edge	2124.7

The slighter trenches are three in number :--

NORTH TO SOUTH.

N.N.E. trench axis cuts N. trench axis N. of central line	116.0
Trench by N.E. socket, end of axis from N. side of casing	643.3
Trench by N.E. socket, on the axis, from N. side of casing	1630.8
Trench by trial passages, ends of axis N. of central line	1563.3
	1274.4

EAST TO WEST.

N.N.E. trench, axis cuts pavement, from N.E. corner	647.2
Trench by N.E. socket, end of axis from E. side of casing	203.2
Trench by N.E. socket, on the axis, from E. side of casing	434.1
Trench by trial passages, ends of axis E. of Pyramid base	3161.6
	3167.6

The subterranean passages are in one group :--

NORTH TO SOUTH.

Trial passages axis, N. of central line, at the station marks	2233.6
	1220.8

EAST TO WEST.

Trial passages axis, E. of central line, at the station marks	3446.7
	3441.2

Hence it seems that the axial length of the E.N.E. trench outside the basalt paving is intended to be the same as the axial length of the North and South trenches.

The angles of the axes of these trenches are as follow :--

	To E. Face of Pyramid.	To true North.
N. trench	+ 7' 53"	+ 3' 56"
S. trench	+ 4' 09"	+ 12"
E.N.E. trench	+ 76º 02' 26"	+ 75º 58' 23"
N.N.E. trench	+ 24º 25' 34"	+ 24º 21' 37"
Trench by N.E. socket	+ 13º 09' 38"	+13º 5' 41"
Trench by trial passages	– 1º 11'	– 1º 15'
Trial passages	+ 18' 40"	+ 14' 43"

Thus the angles between the trenches are: S. trench to E.N.E. trench, 104º I' 43" (or 2 X 52º 0' 52"); and E.N.E. to N.N.E. trench, 51º 36' 52."

With regard to the details of these rock cuttings, the forms of the ends of the N. and S. trenches were plotted from accurate offsets (see P1. iiia.); and there is little of exact detail in the cutting to be stated. The axes at the ends were estimated by means of the plans here given, but on double this scale; and the rock is so roughly cut in most parts that nothing nearer than an inch need be considered. The position of the inner end of the N. trench is not very exactly fixed, an omission in measurement affecting it, mainly from N. to S. In this trench I excavated to 110 below the present surface of the sand, or about 220 below the rock surface, without finding any bottom. The S. trench is more regular than the N. trench; at the outer end its width is 205 to 206, and at the inner end 134.2: it has a curious ledge around the inner end at 25 below the top surface. At the outer end the rock is cut, clearly to receive stones, and some plaster remains there; also some stones remain fitted in the rock on the W. side of this trench. Built stones also occur in the N., E.N.E., and N.N.E. trenches. From the inner end of the S. trench, a narrow groove is cut in the rock, leading into the rock-cut bed of the basalt pavement; this groove was filled for a short way near the end of the trench by stone mortared in. It was evidently in process of being cut, as the hollows in the sides of it were the regular course of rock-cutting. The rock beside the trenches is dressed flat, particularly on the E. of the N. trench, and the W. of the S. trench, where the built stones occur. There is a short sort of trench, on the E. side of the S. trench (not in plan); it is about 25 wide, 70 long, and 50 deep, with a rounded bottom; the length E. and W.

The E.N.E. trench is very different to the others; it has a broad ledge at the outer end, and this ledge runs along the sides of the trench, dipping downwards until it reaches the bottom towards the inner end: the bottom sloping upwards to the surface at the inner end. There are stones let into this ledge, and mortared in place, and marks of many other stones with mortared beds, all intended apparently to make good the ledge as a smooth bed for some construction to lie upon. The bottom of this trench I traced all over, by excavations across and along it; looking from the outer end, there first came two ledges-the lower one merely a remainder of uncut rock, with grooves left for quarrying it-then the bottom was found about 200 inches below ground level; from this it sloped down at about 20º for about 200 inches; then ran flat for 300 or 400; and then sloped up for 300 or 400; then rose vertically, for some way; and then, from about 120 below ground level, it went up a uniform slope to near the surface, where it was lost at the inner end under high heaps of chips. At the outer end the width near the top is 152.8, and at 25 down 148.2 ; the lower space between the sides of the ledge widens rapidly to the middle, from the end where it is 43.0 wide above and 35.0 below. Towards the inner end the rock is very well cut; it has a row of very rough holes, about 6 diam., in the dressed rock along the N. edge of the trench, near the inner end. This dressed side of the trench ends sharply, turning to N. at 1603.6 from outer end of the trench axis; the width here is 170.I, or 172.3 at a small step back in S. side, a little E. of this point. The trench had not been clear for a long time, as many rudely-buried common mummies were cut through in clearing it; they were lying only just beneath the sand and rubbish in the bottom.

The N.N.E. trench was traced by excavations along the whole length of 2,840 inches, up to where it is covered by the enclosure wall of the kiosk. It is fairly straight, varying from the mean axis 2.1, on an average of five points fixed along it. The depth varies from 14 to 20 inches below the general surface. It is 38, 40, 39.2, and 36 in width, from the outer end up to a point 740 along it from the basalt pavement; here it contracts roughly and irregularly, and reaches a narrow part 18.2 wide at 644 from the pavement. The sides are built about here, and deeply covered with broken stones. Hence it runs on, till, close to the edge of the basalt pavement, it branches in two, and narrows yet more; one line runs W., and another turning nearly due S., emerges on the pavement edge at 629.8 to 633.4 from the N.E. corner of the pavement, being there only 3.6 wide. From this remarkable forking, it is evident that the trench cannot have been made with any ideas of sighting along it, or of its marking out a direction or azimuth; and, starting as it does, from the basalt pavement (or from any building which stood there), and running with a steady fall to the nearest point of the cliff edge, it seems exactly as if intended for a drain; the more so as there is plainly a good deal of water-weanng at a point where it falls sharply, at its enlargement. The forking of the inner end is not cut in the rock, but in a large block of limestone.

The trench by the N.E. socket is just like the N.N.E. trench in its cutting and size; and it also narrows at the inner end, though only for about 20 inches length. It has a steady fall like the N.N.E. trench; falling from the S. end 5.5 at 50, 8.5 at 100, 14.3 at 190, 21.0 at 300, and 27.0 at 400 inches. The inner end is turned parallel to the Pyramid, the sides curving slightly to fit it.

The rock cuttings by it are evidently the half-finished remains of a general dressing down of the rock; the hollows are from 3 to 6 inches deep, and so very irregular that they do not need any description beside the plan (P1. ii.).

The trench beside the trial passages is slight, being but 6 deep at N. and 17 at S.; it is 29.0 wide at N., 26.5 in middle, and 27.9 at S. Its length is 289, with square ends. The sides are vertical at the N., narrowing 3.5 to bottom at S.; ends shortening 3.0 to bottom. The bottom dips slightly to the S., the levels from the N. running 0, -- 1.7, -- 2.2, -- 3.2, arid -- 5.8.

30. The trial passages P1. iii b. are a wholly different class of works to the preceding, being a model of the Great Pyramid passages, shortened in length, but of full size in width and height. Their mean dimensions -and mean differences from those dimensions- as against the similar parts of the Great Pyramid, are:--

26º 32' mean difference .24'	Pyramid passage angle 26º 27' mean diff. 4'
41.46 mean difference .09	Pyramid passage widths 41.53 mean diff. .07
47.37 mean difference .13	Pyramid passage heights 47.24 mean diff. .05
23.60 mean difference .08	Pyramid ramp heights 23.86 mean diff. .32
81.2 mean difference .6	Pyramid gallery widths 82.42 mean diff. .44
28.63 mean difference .54	Pyramid well widths 28.2 mean diff. .3

The details of the measurements of each part are all entered on the section (P1. iiib.). The vertical shaft here is only analogous in size, and not in position, to the well in the Pyramid gallery; and it is the only feature which is not an exact copy of the Great Pyramid passages, as far as we know them. The resemblance in all other respects is striking, even around the beginning of the Queen's Chamber passage, and at the contraction to hold the plug-blocks in the ascending passage of the Pyramid (see section 38). The upper part of the vertical shaft is filled with hardened stone chips; but on clearing the ground over it, I found the square mouth on the surface. The whole of these passages are very smoothly and truly cut, the mean differences in the dimensions being but little more than in the finely finished Pyramid masonry. The part similar to the gallery is the worst executed part ; and in no place are the corners worked quite sharp, generally being left with radius about .15. The N. end is cut in steps for fitting masonry on to it; and I was told that it was as recently as 1877 that the built part of it was broken away by Arabs, and it appeared to have been recently disturbed ; in Vyse's section, however, the roof is of the present length, so the removal must have been from the floor. By theodolite observations the plane of the passage is straight and vertical within 5' or less.

31. Having thus finished the statement of the outside of the Pyramid and the works surrounding it, the next subject is the connection of the outside and inside of the building.

To determine the exact place of the passages and chambers in relation to the whole Pyramid, a station of the triangulation was fixed in a hollow just on the end of the entrance passage floor and this was thoroughly connected with three main stations. Levelling was also carried up from the casing and pavement below, to this station, and to the courses near it. Thus the inside, as far as Mamun's Hole, is completely connected with the outside; and in the ascending passages beyond that, there is only 2' of azimuth in doubt.

32. The original length of the entrance passage has not hitherto been known, except by a rough allowance for the lost casing. But after seeing the entrances of the Third Pyramid, the South Pyramid of Dahshur, and the Pyramid of Medum, all of which retain their casing, there seemed scarcely a question but that the rule was for the doorway of a Pyramid to occupy the height of exactly one or two courses on the outside. That the casing courses were on the same levels as the present core courses, is not to be doubted, as they are so in the other Pyramids which retain their casing, and at the foot of the Great pyramid *

* The awkward restoration of the casing that Prof, Smyth adopted (Life and Work, P1. iii., 3) was forced on him by his mistaken assumption of the pavement level 20 inches under the truth (L. and W. ii. 137); hence by Vyse's casing stone measures he made the casing break joint with the core, in defiance of Vyse's explicit drawing of its position; and was obliged to reduce the pavement to 5 or 10 inches, in place of the 21 inches recorded by Vyse. The drawing of "hacking stones," at the foot of P1. 1., vol. iii., L. and W., is equally at fault; the casing stones which remain in the middle of the side, ending directly against the core masonry; and the core at the corners only leaving 34 inches for the casing thickness, No backing stones exist behind the casing of the Third Pyramid or the cased Dahshur Pyramid.

The next step is to see if there is a course equal to the vertical height of the doorway; and, if so, where such a course occurs. Now the vertical height of the doorway on the sloping face of the Pyramid (or difference of level of its top and base) would be 37.95 if the passage mouth was the same height as the present end, or 37.78 if the passage was exactly the same as the very carefully wrought courses of the King's Chamber, with which it is clearly intended to be identical. On looking to the diagram of courses (P1. viii.) it is seen that at the I9th course is a sudden increase of thickness, none being so large for 11 courses before it and 14 after it. And this specially enlarged course is of exactly the required height of the doorway, its measures running thus :--

By levelling at entrance 37.67 by measuring courses 37.8 ; by N.E. 38.1, S.E. 37.6, NW. 37.5, SW. 39'.1	mean 37.94 ± .17	doorway height 37.95 or 37.78

Here the agreement is so exact that it is far within the small uncertainties of the two dimensions. Hence, if the passage emerged at the 19th course it would exactly occupy its height (see P1. xi.). * Besides this, it will be observed that there are two unusually small courses next over this, being the smallest that occur till reaching the 77th course. The explanation of these is clear, if the doorway came out in the 19th course ; an unusually thick lintel course was needed, so two thinner courses were put in, that they might be united for obtaining extra thickness, as is done over the King's Chamber doorway. These two courses are also occasionally united in the core masonry.

The crucial test then is, supposing the passage prolonged outwards till it intersects this course, how will its end, and the face of the casing, stand to the casing stones at the foot of the Pyramid? The answer has been already given in the list of determinations of the casing angle. It requires an angle of slope of 51º 53' 20" ± 1'; and this is so close to the angle shown by other remains that it conclusively clenches the result to which we are led by the exact equality of the abnormal course height with the doorway height.

The data for calculating the result are (1) levels of the 19th course by entrance 668.30 and 705.97; (2) floor of passage at station mark, level 611.2 (3) which is inside the edge of the base of the casing horizontally, 638.4; (4) entrance passage angle at mouth 26º 29' ± 1' ; (5) entrance passage height 47.26.

33. By a similar method the air channels give a determination of the angle of the faces. It is true that the channels did not occupy a whole course like the entrance; but as they are uniformly cut out as an inverted trough in the under side of a block' which is laid on a broad bed, it is almost certain that they similarly continued to the outside, through the one---or perhaps two---stones now stripped off; and also that their floors thus started at a course level (see P1. xi.). **

* It should be explained that this is called the 20th course by Prof. Smyth, owing to his error about the 1st course and pavement level. His measure of it is 38 inches, and the two French measures give it as 37 and 38 inches.

** In the section of the S. air channel mouth published by Prof. Smyth, certainly "the joints are not put in from any measure," nor is any other feature of it. The passage, its bed, and top, are all about half of their true size, and the form of it is unlike anything that has been there, at least since Vyse's time.

If this, then, were the case (as the N. channel cannot by its position have come out in any but the 103rd course on the face, and the S. channel in any but the 104th), they would show that the casing rose on the N. face at 51º 51' 30", and on the S. face at 51º 57' 30", as before stated. The various data are entered on the diagram of the channel mouths. The levels were fixed by measuring several courses above and below the present mouths, and thus connecting them to the course levelling at the corners of the Pyramid. With regard to the main part of these air channels, the details are given further on in the measures of the King's Chamber (section 56); and it is disappointing that they vary so much in azimuth and altitude, that they are useless for connecting the measures of the inside and outside of the Pyramid.

34. The sloping blocks over the entrance to the Pyramid, and the space below them, were examined (partly by means of a ladder), and measured ; but the details are not worth producing here, as the work of them is so rough. The large blocks are as follows, in general size :--

	E. upper.	W. upper.	E. lower.	W. lower
Length on top	(185)	(194)	151 + ×	167.7
Length below	117½	121	84 + ×	107.6
Breadth	80.0 to 91½	88.3	82.6	81.6
Height of mid-line	(114)		91	
Lean of face	20' to 2º in	2º 20' in	20' to 30' out	25' to 30' out
Angle on top	35º 40' to 39º 50' in	mean 40º	38º 45' to 50'	39º 30'
Angle on base	38º 45' to 50' in	39º 30'	39º 20' to 50'	39º 30' to 55'
Angle on butment	49º 50' to 50º 10' in	50º 40'	hidden	50º 30'

The measures in brackets are deduced from the angles and other measures. These blocks are much like a slice of the side of a casing stone in their angle; but their breadth and length are about half as large again as any of the casing stones. Their mean angle from 12 measures is 50º 28' ± 5'. The thickness of these blocks is only 33 inches, and there are no others exactly behind them, as I could see the horizontal joints of the stones running on behind them for some inches. On the faces of these blocks are many traces of the mortaring which joined to the sloping blocks next in front of them. These were placed some 70 inches lower at the top, and were not

so deep vertically. By the fragment left on the E. side, the faces of these blocks were vertical. In front of these came the third pair, similar, but leaning some 7½º or 8º inwards on the face, judging by a remaining fragment. Probably a fourth and fifth pair were also placed here (see P1. ix.); and the abutment of the fifth pair shows an angle of 70½º or 73º in place of 50º. The successive lowering of the tops, leaning the faces in, and flattening the angle of slope of the stones as they approach the outside, being apparently to prevent their coming too close to the casing. These sloping blocks were probably not all stripped away, as at present, until recently, as there is a graffito, dated 1476 (half destroyed by the mock-antique Prussian inscription) on the face of the remaining block where it is now inaccessible, but just above where the next pair of blocks were placed. The sloping blocks are of remarkably soft fine-grained limestone, about the best that I have seen, much like that of the roofing of the chamber in Pepi's Pyramid; and it is peculiar for weathering very quickly to the brown tint, proper to the fine Mokattam limestone, darkening completely in about twenty years, to judge by the modern-dated graffiti.

Interior passageways and chambers ... sectional views

35. Having, then, fixed the original position of the doorway of the Pyramid, we may state that it was at 668.2 ± .1 above the pavement of the Pyramid; 524.1 ± .3 horizontally inside (or S. of) the N. edge of the Pyramid casing; and its middle 287.0 ± .8 E. of the centre * of the Pyramid ; or 3723.6 from E. side, and 4297.6 from W. side, at its level; the probable error being that of fixing the length of the sides.

* Whenever any point is described as E. of the centre of the Pyramid, it is uniformly meant that it is that amount E. of a vertical plane, parallel to the mean of the Pyramid's E. and W. sides, and which passes through the centre of the Pyramid. Similarly of similar descriptions N., S., and W.

Thus we have the following positions in the entrance passage, reducing all to the true beginning of the floor.

		W. Floor	W. Wall Base	W. Wall Top	W. Roof	E. Roof	E. Wall Top
Doorway, original		0 ± .3	0 ± .3				
End of "basement sheet"		124.2					
Station mark		127.90					
Prof. Smyth's joint numbers	1	178.75					
	2	226.46					
	1		276.63				
	3	285.29					
	2		331.79				
	4	340.56					
	2			348.10			
	5	406.04					
	3		414.21				
	6	465.46					
	4		474.02				
Scored line			481.59				
	5		516.26				
	7	531.67					
	6		551.66				
	8	584.15					
	7		606.87				
	8		651.91				
	9		686.98				
	10	700.28					
	11	736.28					
	10		763.70				
	12	776.39					
	11		806.14				
	13	827.16					
	12		865.32				
	14	878.58					
	13		891.79				

		W. Floor	W. Wall Base	W. Wall Top	W. Roof	E. Roof	E. Wall Top
floor ascending passage	15	915.09					
	14		926.69				
	16	963.61					
	15		967.14				
	16		996.27				
	17	1003.69					
	18	1028.59					
	17		1056.78				
	19	1063.82					
	18		1106.13				
		1110.64					
	20	1127.71					
	19		1136.06				
	21	1174.22					1163.6
	20		1177.14	1177.7			
					1188.1		
						1192.4.1	
							1207.1
				1232.1			
						1243.7	
							1262.3
						1296.1	
				1318.5 Rock			
					1340.1 Rock		
							1347.5 Rock.
						1350.7 Rock	

The above measures were taken by rods from 124.2 to 285.29 (the rods jointing together with butt ends), by steel tape from 276.63 to 1177.14, and by rods from 1163.6 to the rock; all duly corrected for temperature. On comparing them with Professor Smyth's measures, it will be found that his measures make the passage length about an inch shorter on an average; this is fairly accounted for (1) by his being all piece-meal measures added together, (2) by the rude method of making scratches with a **screw-driver** to mark the lengths of rod on the stone (L. and W. ii., 46), and (3) by there being "always a certain amount of risk as to the measuring rod slipping on the inclined floor" (L and W. ii., 35). All these errors would make the reading of the length shorter than it should be; and all were avoided by the use of a steel tape lying on the side of the floor. Nevertheless, I tested again, by rod measure, some of the points where the difference of Professor Smyth's measures were greatest from the steel tape, and they come out thus :--

Between joints	**By steel tape**	**Again by rods**	**By Prof Smyth**
5 to 6 on floor	59.42	59.45	59.2
7 on wall to 8 on floor	22.72	22.72	22.2
14 on wall to 15 on floor	11.60	11.58	10.9
14 on wall to 16 on floor	36.92	36.93	37.6
15 on wall to 16 on floor	3.53	3.47	2.9

These will practically show what errors may creep in, by not using a continuous measure like a steel tape. The

object of measuring the joints, as well as the total length, by steel tape, is sufficiently illustrated by this comparison.

One source of error may arise from following the coursely-scratched prolongations of the anciently drawn lines, and of the ascending passage floor and roof. These have been made by modern measurers; and they were always rejected, and a more accurate method employed.

The measures from the steel tape onwards, by rods, down to the end of the built passage, where it rests on the rock, are not of the same accuracy as the others; the broken parts of th passage sides, and the awkwardness of measuring over the large block of granite, without any flat surface even to hold the rods against, prevented my taking more care over a point where accuracy is probably not of importance.

For the total length of the entrance passage, down to the subterranean rock.cut part, only a rough measurement by the 140-inch poles was made, owing to the encumbered condition of it. The poles were laid on the rubbish over the floor, and where any great difference of position was required, the ends were plumbed one over the other, and the result is probably only true within two or three inches. The points noted down the course of the passage, reckoning from the original entrance (i.e., the beginning of the rock on the E. side of the roof being 1350.7), are the following:--

	E.		W.
Beginning of inserted stones, filling a fissure.	1,569		1,555
Joint in these stones.	1,595		None
End of these inserted stones.	1,629		1,595
Sides of passage much scaled, 1 or 2 " off, beyond here		2,750	
Fissure in rock	3,086 - 3,116		3,066 - 3096
Mouth of passage to Gallery			3,825 - 3,856
End of sloping roof (4,137 Vyse, corrected for casing).	4,143		

36. The azimuth and straightness of the passage were carefully measured. The azimuth down the built part was taken by reference to the triangulation, which in its turn was fixed by six observations of Polaris at elongation, from a favourable station (G). The azimuth to the bottom of the rock-cut passage was observed independently, by five observations of Polaris at elongation. The observations of the straightness throughout gives a check by combining these two methods, and they are thus found to agree within 19", or just the sum of their probable errors, equal to only .09 inch lineally on the azimuth of the built part.

The results are :--

	Azimuth	Altitude
Mean axis of whole length.	– 3' 44" ± 10"	**26º 31' 23" ± 5" ?**
Mean axis of built part alone.	– 5' 49" ± 7"	
Same by offsets from 3' 44" axis.	– 5' 28" ± 12"	26º 26' 42" ± 20"?
(Same by Prof. Smyth, two days.	– 4' 27" and – 5' 34"	26º 26' 43" ± 60")

The observations of the straightness of the walls, floor, and roof of the passage, when all reduced to offsets from its mean axis of the whole length stand thus :--

Distance from original entrance	From – 3' 44" azim. W.	Mid.	E.	**From 26º 31' 23" alt** Roof.	Mid.	Floor.
460	21.1	.3 W.	20.5	23.2	– .4	– 24.1
710	20.9	.2 W.	20.6	23.4	– .2	– 23.9
990	20.7	0	20.8	24.1	+ .4	– 23.3
1110						– 23.4
1291	21.1?	.1 E.	21.3			
1505	20.5	.2 E.	21.0	23.8		
1741	20.4	.4 E.	21.1	23.6	– .1	– 23.9
2069	20.8	.2 E.	21.1	23.4	– .4	– 24.2
2481	21.6	.3 W.	20.9	23.4		
2971	21.0	0	21.0			
3711	21.3	.4 W.	20.5	24.3	0	– 24.3
4113?	21.3	.4 W.	20.5	23.6	– .6?	– 24.9?
4140	...	...	20.8	23.9		
Mean error		.23			.30	

(Floor at 1110 interpolated from clinometer curve.)

But the passage in the built part, and indeed for some 40 feet below that, is far straighter in azimuth than the lower part; taking this upper 2/5ths of it alone, it has a mean axis of -- 5' 49" ± 7" In azimuth, and varies thus :--

		W.	Mid.	E.
At	460	20.86	.06	20.77
	710	20.78	0	20.77
	990	20.70	.05 E.	20.80
	1291	21.23	0	21.22
	1505	20.75	0	20.75
	1741	20.76	.01 W.	20.74
Mean error			.02	

These offsets only being read to 1/20th inch (the 1/100ths merely resulting from computation) it is remarkable that the errors of the mid-line of the passage are so minute; and it shows that in this particular we have not yet gone within the builder's accuracy; readings to 1/100th inch or to I" on the longer distances, are now required.

The absolute position, then, of the middle of the S. end of the entrance passage floor will be, in level, 668.2 -- (4140 X sin. 26º 31' 23") -- .8 difference of floor offsets = -- 1181 ± 1 ?; in distance from N. base of pyramid 524.I + 3704.3 = 4228 ± 2? or 306 N. from mid-plane; and in distance E. from the mid-plane 287.0 -- [sin. (3' 55" -- 3' 44") x 3704] -- .4 difference of offsets = 286.4 ± 1.0.

37. The Subterranean chambers and passages are all cut roughly in the rock. The entrance passage has a flat end, square with its axis (within at least 1º), and out of this end a smaller horizontal passage proceeds, leaving a margin of the flat end along the top and two sides. This margin is 4.5 wide at E., 3.2 at W., and 5.4 to 6.0 from E. to W. along the top.

The dimensions and distances are as follow, from the S. end of the floor of the entrance passage (as deduced from the roof, which is better preserved) ; and the axial positions and levels are by theodolite observations :--

	Distance from End of E.P. Floor.	Distance from Mid. Plane of Pyramid.	Width E. to W. Top. Base.	Mid. from Entrance Axis, continued.	Mid. E. from Mid line of Pyramid.	..Height.. E. W.	Level above End of E. P. floor.	Level below Pyramid Pavement.
Beginning of Horiz Passage	0	306N.	40.8	.4W.	286.4	48.5	0	- 1181 floor
	20		32.9	1.0W.	285.8		Top + 38.3	- 1143 roof
Fissure	76W. 91E.							
In Passage	121		32.3 32.4					
N Door of S Chamber	218	88N.	31.6 32.7					
S Door of S Chamber	291	15N.	31.9 33.0					
N Door of L Chamber	346 *	40S.	32.0 33.3	.5W.	286.3	35.5 36.0	Top + 38.9	- 1142 roof
S Door of L Chamber	672	366S.	29.5 29.5	1.9W.	284.9	31.0 + × **	Top - 6.6	- 1188 roof
In S Passage	760		29.6 27.3					
In S Passage	900		26.7 26.7			26.3 26.0		
In S Passage	1040		28.1 29.0			28.6 27.0		
In S Passage	1180		30.1 30.0			29.5 29.3		
In S Passage End	1318	1012S.	26.0	9.7W.	277.1		Top - 2.6	- 1184 roof
Large Chamber, E. Wall 325.9; at 100 from West. Wall 329.6?; N. Wall 553.5; S. Wall 554.1							Top +125.3 #	- 1056 roof
Side Chamber W.Wall 69½ to 70½ ; N.Wall 70.3; S.Wall 72.3							Top + 40 to + 48	- 1137 roof

The large chamber walls are therefore distant from the Pyramid central axis, 302.9 E. at N. wall; 299.6 E. at S. wall; 250.6 W. at N. wall; 254.5 W. at S. wall; 40 S. and 366 S. The central axis thus not passing through the chamber, but 40 inches inside the rock of the N. side.

In the chart above :--

* E. side of door-sill is at 351, and W. side 347, the wall not being filly dressed down there.

** This doorway rounds off at the top, rising 1½ inches in the 10 inches.

\# The top is + 124.3 at N. doorway, 125.4 to 127.6 at S. doorway; the roof being cut away higher, just in the corner.

The side chamber is an enlargement of the passage, westward and upward, as are all the chambers of the Pyramid; it is very rough and uneven, and encumbered now with large blocks of stone. The large chamber is most clearly unfinished, both in the dressing of the walls, and more especially in the excavation for the floor. The walls have an average irregularity estimated at ±.7 and projecting lumps of rock are left untouched in some parts. The roof is more irregular, estimated average variation ±3. The floor is most irregular, at the W. end it rises at the highest to only 10 inches from the roof; and over all the western half of the chamber it is irregularly trenched with the cuttings made by workmen to dislodge blocks of the rock. It is, in fact, an interesting specimen of quarrying, but unfortunately now completely choked up, by Perring having stowed away there all the pieces of limestone taken out of his shaft in the floor. After dislodging several blocks, I crawled in over the knobs and ridges of rock, until jammed tight from chest to hack in one place; and thence I pushed about one 140-inch rod, by means of the other, so as to measure the length up to the Western end. To measure along the W. side is impossible, without clearing away a large quantity of stones; and as there is no place to stack them safely without their going down the shaft, I could only measure the width at 100 from the W. end, perhaps somewhat askew. The lower--eastern--part of the floor, 140 below the roof, which is cotnparatively flat, is, nevertheless, very irregular and roughly trenched, quite unfinished. The best worked floor surface is just around the square shaft, 198 below the roof, and about 40 below the main part of the floor, which is 155 below roof on a knob of rock beside the shaft. The square shaft is not parallel to the chamber, but is placed nearly diagonally.*

* Like the shaft of the tomb chamber of Ti at Sakkara; an unusual plan.

Its distances to the walls are, N.W. corner 135 to N. wall ; N.E. corner 6o to E. wall ; S.E. corner 90 to S. wall. Its sides are, N.E. 68 to 75? S.E. 82½ ; S.W. 80; N.W. 70 above, 79 below (the N. corner being rounded above); N. to S. diagonal 100. The S.E. and S.W. sides stop at 67 deep, or 265 below roof, or 1,321 under pavement ; leaving a ledge about 20 inches wide, a second or deeper part of the shaft goes downwards, the N.E. and N.W. sides being continuous with those of the upper part ; it is, in fact, a smaller shaft descending out of the N. corner of the larger. The sides of the smaller shaft are, N.E. 57? S.E. 53? S.W. 60, N.W. 56. The original depth of the smaller shaft I could not see, it was apparently about 40 inches according to Vyse, when Perring sunk his round shaft down in the bottom of the ancient square shaft. This hole in the dimly-lighted chamber, about 30 feet deep (with water in it after heavy rains have rushed down the entrance passage), and with a very irregular and wide opening, makes

measurement about here somewhat unpleasant. I avoided filling the shaft with the earth removed from the passage, or with the stones which Perring excavated from it, in case anyone should afterwards wish to excavate farther at the bottom. The southern passage is very rough, apparently merely a first drift-way, only just large enough to work in, intended to be afterwards enlarged, and smoothed; its sides wind 6 or 8 inches in and out.

38. The Ascending passage from the entrance passage is somewhat troublesome to measure, owing to the large plugs of granite that fill some 15 feet of its lower part; and also to the irregular way in which much of its floor is broken up.

For connecting it with the entrance passage, we must first settle the most probable value of its angle, in order to carry on the projection of its floor; and to complete it over the plugging and breakage, which prevent direct measure- ment. The angle of the whole passage will be discussed further on ; it will suffice to say here that the mean angle is 26º 2' 30"; and there is therefore a presumption that the plugged part is about the same angle, and not the 26½ º of the entrance passage. This is confirmed by direct plumb-line measure of the angle of the plug-blocks at their lower end, giving 26º 7' (± 2'?); and noting that the end is square with the portion of passage beyond it to within 5'. Also the actual angle of the plug-blocks may be computed from Prof. Smyth's sloping measures, combined with my levelling between the floors of the passages, and plumbing up to the lower end of the plugs.*

* The elements in question are (1) Prof Smyth's plumb-line 48.5 on slope below his zero in Ascending passage ; and (2) 180.5 on slope of entrance passage, below beginning of Ascending roof. (3) My level in A. P., 71.3 on slope above C.P.S.'s zero in A.P. (4) My level in E.P. 1015.0 on slope below C.P.S.'s E.P. zero. (5) Difference of my A.P. and E.P. level marks 156.2 vertically. (6) My plumb-line on E.P. floor 1027.3 on slope below C.P.S.'s E.P. zero. (7) Height on my plumb to floor of A.P. 37.0. (8) height of plug-blocks 47.3, and angle of end 26º 7', (9) Angle of E.P. at junction 26º 21'. From these measures we get 125.1 tan. θ +142.9 sin. θ = 124.7 ; ∴ θ = 26º 12½'

This gives 26º 12½' for the angle of the lower 300 inches of the passage; and 5' of variation would require a difference of .4 inch vertical on .9 sloping. Hence the other data confirm this so far, that it had better be adopted as the angle through the plugged part; until some one shall improve on Prof. Smyth's sloping measure, or on my levelling.

The junction of the passages was not projected over the broken part un- certainly, as had been done before; but a plumb-line was hung from the W. side of the Ascending passage roof, in front of the plug-blocks; and measures vertical, perpendicular, and sloping, were taken to the plugs, the fragments of the ascending, and the top and bottom of the entrance passage. Thus the whole was knit together to a true vertical line, the place of which was fixed on the entrance floor. From the mean of these measures, and 26º 12½ ' as the ascending angle, with 26º 21' as the descending angle at that spot (by Prof Smyth), the Ascending passage roof starts vertically over 1110.90 on the sloping floor of the entrance, reckoning from the casing face; and the floor cuts the entrance floor at 1110.64 from the same, both probably ±.1.

Further, the lower end of the plug-block is 74.19 from the intersection of the floors; and the upper end 50.76 from the intersection of the roofs. Having thus fixed the beginning of the Ascending passage, by the point where its floor produced onwards intersects the floor of the entrance passage, we can proceed up the Ascending passage from this as a starting point. The distance past the plug-blocks being determined as above described, and that from the plug-blocks to the S. end of the passage, by steel tape measure on the E. side of the floor; then, the tape being corrected for temperature and tension, the results are thus, on the sloping floor :--

		Floor, E. side.	Base of E. wall.
Junction of passage floors		0	0
Beginning of actual floor		59.8	
Base of plug-blocks		74.2	
Top of plug-blocks, present		252.7	
Top of plug-blocks, ancient		277?	
Joint numbers.			
Smyth's.	Dixon's.		
1	27	298.2	298.2
(Petrie's levelling mark		324.0	
2	26	about 333.6	333.6
	25		374.9
6	23	496.6	496.6
7	22	552.3	552.3
	21		593.3
8		604.4	
	20		637.9
	19		690.3
10	18	716.3	716.1
11	17	749.0	748.9
12		799.1	
	16		812.1
	14		848.1
13		854.2	
15	13	922.4	922.2
16	12	955.0	955.3
	11		1006.9
17		1008.0	
	10		1044.9
19		1080.3	
	9		1095.0
20	8	1130.0	1129.9
21	7	1161.5	1161.5
22		1202.4	
	6		1214.2
23		1255.4	
	5		1273.2
25	4	1337.9	1337.9
26		1368.6	
	3		1377.7
27		1427.1	
28		1488.7	
	2		1515.5
Gallery, plumb from wall over door		1546.5	
29 Floor joint		1546.8	
Wall joint and edge over door	1		1547.0

On comparing these measures with Prof. Smyth's, it will be seen that he makes the passage about 3 inches shorter; and that this difference mainly occurs in the lower part, where the floor is much broken. Several lengths were therefore measured as tests, just as in the entrance passage, and the results are :--

	1st measure by tape.	2nd measure by tape.	Prof. Smyth, by one rod.
Mark (1) to mark (2)	50.0	50.1	
Mark (1) to 22 (Dixon)	56.3	56.3	
22 Dixon to 21 Dixon	40.9] 52.1	41.0] 52.1	49.7
21 Dixon to 8 Smyth	11.2]	11.1]	
8 Smyth to 20 Dixon	33.3	33.5	
20 Dixon to mark (3)	8.3	8.2	
		by rods	
11 Smyth to 12 Smyth	50.1	50.2	50.2
12 Smyth to 16 Dixon	13.0]	13.3]	55.3
16 Dixon to 14 Dixon	36.1] 55.1	36.1] 55.1	
14 Dixon to 13 Smyth	6.1]	5.7]	67.7
13 Smyth to 15 Smyth	68.2	68.4	

The close agreement of these two series of measures, particularly in those parts twice measured by tape, will show (as in the entrance passage) that the error is certainly in the rod measures, and due to the same causes as the error in the entrance passage, i.e., slipping, irregular placing on broken floor, and the marking off of each length.

The result therefore is that from the intersections of entrance and ascending passage floors, to the floor joint at the E. side of the grand gallery doorway, is 1546.8 on the slope.*

* On the W. side this joint is 1.2 N. of the side joint of doorway.

The granite plugs are kept back from slipping down by the narrowing of the lower end of the passage, to which contraction they fit. Thus at the lower, or N. end, the plug is but 38.2 wide in place of 41.6 at the upper end: the height, however, is unaltered, being at lower end 47.30 E., 47.15 mid, 47.26 W.; and at upper, or S. end 47.3. In the trial passages the breadth is contracted from 41.6 to 38.0 and 37.5 like this, but the height is also contracted there from 47.3 to 42.3. These plug-blocks are cut out of boulder stones of red granite, and have not the faces cut sufficiently to remove the rounded outer surfaces at the corners: also the faces next each other are never very flat, being wavy about ±.3. These particulars I was able to see, by putting my head in between the rounded edges of the 2nd and 3rd blocks from the top, which are not in contact; the 2nd having jammed tight 4 inches above the 3rd. The present top one is not the original end; it is roughly broken, and there is a bit of granite still cemented to the floor some way farther South of it. From appearances there I estimated that originally the plug was 24 inches beyond its present end.

It has been a favourite idea with some, that two horizontal joints in the passage roof just south of the plugs, were the beginning of a concealed passage: I therefore carefully examined them. They are 60.5 (or 60.1 second measure) apart vertically, and therefore quite different to the passages of the Pyramid, which are 47 perpendicularly or 52 vertically. Further, there is no possibility of the blocking up of a passage existing there; as the stone of the roof is continuous, all in one with the sides ; the three roof-blocks between the two horizontal joints are all girdle-blocks, either wholly round the passage, or partially so; and the block N. of these is a long one, over 125 inches from E. to W., and continuous into both walls. These vertical girdle-blocks are a most curious feature of this passage (first observed and measured by Mr. Waynman Dixon, C.E.), and occur at intervals of io cubits (206.3 to 208.9 inches) in the passage measuring along the slope. All the stones that can be examined round the plugs are partial girdle-blocks, evidently to prevent the plugs forcing the masonry apart, by being wedged into the contracted passage. Many of the stones about the blocks in Mamun's Hole are over 10 or 11 feet long; the ends are invisible, but probably they are about 15 feet over all.

Interior passageways and chambers ... sectional views

39. For the angle of the passage, and its straightness, it will be well to consider it all in one with the gallery floor, as they were gauged together all in one length. The angle of slope I did not observe, as I considered that that had been settled by Prof Smyth; but the azimuth was observed, by a chain of three theodolites, round from the entrance passage. The straightness was observed by offsets to floor and side all along it, read from a telescope at the upper end of the plug-blocks. When I came to plot the results, I found that there were no measures taken at the point where Prof. Smyth's theodolite was set up. The sloping floor is nowhere, having been entirely cut away at the beginning of the gallery; and the top of the ramp (to which the theodolite had been referred) was not offsetted by me, nor was its slope measured by Prof Smyth's clinometer for 300 inches from the place. Hence we cannot say exactly what direct relation the theodolite bore to the passage; but we can obtain the angle of slope very satisfactorily, by taking the angles observed to signal at bottom of ascending passage, and to signal at top of gallery, and then (knowing the distauces of these signals) calculate the angle of slope from signal to signal. This, when corrected for lower signal being 3 too high, gives **26º 12' 50"** for mean angle of both passage and gallery together. Hence, from my offsets to the places of these signals, the absolute angle, and the variations from it, can be obtained for either part independently. Thus we have the form and direction of the ascending passage, reckoning from the beginning of its floor on the entrance passage floor, with its variations, as follows :--

From beginning	**From – 4' ± 3' azimuth**			From **26º 2' 30"** altitude		
	W.	**mid.**	**E.**	**roof.**	**mid.**	**E. floor.**
69				23.1	– .5	24.1
260	20.8	0	20.7	23.6	0	23.6
520			21.6			23.5
650			20.9			22.4
700			20.7			
840			21.4			23.3
1045			21.3			23.7
1220			21.9			24.1
1365			21.2			23.9
1540	21.0	0	21.1	23.9	+ .1	23.6

The surfaces are so much decayed and exfoliated, that it is only just at the ends that two original faces can be found opposite to one another; hence the width and height cannot be measured, and the offsets can only be stated to one surface.

From this altitude, the sloping length of the passage being 1546.8, the horizontal length will be 1389.5, and the vertical height 679.7, both being corrected for difference in the offsets of the ends. The determination of the azimuth has, unhappily, a large probable error, ± 3' (owing to bad foundation for the theodolite in Mamun's Hole); and its direction, -- 4', is so close to that of the Pyramid side, that it may be assumed parallel to that ± 3'. This, on the passage length, = 1.2 inches for the probable error of the place of the upper end of the passage, in E. to W. direction in the Pyramid.

These, added to previous amounts, give for the absolute place of the floor end at the latitude of the E. wall of the gallery (172.9 + 679.7) = 852.6 ± .3 level above pavement; (1517.8 + I389.5) = 2907.3 ± .6 horizontally from N. edge of Pyramid, or 1626.8 ± .8 northwards from centre; and 287 ± 1.5 for middle of passage eastward from centre of Pyramid.

40. The horizontal passage leading to the Queen's Chamber is the next part to be considered. This was measured with steel tape all along, and the levels of it taken with theodolite. The results for its length and levels are thus, reckoning from the mean door of the gallery at 1546.8 from beginning of ascending passage :--

	Distance from Doorway	Northward from Pyramid centre	Floor level	∴ Roof level
Mean doorway on floor	0	1626.8 ± .8	852.6 ± .3	
On flat floor	52	1575 ± .8	858.4 ± .3	
Floor joint, No. 8, Smyth	312.0	1314.8 ± .8	857.4 ± .3	903.8
Floor joint, No. 16,	623.0	1003.8 ± .8	856.1 ± .3	902.3
Floor joint, No. 21,	870.2	756.6 ± .8		
On floor	1000	627 ± .8	856.2 ± .3	902.4
Floor joint, No.25, Smyth	1177.7	449.1 ± .8		
Step in floor	1307.0	319.8 ± .8	854.6 ± .3	901.0
			834.9 ± .3	
Chamber N. wall, top of door	1523.9	102.9 ± .8		
Chamber N. wall, side of door	1524.8	102.0 ± .8		
Floor joint, No.30, Smyth	1527.0	99.8 ± .8		
Niche, N. side	1620.7	6.1 ± .8	834.4 ± .3	
Niche, first lapping				901.3
Chamber, E. apex	1626.5	.3 ± .8		1080.1

The azimuth of this passage was not measured, but the beginning of it is 287 ± 1.5 E. of the middle of the Pyramid ; then for the axis of it at the end we may say the same, or 287 ± 3, since the gallery above it only differs about two inches from that quantity. In the above measures of length there is a steadily accumulating difference of about 1 in 300 between Prof. Smyth's measures and these, for which it seems difficult to account; but as in the other passages, I have always found on retesting the measures, that such differences are due to errors in the cumulative single rod measures, and not in my steel tape (which was always verified at the starting point after measuring), it seems unlikely that the steel tape should be in error here. Hence I should adopt these measures without alteration.

41. In the Queen's Chamber it seems, from the foregoing statement, that the ridge of the roof is exactly in tbe mid-place of the Pyramid, equidistant from N. and S. sides; it only varies from this plane by a less amount than the probable error of the determination. x

The size of the chamber (after allowing suitably in each part for the incrus-tation of salt) is on an average 205.85 wide, and 226.47 long, 184.47 high on N. and S. walls, and 245.1 high to the top of the roof ridge on E. and W. walls. The variations of the horizontal quantities in detail are as follows, from the mean dimensions.

Above Floor	From below Apex, E. Wall.			From below Apex, W. Wall.			Below Ridge of Roof.		
	To N. Wall.	(sum)	To S. Wall.	To S. Wall.	(sum)	To N. Wall.	W.Wall.	to	E.Wall.
Mean of All	102.92	205.68	102.76	102.67	206.02	103.35		226.47	
240							– .46	225.51	– .50
210							– .31	225.79	– .37
180	+ .16	205.67	– .17	– .14	broken		– .24	226.12	– .11
156	+ .06	205.60	– .14						
127	+ .10	205.72	– .06	– .16	206.15	+ .29	0	226.37	– .10
99	+ .02	205.79	+ .09						
76				– .09	205.68	– .25	+ .24		
67	– .32	205.63	+ .27				+ .27	226.91	+ .17
8				+ .37	206.29	– .06			
0							+ .45	227.47	+ .55

For example, to take the first entries, at 180 inches over the floor, on the E. wall, the N. wall is (102.92 + .16) = 103.08 from a vertical line below the apex of the roof; and the S. wall is (102.76 --.17) = 102.59 from the same apex line : the sum of these quantities, or the total width, being 205.67. Thus the mean distances of the N. and S. walls from the apex on the E. and W. walls is given at the top of each column ; and beneath that the small variations from those mean vertical wall faces. In the last division are given the distances of the E. and W. walls apart, below their apices ; both the mean dimension, the variations from it, and the total at each point. It will be observed that the E. and W. walls have both a uniform tilt inwards; if we allow 14' for this as an average, the mean from a straight line inclined that amount is .057 on E. and .025 on W. ; a remarkably small amount of error, comparable to the extremely fine work and close joints of the stones themselves. Also the ridge of the roof is not exactly over the middle of the

chamber at either end. Beside the above resulting length of the middle of the chamber on the floor, separate measures were taken on the two walls; these give N. 227.41, middle (from above) 227.47, S. 227.61 ; mean of all 227.50 for floor length.

42. In the matter of height, the courses vary a good deal ; and far more care was spent on the closeness, than on the regularity of the joints. For a starting point in measurement, the general floor is hopelessly irregular, consisting plainly of rough core masonry; and furthermore, it has been built over with similar rough masonry, which was afterwards stripped down to insert the chamber walls. This is proved by there being no fewer than eight edges of sunken spaces upon it, made (according to the universal habit of pyramid builders) to let in the inequalities of the upper course into the surface of the course below it. These sunken edges are well seen in other parts of the core masonry, and their meaning here is unequivocal. But all round the chamber, and the lower part of the passage leading to it, is a footing of fine stone, at the rough floor level; this projects I to 4 inches from the base of the walls, apparently as if intended as a support for flooring blocks, which have never been introduced. It is to this footing or ledge that we must refer as the starting point; though what floor was ever intended to have been inserted (like the floor of the King's Chamber, which is inserted between its walls) we cannot now say. Certainly, a floor at the level of the higher part of the passage, would not reconcile everything ; as that higher floor is also not a finished surface, but has sundry large round holes in it, like those in the chamber floor and elsewhere; intended, apparently, for use in process of building. Starting, however, from this footing at the base of the walls, the mean elevation of each course above the floor is as follows, with the variation + or - from the mean scale, at eleven points around the chamber :--

Mean of Corners	N.W. Corner			N.E. Corner			E. Side	Niche	S.E. Corner			S.W. Corner			W. Side
	W.		N.	N.		E.	Mid		E.		S.	S		W.	Mid
245.1							N.+1.0								S. -.5
214.35							S. -.1								N. -.6
184.47		- .37			- .18		+ 2.05								- 2.05
179.09	+ .67					- .73	- .47	- .47	- .39	- .01			+ .55	+ .45	- .67
156.07	+ .23		- .05	+ .67		- .09	+ .33	+ .29	+ .01		- .35	- .49		- .01	- .17
127.13	- .23		- .11	- .03		+ .12	+ .17	+ .28	+ .50		+ .31	- .41		- .20	- .33
99.13	+ .01		- .17	- .13		+ .05	- .03	+ .05	+ .32		- .11	- .09		+ .08	- .13
67.44	+ .28		+ .06	- .23		0	+ .09	- .12	+ .06		- .22	- .05		+ .09	- .05
34.13	+ .01		- .24	door		0	+ .17	- .01	+ .22		+ .02	+ 3.08		+ 3.38	- .19
0		- .18			+ .20		- .2	+ .42							- .26

The mean course thicknesses, and their mean differences being-from the base upwards-thus : - 34.13 m.d. '19, 33.31 m.d. .18, 31.69 m.d. .14, 28.00 m.d. .21, 28.94 m.d. .27, 28.40 m.d. .48 to top of N. and S. walls. In the first column above, 245'1 is the apex of the E. and W. walls, where the sloping roof stones end at their junction; and the differences entered here, N. and S., are due to the N. and S. slabs not ending at the same level, one having fallen a little below the other in building; the highest shows, therefore, probably the intended point, and this is 1080.1 above the pavement. 214.35, in the first column, refers to the topmost joint on the E. and W. walls. 184.47 is the top of the N. and S. walls, and a joint on the E. and W. walls. 179.09 is a joint that occurs at each side of the E. and W. walls, but which does not run far, being soon shifted upward to the 184 level. 156.07, 127.13, 99.13, are all joint levels around the chamber. 67.44 is a joint level, signalized by the top of the doorway and of the channel mouths in N. and S. walls. 34.13 is a course around the chamber. And 0 is the fine stone footing of the walls, which is about the level of the variable and rough floor of the chamber. It must be remcmbered that the above figures only give differences from a mean scale, and do not profess to be levels; the columns, in fact, being only rigidly connected at the two sides of any one corner, which hence have no dividing line between them in the table. Assuming, however, that the above series of heights of E. and W. walls are pretty closely adjusted to the heights in the corners next to each, we have for the sloping roof block, the following figures, calculating from the above quantities :--

	E. end, N. side.	W. end, N. side.	E. end, S. side.	W. end, S. side.
Sloping length	120.00	119.96	119.12	118.59
Angle	30º 48'	30º 14'	30º 33'	30º 10'

These roof blocks are seen-where Howard Vyse excavated beneath one at the N.W. corner-to go back 121.6 on slope, behind the wall face; this, coupled with the thickness of these blocks (which is certain, by similar examples elsewhere, to be considerable) throws the centre of gravity of each of the slabs well behind the wall face,* so that they could be placed in position without pressing one on another. Hence there is never any arch thrust so long as the blocks are intact ; they act solely as cantilevers, with the capability of yielding arched support in case they should be broken.

* As at Sakkara, in the Pyramid of Pepi.

The projection on the western side of the doorway, mentioned by Professor Smyth, is really a surplus left on both sides of the corner ; in order to protect the stone in transit and in course of building. This undressed part in the chamber, is cut away down to the true

surface at the top and at the middle joint, in order to show the workman exactly to where it needed to be dressed in finishing it off; The excess in the chamber begins 1.3 below joint at top of doorway, and thence projects 1.4, with a width of 5.5; it is dressed away for 1'05 at the middle joint, and then continues sloping away rather thinner down to the floor. The projection into the passage is 1'5 maximum at base, usually .8 ; and it is 5.5 maximum width,or usually 4.5.

43. The niche in the eastern wall of this chamber, from its supposed connection with a standard of measure, was very closely examined. Its original depth back was certainly only 41 inches at every part from the bottom upwards. The surface that might be supposed to belong to the side of a deeper part, is only that of a joint of masonry, one stone of which has been broken up and removed; this is evident as there is mortar sticking to it, and as it is pick-dressed, quite different to the fine surfaces of the niche sides ; beside this, it is not flush with the side, or any of the overlappings of the niche; and moreover, all down the niche sides are the traces of the edge of the back, at 41 from the front, where it has been broken away.

The general form of the niche was a recess 41 inches (2 cubits) deep back 62 inches (3 cubits) wide at base, and diminishing its width by four successive overlappings of the sides (at each wall course), each of ¼ cubit wide, until at 156 high it was only 20 (1cubit) wide, and was finally roofed across at 184 high. Thus, of the 3 cubits width of the base, one cubit was absorbed on each side by the overlappings, leaving one cubit width at the top. This cubit is the regular cubit of 20.6 inches, and there is no evidence of a cubit of 25 inches here. The exact dimensions of every part are as follow, giving the mean dimensions, and the variations of each part, + or --, from the mean. All corrected for the salt exudation on the two lower laps, as estimated at each point; there is no salt on the upper three laps :--

44. The channels leading from this chamber were measured by the goniometer already described (A, section 10); they are exactly like the air channels in the King's Chamber in their appearance, but were covered over the mouth by a plate of stone, left not cut through in the chamber wall; no outer end has yet been found for either of them, though searched for by Mr. Waynman Dixon, C.E., who first discovered them, and also by myself on the N. face of the Pyramid.

The N. channel is 8.6 high, and about 8 wide in the chamber wall, running horizontally for 76 inches, and then turning upwards. The S. channel is 8.8 high, and runs 80.0 to its turn upwards. The mean angles, measured between the horizontal part and the ascending slope of the channels, are thus :--

N. Channel				S. Channel			
W.	Mid.	E.	Mean	W.	Mid.	E.	Mean
37º 33'	37º 25'	37º 25'	37º 28'	38º 28'	38º 20'	38º 35'	38º 28'

each statement being the mean of two observations, which never differed more than 6'. Hence, if these channels were continued to the outside of the Pyramid, their floors would end on the Pyramid faces at 2641.3 above the base, and 2460.8 from the centre of the Pyramid on the N. face; and at 2679.1 above the base, and 2431.2 from the centre on the S. face. I observed something like the mouth of a hole in the 85th course on the S. face, scanning it with a telescope from below; but I was hindered from examining it closely.

Interior passageways and chambers ... sectional views

45. Returning now to the gallery from which we diverged to the Queen's Chamber, the length of the gallery was measured like the other passages, with the steel tape, but not many joints were measured, and those were on the E. ramp, on which the tape was laid at 6 inches from the edge. The offsets to the floor and E. ramp were also read, in continuation of the series of the ascending passage, as explained before (section 39). The results are as follow, starting from the N. wall of the gallery, at 1546.8 from beginning of ascending passage.

	Distance on slope	Variations from mean axis of +1'20" azimuth			Variations from mean axis of **26° 16'40"** altitude	
		W.	Mid.	E.	Ramp top	Floor
N. wall	0	...	...	...	{1.6	22.3}
At	30	20.9	.1 E.	21.2	...	...
First joint, vertical	44.6	...	...	...	...	...
At	150	20.7	.2 W.	20.3	...	...
Joint at "cut off" vertical	223.2	...	...	...	...	...
Face of "cut off"	223.7	...	...	...	...	...
Second "cut off"	263.8	...	...	...	...	...
Joint	264.1	20.9	0	20.9	2.0	22.9
At	400	21.0	.2 E.	21.4	2.3	23.1
At	700	20.8	.4 E.	21.6	2.6	23.6
Joint	912.4	...	...	...	...	...
At	1000	21.1	0	21.0	1.5	23.4
Joint, broken to next	1087.0	...	...	...	...	...
Joint	1186.5	...	...	...	...	...
At	1300	21.5	.3 W.	20.8	2.3	23.3
Joint	1454.6	...	...	...	...	...
At	1600	21.2	.1 E.	21.4	2.1	22.2
Ramp end	1815.5	21.3	0	21.2	1.8	22.1
S. wall, in same line	1883.6	...	...	...	...	...

In the variations in altitude, the height of the axis above the ramp top is stated, as well as its height over the floor. The axis, though different in azimuth and altitude from that of the ascending passage, is reckoned to start from the end of it; hence the offsets are a continuous series, though measured from a line which is bent on passing from the passage to the gallery. The first-stated floor offset here (in brackets) is not what the continuation of the floor of the ascending passage actually is at the point; but it is the virtual floor of the gallery, i.e., where it would come if the trend of the rest of the gallery was continued, and also (judging by the altitude observations of Prof Smyth) where it would come if continued parallel to the ramp top.

By successive rod measures, Prof. Smyth made the gallery 8 shorter than it appears by this continuous measure; but the continuous measure is certainly better in principle and also in practice, as we have seen in the other passages. The steel tape of 1200 inches required to be shifted in order to measure from one end to the other of the gallery, and three points were common to both tape lengths ; the distances between these points were 305.5 by first, 305.6 by second measure, and 480.2 by both first and second measures, showing the same accuracy in this as in the taping of the other passages. The difference between Prof. Smyth's measures and the taping occurs almost entirely from the N. wall to the cut out in the floor, and is probably due to want of

straightness and squareness in one or other of those surfaces.

Hence the floor of the gallery intersects the S. wall at **1689.0 ± .5** above the pavement; at 61.7 ± .8 S. of the Pyramid centre; and its middle is 284.4 ± 2.8 E. of the Pyramid centre; reckoning the measures of length and angle continuously through from the plug-blocks upwards, so as to avoid all un-certainties of connection at the beginning of the gallery, and duly correcting for difference in offsets.

46. The holes cut in the ramps or benches, along the sides of the gallery (see section of them in P1. ix.), the blocks inserted in the wall over each, and the rough chopping out of a groove across each block-all these features are as yet inexplicable. One remarkable point is that the holes are alternately long and short, on both sides of the gallery; the mean of the long holes is 23.32, with an average variation of .73, and the mean of the short holes is 20.51, with average variation .40. Thus the horizontal length of a long hole is equal to the sloping length of a short hole, both being one cubit. This relation is true within less than half their average variations.

The roof of the gallery and its walls are not well known, owing to the difficulty of reaching them. By means of ladders, that I made jointing together, I was able to thoroughly examine both ends and parts of the sides of the gallery. The roof stones are set each at a steeper slope than the passage, in order that the lower edge of each stone should hitch like a paul into a ratchet-cut in the top of the walls; hence no stone can press on the one below it, so as to cause a cumulative pressure all down the roof; and each stone is separately upheld by the side walls across which it lies. The depth of two of these ratchet-cuts, at the S. end, I measured as 1.0 and 1.9 to 2.0; and the angles of the two slabs there 28º 0' to 28º 18', and 27º 56' to 28º 30', mean 28º 11'; which on a mean slab 52.2 from N. to S., would differ 1.74 inches from the passage slope. The edge of the southernmost slab is 14.5 from the S. wall; the next slab is 47.4 from N. to S.

The verticality of the ends of the gallery was measured from a plumb-line; and bottom of each of the laps of stone and the horizontal distances of the top from the ends of the roof are thus:--

Laps		N. End		Lean out	S. End	Lean in	High on S. End	Lap on W. side
8		0 ?			0		33.6	
7	top	3.0			2.9			2.3
7				0		– .08	33.7	
7	base	3.0			2.8			
			h					
6	top	6.2			5.8			3.1
6				+ .2		0	33.0	
6	base	6.0			5.8			
			s					
5	top	9.1			9.00			3.0
5				+ .6		0	34.0	
5	base	8.5			9.00			
			h					
4	top	11.9			12.08			2.9
4				– .2		+ .10	33.8	
4	base	12.1			12.18			
			h					
3	top	15.1			15.08			
3				+ .1		+ .10		
3	base	15.0			15.18			
			s					
2	top	19.7			18.10			
2				+ .1		+ .45		
2	base	19.5			18.55			
1	top	19.6			21.5			
1				+ .4	21.7	– .25		
1	base	19.2			21.25			
				+ 1.2		+ .32		

The letters h and s in the column of the N. end show the under edge of the lap of stone to be either horizontal or sloping; on the S. end it is always horizontal. The width of the top of the gallery is 40.9 at N., and 41.3 at S. end. The remarkable groove in the lower part of the third lap,. along the whole length of the sides, was measured thus, perpendicularly :--

	N. W.	N. E.	S. W.	S. E.	mean
Groove upwards from lap edge	11.7	11.8	11.2	11.0	11.4
	to 5.4	5.7	5.1	5.1	– 6.1 5.3

At the S.W. it is cut to a depth of 8 inch, at the S.E. to .6 (?); the upper edge of it is often ill-defined and sloping. According to Prof. Smyth the mean height of this lap above the gallery floor is I66.2 ± .8 vertically; hence the groove is at 172.1 to 179.0 vertically over the floor, and its lower edge is there-fore at half the height of the gallery, that varying from 167 to 172. The pickmarks in the groove on the S. end of the W. side are horizontal, and not along the groove, showing that it was cut out after the walls were built, which agrees with its rough appearance. It belongs to the same curious class of rough alterations as the blocks inserted in the sides of the gallery and the rude grooves cut away across them.

At the top of the N. end is a large forced hole, cut by Vyse in 1837, and still quite fresh-looking. The whole of the top lap of stone is so entirely cut away there that I could not decide to where it had come, and only suppose it to project 3 inches, like the others.

From this the length of the roof of the gallery is 1688.9 -- 40.45 = 1648.4 horizontal, or 1838.6 sloping.

By plumb-line measure at the S. end, the roof on the E side is inside the floor edge (or overhangs) 20.50, and on the W. side 20.40. On the S. end (eliminating the lean) the projection is 20.9, and on N. 20.4; mean of all, 20.55, for the sum of the seven projections of the laps, or one cubit, the laps being then one palm each in breadth. Thus the laps overhang the ramps along the gallery sides, and the space between the ramps (2 cubits), is equal to the space between the walls at the top.

The remarkable shaft, or "well", that leads away from the lower end of the gallery down to the subterranean passage, was fully measured about its mouth but it appears to be so rough and so evidently utilitarian (for the exit of work- men) that it is not worth while to publish more complete measures than those of Prof. Smyth. As, however, the position of its mouth has been supposed to have a meaning, it should be stated that the opening is from 21.8 to 49.0 horizontally from N. wall of gallery on floor, 21.8 to 48.7 near its top, and 21.9 to 48.9 by the sloping distance reduced. Thus the middle of it is at 35.40, 35.25, or 35.37 by different methods. The part of the shaft that passes through a rock fissure filled with gravel (often called the "grotto") has been steined with 10 courses of small stones, varying from 7¼ to 8 inches in height.

At the upper end of the gallery, we have already stated the S. wall to be 61.7 ± .8 5. of the Pyramid centre; and hence the face of the great step at the head of the gallery (which descends behind both floor and ramps) is (61.7 -- 61.3) = .4 ± .8 S. of the Pyramid centre. It may, therefore, be taken as intended that the face of this step, and the transition from sloping to horizontal surfaces, signalizes the transit from the Northern to the Southern half of the Pyramid. This same mid-plane of the Pyramid being also signalized by the mid-plane of the Queen's Chamber, which is measured as .3 ± .8 N. of the Pyramid centre.

The ramps along the sides, where they join this great step, are very irregular. Their top surfaces slope away downwards toward the side walls; thus the E. ramp top varies from 13.20 to 12.18 below the step from E. to W., and the W. ramp top from 12.82 to 12.2 (?) from W. to E. At present, more-over, the ends of the ramps are parted away from the face of the step by .30 on E. and .44 on W., an amount which has been duly subtracted from my length measures of the gallery. Beside this, the top of the step itself, though, straight, is far from level, the W. side being about 1.0 higher than the E. side. And the sloping floor seems to be also out of level by an equal amount in the opposite direction ; since on the half width of the step (i.e., between the ramps) the height of the step face is 34.92 or 35.0 on E., and 35.80 or 35.85 on W. The length of the step from N. to S. is on E. side 61.0, and on W. 61.5. All these measurements are very carefully taken with elimination of wear, fractures, and shifting of the stones at the joints. Hence, at the line along which I measured, 6 inches from the edge of the ramp, the step will be 61.1 long; and this at the angle 26° 12' 50" (by which the end of the gallery was calculated from the plug-blocks) will be 30.08 vertically, for the virtual * above the actual floor end.

* The virtual floor end is where the general floor slope, if carried on through the step, would intersect the plane of the S. wall.

Then the top of the step will (by above measures) be here 34.88 above actual floor end, and the step dips about .64 to the S. wall at this part ; so the top of the step at the S. wall is 34.88 -- .64 -- 30.08 = 4.16 (say ± .2) above the virtual floor end at the line of taping. And as the virtual floor end is at 1689.0 ± .5, the step surface at the E. side of the S. doorway is 1693.2 ± .6 over the pavement.

47. The Antechamber and its passages were measured both by steel tape and rods, in one length, from the step to the King's Chamber; and the joints and floor levels are as follow :--

	Along Floor on E. side	Southwards from centre of Pyramid	Level over virtual end of Gallery ± .2	Level over pavement ± .6
Face of step	– 61.32	.4	4.7 E. 5.6 W.	1693.7 to 1694.6
S. wall of Gallery	0	61.7	4.2 E.	1693.2
N. end of Antechamber	52.02	113.7		
Joint, granite begins	64.90	126.6	3.6 and 3.9	1692.6 and 1692.9
Granite of wall begins	75.26	137.0		
Edge of wall begins	91.79	153.5		
Joint of floor	112.15	173.8	3.7 and 3.2	1692.7 and 1692.2
Edge of wall groove	113.58	175.2		
Edge of wall groove	119.26	181.0		

	Along floor on E. side	Southwards from centre of Pyramid	Level over virtual end of Gallery ± .2	Level over pavement ± .6
Joint of wall	134.17	195.9		
S. end of Antechamber	168.10	229.8		
Joint of floor	198.41	260.1	2.9 and 2.8	1691.9 and 1691.8
Base of King's ch. wall	268.9	330.6	– .5	1688.5
End of passage floor	269.04	330.7	3.0	1692.0
Raised floor, King's ch.	269.17	330.9	3.8	1692.8

These measures vary somewhat from those of Professor Smyth in 1865; and, comparing the greatest differences, they stand thus :--

	Steel tape 1882	Rods 1880	Rods 1865
N. end Antichamber to joint S. of it	12.88	12.88	13.6
Next joint to S. end of Antichamber	55.95	55.73 and 55.80	55.5

So here, as elsewhere, the measures in 1880 - 2 by steel tape and rods, entirely independent of each other, agree fairly together, and suggest that the 1865 rod measures were somewhat in error. This is due generally to the latter starting from different points on different occasions, and to their different series being insufficiently locked together. Hence I adopt the steel tape measures as the most satisfactory.

48. Taking the Antechamber alone, we may say that its dimensions above the granite wainscot of the sides, are as follow :--

	Length N. to S.				Breadth E. to W.			
Height above floor	**2 from W.**	**Middle**	**12 from E.**	**E. side**	**2 from N.**	**40 from N.**	**76 from N.**	**2 from S.**
147	116.85	116.22	116.05	115.65	64.80	64.48	64.96	64.76
129	117.00	116.18	116.03	115.37	64.72	64.98	65.26	65.25
114	117.00	116.11	115.73	114.07	65.06	65.00	65.48	65.21
95	116.55		115.91					
70	116.58		115.93					
45	115.91		116.12					

Diagonals N.W to S.E [133.15 at 2 from ceiling. 133.14
133.07 over wainscot. 132.98] N.E to S.W.

The height was measured as follows :--

	Near N. wall	14 from North	59 from North	61 from North	S. wall
At E. side	149.47	149.09	149.17	149.62	149.63
Middle	149.53			149.64	149.64
At W. side	149.32	149.01	149.10	149.65	149.57
Mean	149.44	149.05	149.13	149.64	149.61
Above gallery end	153.04	152.95	152.83	152.84	152.61

The mean length is thus 116.30 (by the two series from top to base), breadth 65.00, and height 149.35 ; or the ceiling over the virtual end of the gallery floor, 152.85 ± .2, and 1841.8 ± .6 over the pavement.

49. Coming now to details of the walls, the rough and course workmanship is astonishing, in comparison with the exquisite masonry of the casing and entrance of the Pyramid; and the main object in giving the following details is to show how badly pyramid masons could work. The great variation in the foregoing measures illustrates this. The N. wall is all rough picked work, with 2 variation commonly; there is a great irregular flaw, and a piece broken out of the stone about the level of the top of the leaf, as much as 1 inch deep. The E. wall has the granite by the side of the leaf wavy and winding, and bulbous at the base, projecting 1.4. On the wainscot block at the S. end of this wall, which is all in one with the S. end of the chamber, are two conjoined deep scores or scrapes nearly vertical, much like the beginning of a regular groove; their distance from the S. wall is 3.6 to 7.2 at 90, and 2.6 to 6.4 at 52 from floor, where they end; they are .48 deep at maximum. The S. wall has all up the E. side of it, over the wainscot, a projection, just equal in width to the wainscot, and varying in thickness from .31 at top to 1.7 half-way down, and thence fading off down to the top of the wainscot. On the W. side of the S. wall the granite has been daubed over for 2 to 6 inches in breadth, with a thin coat of cement; this, at 1 inch from the side is .35 thick ; also at 13 from the W. side is a slight sinking of the granite, from .34 to .60 in depth, all quite ill-defined. The W. wall has the top of the granite wainscot uneven, rising toward the front, and there sinking suddenly .35 at 1.4 from the front edge. The southern of the three semicircular hollows on the top of this wainscot (see P1. xii.)* has the granite defective at the back of it, and is backed with rough limestone there.

* The forms of the curves are plotted from offsets taken at every inch along them.

The southernmost stone over the wainscot is dressed very flat and true, but rough, + or -- .03. The next block has a raised edge to it on the S. side (figured by Prof. Smyth), and along the base of it, which consists of granite left rough, not dressed away in finishing; about 4 inches wide, and .4 projection along the lower edge of the block; and 2 wide and 1.2 maximum projection at the side. The other edges of this block were marked out by saw-cuts in the granite, about .2 deep, to guide the workmen in dressing the face.

The various courses and stones of the chamber were measured, but,the only points of interest are the following.

The south wall has four vertical grooves all up it, which have been hitherto supposed to have extended down to the top of the passage to the King's Chamber. This was not the case, however; for, though much broken away, it is still clear that they became

shallower as they neared the bottom, and probably ended leaving an unbroken flat surface over the doorway. Their depths (as well as the forms of their sides) show this, as follows :--

Height above door	E. groove	2nd	3rd	W. groove
at 10 at 7 at 5	2.8 2.5 1.75	much broken	slight curve	2.8 at 8 2.5 at 7 2.0 at 5½

50. The granite leaf which stretches across the chamber, resting in grooves cut in the granite wainscots, must be somewhat less in width than the breadth between the grooves, i.e., 48.46 to 48.76. Its other dimensions were carefully ascertained, as much theoretic importance had been attached to them ; though to anyone looking at the object itself, the roughness and irregularity of it would put any accuracy of workmanship out of the question. The thickness of the two stones that form it was gauged by means of plumb-lines at 33 points; it varies from 15.16 to 16.20, but the details are scarcely worth printing. This leaf is not simply a flat slab of granite, but on both its upper and lower parts it has a projection on its N. side, about 1 inch thick, where it is included in the side grooves. The edge of this projection down the W. side has been marked out by a saw cut; and the whole of the granite on the inner side of this cut has been dressed away all over the face of the leaf, leaving only one patch or boss of the original surface of the block.

This boss, of which so much has been made by theorists, is merely a very rough projection, like innumerable others that may be seen ; left originally for the purpose of lifting the blocks. When a building was finished these bosses were knocked away (I picked up a loose one among waste heaps at Gizeh) and the part was dressed down and polished like the rest of the stone. It is only in unimportant parts that they are left entire. This boss on the leaf is very ill-defined, being anything between 4.7 and 5.2 wide, and between 3.3 and 3.5 high on its outer face ; at its junction with the block it is still less defined, and might be reckoned anything between 7.2 and 8.2 wide, and 5.6 to 6.6 high. It projects .94 to 1.10 from the block, according to the irregularities of the rough hammer-dressing. Anything more absurdly unsuited for a standard of measure it would be difficult to conceive. I write these remarks with a sharp plaster cast of it before me that I took in 1881. Traces of another boss remain on the W. wall of the Antechamber, above the wainscot; here there has been a boss 12 inches wide and 9 high, which has been knocked away, and the surface rough dressed, though the rest of the face of the stone is ground down elsewhere. The block has been turned in building, so that the flat under-edge of the boss is toward the N. Remains of another boss may be seen on a block in the passage to the King's Chamber; remains of 15 or 16 others in the King's Chamber; 5 others complete in the spaces above that ; and many on the casing of the Third Pyramid and elsewhere (see P1. xii.). The E. to W. breadth of the leaf between its side ledges in the grooves, varies from 40.6 to 41.2 at different heights up the middles of the ledges; but furthermore, the edges are not square, and we may say that 40 to 42 will about represent its irregularity. Yet this was another so-called "standard of measure" of the theorists. The top of the upper block of the leaf is a mere natural surface of the granite boulder out of which it was cut, utterly rough and irregular; and not materially broken away as it dips down deeply into the grooves, and is there plastered over. It varies from 51.24 to 59.0, and perhaps more, below the ceiling. Yet the cubic volume of this block was eagerly worked out by the theorists.

51. The King's Chamber was more completely measured than any other part of the Pyramid ; the distances of the walls apart, their verticality in each corner, the course heights, and the levels were completely observed ; and the results are given in Plate xiii., in which all variations from the mean amounts are shown on their actual size. The principle of concentrated errors enables the eye to grasp at once the character of the variations in workmanship, in a way that no table of figures could show it.

For example, the N. wall is on an average 412.59 inches long (see bottom of P1. xiii.); but the "face of West end" (see left hand of plate) is at the top .18 outside the mean vertical line, and the "face of East end" is .42 inside the mean vertical ; hence at the top the length is actually (.42 - .18) shorter than the mean, i.e., it is 412.35. The line of the ceiling on the W. edge of the N. wall will be seen to be .18 over the mean level of the course, marked "5" at each side of the sheet; and the ceiling line at the E. edge is as much as 1.00 over the same mean level; hence the ceiling slopes .82 on its length along the N. side. Referring now to the floor or to the 1st course, where the mean levels are marked by continuous straight lines all across the diagram, it will be seen how far the variable lines of the "Actual First course" or "Actual Floor" fluctuate up and down, in relation to their mean level; the first course, beginning at the N.W., is at .23 over its mean level (marked 1 at the edge), and runs upward until it is 1.03 over its mean level at the N.E., then down to below mean level at the S.E., then still further down along the S. wall, turning a little up to the S.W. corner, and then rapidly rising to above its mean level again at the N.W. corner, whence we started. Only the first course and floor were directly levelled all round; the upper courses were connected by vertical measures in each corner, hence their fluctuations along the sides were not measured, and they are only marked by broken lines. On looking down, say, the "Face of the West-end" from joint 5 to 4, it is seen that the line bends out, showing the stone to be slightly hollowed ;* but on the average it is about square with the course line; and any error seen in squareness of angle in the diagram, represents only 1/50 of the actual angular error, or 5º equals 6'.

* The middle of the course was only thus offsetted on the top course; the other courses were read on at the top and base of each, to give their errors of cutting and of placing.

Then, below that, it is seen that the line from joint 4 to 3 begins very slightly outside the line from joint 5 to 4; showing that the stone of the 4th course is set back by that amount, owing to error in placing it. Similarly the squareness of faces, and truth of setting of the stones, is shown for all the other courses in each corner. In fact, a paper model, showing all the errors on the actual scale, might be made by cutting out four sides, following the outlines of the faces of the walls as here marked, and bending each side to make it fit to the irregular edge of its adjacent side.

This diagram will represent with quite sufficient accuracy, without numerical tables, the small errors of this chamber; especially as it must be remembered that this shows its actual state, and not precisely its original form. On every side the joints of the stones have separated, and the whole chamber is shaken larger. By examining the joints all round the 2nd course, the sum of the estimated openings is, 3 joints opened on N. side, total = .19; 1 joint on E. = .14; 5 joints on S=.41; 2 joints on W. = .38. And these quantities must be deducted from the measures, in order to get the true original lengths of the chamber. I also observed, in measuring the top near the W., that the width from N. to S. is lengthened .3 by a crack at the S. side.

These openings or cracks are but the milder signs of the great injury that the whole chamber has sustained, probably by an earthquake, when every roof beam was broken across near the South side; and since which the whole of the granite ceiling (weighing some 400 tons), is upheld solely by sticking and thrusting. Not only has this wreck overtaken the chamber itself, but in every one of the spaces above it are the massive roof-beams either cracked across or torn out of the wall, niore or less, at the South side; and the great Eastern and Western walls of limestone, between, and independent of which, the whole of these construction chambers are built, have sunk bodily. All these motions are yet but small-only a matter of an inch or two-but enough to wreck the theoretical strength and stability of these chambers, and to make their downfall a mere question of time and earthquakes.

52. Applying, then, these corrections of the opened joints to the lengths of the lower course -and also, as being the most likely correction, to the upper parts as well-we have the following values for the original lengths of the chamber, and for the error of squareness of the present corner angles.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Top	412.14	+ 0' 4"	206.30	– 0' 35"	411.88	+ 1' 35"	206.04	– 1' 4"
Mean	412.40	– 2' 57"	206.29	+ 2' 20"	412.11	– 1' 2"	205.97	+ 1' 39"
Base	412.78	– 4' 54"	206.43	+ 4' 40"	412.53	– 4' 5"	206.16	+ 4' 19"

Now it will be observed that though the lengths can be corrected by the sum of the openings, the angles cannot be so corrected, as we do not know which angle the change of length has affected. Hence the present angles are entered above, with the reservation that the sides having altered about 1 in 1,000 of their length, the original angles may have easily been 3' or 4' different; and, therefore, all that we can say about the angles is, that the builders were probably not 5' in error, and very possibly less than that; also that the errors change sign from base to top, so that each course must be a true right angle at some level up it.

Probably the base of the chamber was the part most carefully adjusted and set out; and hence the original value of the cubit used can be most accurately recovered from that part. The four sides there yield a mean value of **20.632 ± .004**, and this is certainly the best determination of the cubit that we can hope for from the Great Pyramid.

The top course of both the E. and W. walls consists of a single stone; on the N. and S. walls the joints of it were measured thus :-- N. wall, E. end 0, joints 62.1, 248.8; S. wall, E. end 0, joint 189.2.

The average variation of the thickness of the courses from their mean is .051, the mean being 47.045 between similar joints, or including the top course, which was necessarily measured in a different way, 47.040 ± .013.

53. The roof of the chamber is formed of nine granite beams , of the following breadths, the two side beams partly resting on the ends of the chamber :--

	Along N. side.		Along S. side.		Skew.	Difference of end widths.
	Stones.	Total.	Stones.	Total.		
E.		0 - x		0 - x		
	22.4 + x		17.8 + x			
		22.4		17.8	- 4.6	
	45.5		45.8			+ .3
		67.9		63.6	- 4.3	
	52.5		53.0			+ .5
		120.4		116.6	- 3.8	
	49.1		51.0			+ 1.9
		169.5		167.6	- 1.9	
	53.9		55.4			+ 1.5
		223.4		223.0	- .4	
	44.8		45.8			+ 1.0
		268.2		268.8	+ .6	
	58.1		59.3			+ 1.2
		326.3		328.1	+ 1.8	
	62.7		60.8			- 1.9
		389.0		388.9	- .1	
	23.3 + x		23.4 + x			
W.		412.3 + x		412.3 + x		

The column of "skew" shows the difference in the position of the joints on the opposite sides of the chamber; and the "difference of end widths" the variation between the two ends of the same beam. From this table it seems probable that the roofing in of the chamber was begun at the W end, as the skew of the beams increases up to the E. end; and also as the largest beams, which

would be most likely to be first used, are at the W. end. The numbering of the slabs in the top space above the King's Chamber also begins at the W. end. Vyse, however, states that these "chambers of construction" were begun

These roofing-beams are not of "polished granite", as they have been described; on the contrary, they have rough-dressed surfaces, very fair and true so far as they go, but without any pretence to polish. Round the S.E. corner, for about five feet on each side, the joint is all daubed up with cement laid on by fingers. The crack across the Eastern roof-beam has been also daubed with cement, looking, therefore, as if it had cracked before the chamber was finished.

At the S.W corner, plaster is freely spread over the granite, covering about a square foot altogether.

54. The floor of the chamber, as is well known, is quite disconnected from the walls, and stands somewhat above the base of the lowest course. It is very irregular in its level, not only absolutely, but even in relation to the courses; its dep!h below the first course joint varying 2.29, from 42.94 to 40.65. This variation has been attributed to the sinking caused by excavation beneath it, but this is not the case; it has been only undermined at the W. end beneath the coffer,* and yet the floor over this undermined part is 1½ inches higher in relation to the first course, than it is at the SE. corner; and along the S. side where it has not been mined it varies 1½ inches in relation to the first course. In these cases I refer to the first course line, as that was the builder's conception of level in the chamber, to which they would certainly refer; but if we refer instead to absolute level, the anomalies are as great and the argument is unaffected.

* I know the hole well, having been down into it more than once.

It appears, then, that the floor never was plane or regular; and that, in this respect, it shared the character of the very variable floor of the passage that led to the chamber, no two stones of which are on the same level. The passage floor, even out to the great step in the gallery, is also inserted between the walls, like the floor of the chamber.

55. Among peculiarities of work still remaining, are the traces of 15 bosses or lugs on the faces of the granite blocks , all on the lower course. Those best seen are two on the fourth block of the N. wall, counting from the door; they have been about 12 inches wide and the same high, 14 inches apart, and their flat bottom edges 3 inches from the base of the block (see P1. xii.). They may be very plainly seen by holding a candle close to the wall below them; this shows up the grinding around them, and the slight projection and very much less perfect grinding of the sites of the bosses. There is a remarkable diagonal drafted line across the immense block of granite over the doorway; it appears not to run quite to the lower corner on the E. side; but this is doubtless due to the amount by which the block is built into the E. wall, thus cutting off the end of the diagonal line. This sunken band across the stone appears to have been a true drafted straight line cut in process of working, in order to avoid any twist or wind in the dressing of the face; this method being needful as the block was too large to test by the true planes otherwise used (see section 135).

The position of the King's Chamber in the Pyramid is defined thus: N. wall at base 330.6 ± .8 S. of centre of Pyramid; S. wall **537.0 ± .8** from centre; E. wall (284.4 ± 20.7) = 305.1 ± 3.0 E. of centre; W. wall 107.7 ± 3.0 W. of centre. Base of walls **1686.3 to 1688.5 ± .6** above pavement; actual floor 1691.4 to 1693.7 ± .6 above pavement; ceiling 1921.6 to 1923.7 ± .6 above pavement.

56. The air channels leading from this chamber have been already mentioned (see section 24) and reference has been made to P1. xi. for the positions of their outer ends. The angles of them had not yet been accurately measured, and therefore I carefully observed them by a sliding signal and a theodolite. The angles on the floors of them at different distances from the theodolite station at the present outer ends are thus :--

N. Channel.		S. Channel.	
At 84 to 180	32º 4' 45"	At 0 to 120	45º 25' 6"
At 180 to 300	31º 37' 15"	At 120 to 240	45º 30' 7"
At 300 to 372	30º 43' 15"	At 240 to 360	45º 25' 57"
Mean	31º 33'	At 360 to 480	45º 25' 14"
		At 480 to 600	45º 15' 19"
		At 600 to 720	45º 7'42"
		At 720 to 840	44º 26' 18"
		Mean	45º 13' 40"

For example, on the floor of the N. channel, the angle on the part from 180 to 300 inches from the mouth averages 31º 37' 15"; this is, of course, quite apart from whatever the dip may be from the passage mouth to those points; and it is reduced from the actually observed quantities. The above list of angles are just equiva]ent to observations by a clinometer, sliding to different parts of the passage. It is striking that the slope of both passages continuously increases up to the outside (except just at the mouth of the S. channel) ; hence these quantities, which only extend over a part of either passage, cannot give the true mean slope; probably on the whole length the means would not be greater angles than 31º and 44½º respectively.

The N. channel has been forced open as a working passage for some way inwards, only leaving the floor and W. side perfect. The channel is now blocked, just below the end of the enlarged part, and on working a rod 4½ feet into the sand, it ran against limestone. The sand in the hole has blown in during gales, which sweep up sand like mist. The remains of the original channel show it to have varied from 8.9 to 9.2 (mean 9.0) in width, and to have been 8.72 and 8.74 in height.

The S. channel is blocked by sand at 76 feet down. It is not straight in the clear length, curving more than its own width to the east; and the sides often shift a few tenths of an inch in passing from one stone to another. These details were seen by examining it with a telescope on Feb. 8, and by photo-graphing it on Nov 2, 1881; these being the days on which the sun shines down it at noon. Its width at the top is 8.35 and 8.65, and its height 8.7 to 8.9.

57. The coffer in the King's Chamber is of the usual form of the earliest Egyptian sarcophagi, an approximately flat-sided box of red granite. It has the usual under-cut groove to hold the edge of a lid along the inside of the N., E., and S. sides; the W. side being cut away as low as the groove for the lid to slide over it; and having three pin-holes cut in it for the pins to fall into out of similar holes in the lid, when the lid was put on.
It is not finely wrought, and cannot in this respect rival the coffer in the Second Pyramid. On the outer sides the lines of sawing may be plainly seen: horizontal on the N., a small patch horizontal on the E., vertical on the S., and nearly horizontal on the W.; showing that the masons did not hesitate at cutting a slice of granite 90 inches long, and that the jewelled bronze saw must have been probably about 9 feet long. On the N. end. is a place, near the W. side, where the saw was run too deep into the granite, and was backed out again by the masons; but this fresh start they made was still too deep, and two inches lower they backed out a second time, having altogether cut out more than 1/10 inch deeper than they intended. On the E. inside is a portion of a tube drill hole remaining, where they tilted the drill over into the side by not working it vertically. They tried hard to polish away all that part, and took off about 1/10 inch thickness all round it; but still they had to leave the. side of the hole 1/10 deep, 3 long, and 1.3 wide; the bottom of it is 8 or 9 below the original top of the coffer. They made a similar error on the N. iriside, but of a much less extent. There are traces of horizontal grinding lines on the W. inside. Reference should be made to section 129 for the subject of stone-working in general.

58. The coffer was very thoroughly measured, offsets being taken to 388 points on the outside, to 281 points inside, or 669 in all; besides taking 281 caliper measures.

Before raising it from the floor to measure the bottom, its place as it stood on the chamber floor, tilted up at the S. end by a large pebble under it, was observed thus :--

	N.E. to N. wall	N.W. to N.	N.W. to W.	S.W. to W.	S.W. to S.	S.E. to S.
Top	47.70	48.90	53.34	56.50	67.92	(68.60)
Base	48.35	50.06	53.32	56.54	67.62	68.06

S.E. to S. wall in brackets, was taken at 10 below top, owing to breakage above that.

On raising the coffer no trace of lines was to be found to mark its place on the floor, nor any lines on the floor or bottom of the coffer.

The flint pebble that had been put under the coffer is important If any person wished at present to prop the coffer up, there are multitudes of stone chips in the Pyramid ready to hand. Therefore fetching a pebble from the outside seems to show that the coffer was first lifted at a time when no breakages had been made in the Pyramid, and there were no chips lying about. This suggests that there was some means of access to the upper chambers, which was always available by removing loose blocks without any forcing. If the stones at the top of the shaft leading from the subterranean part to the gallery had been cemented in place, they must have been smashed to break through them, or if there were granite portcullises in the Antechamber, they must also have been destroyed; and it is not likely that any person would take the trouble to fetch a large flint pebble into the innermost part of the Pyramid, if there were stone chips lying in his path.

59. The measurements of the coffer surfaces by means of offsets from arbitrary lines, have all been reduced in both tilt and skew, and are stated as offsets or variations + and -- (i.e., in excess or deficiency of stone) from a set of mean planes. These mean planes, then, are supposed to lie half in and half out of the stone, being in the mean position and direction of the face. The mean planes adopted for the E. and W. sides, both in and out, are all parallel; hence variations from these planes represent errors of flatness of the surfaces, and also errors of parallelism of the quasi-parallel surfaces. The mean planes adopted for the N. and S. ends, both in and out, are similarly all parallel.

The mean planes adopted for the bottom, both in and out, and the top, are also patallel These mean planes of the E. and W. sides, and of the N. and S. ends, are all square with the planes adopted for the bottom and top. There is no exception from parallelism in the system of comparison planes; and but one exception from squareness, in that the N. and S. planes are not adopted square with the E. and W. planes. There was such difference from squareness in the work, that to make the planes square with each other, would have altered the offsets so much as to disguise the small curvatures of the faces; and adopting the planes slightly out of square, makes no difference in taking out quantities of length, surface, or bulk, from the tables of offsets.

The mean planes to which the coffer surfaces are referred here, and from which the actual surfaces differ by an equal amount + and -- , yield the following dimensions : --

N. end thick	5.67	E. side thick	5.87	Inner depth	34.42
Inside length	78.06	Inside width	26.81	Base thick	6.89
S. end thick	5.89	W. side thick	5.82	Outer height	41.31
Outside length	89.62	Outside width	38.50	Ledge depth	1.70

The vertical planes all square with the horizontal; but N. and S. planes cut E. and W. planes at 89º 47' at N.E. and SW. corners, and at 90º 13' at N.W. and S.E. corners.

For convenience of reference the whole coffer was divided by imaginary lines or planes, 6 inches apart in each direction, and represented by rows of chalk spots during the actual measurements. Thus at the S. end the first vertical plane across the coffer from E. to W. is A, through the midst of that end; the second plane is B, which passes 3 inches clear of the end ; then C; and so on to 0, which is 3 inches clear of the N. end; and P the last line, through the midst of the N. end. Then at the W. side the first plane is α , the second β, an inch clear of the side, then γ, δ, ε, ζ ∈ ,an inch clear of the E. side, and η through the E. side. Then vertically the plane *b* is 4 inches above the inside bottom, and *c, d; e, f* are at six-inch intervals ; occasionally, in the most perfect parts, another line, *g* , could be measured on the outside, just at the top. The inside plane, α , was taken at only 3 inches below *b* , or 1 inch over the bottom; but the outside plane, α , was taken the full six inches below *b* , i.e., 4 or 5 inches above the outside bottom. In taking means in the inside the offsets to α are only allowed half weight, as they belong to a much shorter space than the others; they ought, theoretically, to have even less weight, but as the inner planes gather in rapidly, just at the bottom below α , this half weight probably gives the truest results.

Having, then, adopted the above mean planes for the sides, and divided them for reference at every six inches, we can state all the variations of the actual surfaces as being either + (i.e., an excess of stone beyond the plane) or -- (i.e., a deficiency of stone), either inside or outside the coffer.

These variations are as follow, stated in hundredths of an inch :--

OUTSIDE OF COFFER

South end.									**North end.**							
		A	b	C	D	E	F	G	H	J	K	L	M	N	O	P
Top	*g*					+2							-1	-3		
	f	+10	+8	+8	+4	+3	-4	+1	+1	0	-1	-3	-1	0	+1	-1
West	*e*	+12	+7	+14	+5	+1	-1	-5	-6	-8	-10	-12	-8	-5	+3	+5
outside	*d*	+14	+8	+12	+9	+1	-7	-13	-14	-16	-14	-15	-12	-8	+1	+1
	c	+17	+10	+10	+9	+6	-2	-8	-11	-13	-13	-13	-10	-6	0	+3
	b	+20	+10	+9	+9	+2	-4	-9	-10	-14	-12	-11	-7	0	+8	+12
Base	*a*	+21	+10	+9	0	-6	-8	-9	-8	-6	-2	+2	+10	+17	+26	+31

South end.																**North end.**
		A	b	C	D	E	F	G	H	J	K	L	M	N	O	P
Top	*g*	much										+5	+8	+9	+9	
	f	broken			-7	-5	-4	-3	0	+1	+2	+4	+7	+7	+7	+9
East	*e*	away		-8	-6	-5	-3	-2	0	0	+2	+2	+5	+5	+4	+7
outside	*d*	-13	-11	-7	-5	-4	-3	0	+1	+1	+3	+2	+5	+5	+5	+8
	c	-12	-11	-8	-7	-5	-3	-2	+1	+1	+2	+2	+6	+6	+5	+8
	b	-12	-12	-8	-7	-4	-4	-1	+1	+1	+2	+3	+7	+7	+7	+8
Base	*a*	-9	-9	-7	-4	0	+1	+1	+2	+3	+4	+5	+8	+8	+5	+6

West side								**East side**
		α	β	γ	δ	ε	ζ	η
Top	*g*		+39	+35			+21	
	f	+15	+31	+29	+21	+21	+20	+18
North	*e*	+16	+9	+3	-2	+1	+7	+13
outside	*d*	+13	-2	-14	-21	-15	-6	+2
	c	+5	+2	-10	-17	-9	-2	+3
Base	*b*	-3	-3	-3	-9	-8	-4	+2
	a	-6	-12	-20	-36	-27	-4	+13

West side								**East side**
		α	β	γ	δ	ε	ζ	η
Top	*g*							
	f	-12	-7	+1	+2	+7	+24	+34
South	*e*	-12	-12	-9	-4	+3	+22	+34
outside	*d*	-21	-24	-16	-11	-2	+22	+37
	c	-25	-27	-21	-15	+1	+22	+41
Base	*b*	-27	-30	-10	-14	-4	+26	+47
	a	-22	-32	-16	-13	-2	+29	+54

South end.																**North end.**
		A	b	C	D	E	F	G	H	J	K	L	M	N	O	P
West.	α			+15	+15	+17	+13	+12	+16	+11	+5	+1	-7	+9	+4	
	β			+20	+15	+16	+9	+14	+4	+6	-1	-11	-3	+4	-1	
	γ			+22	+22	+19	+8	+8	-2	+1	-4	-9	-18	-4	-8	
Bottom	δ		+10	+17	+21	+9	+3	-3	-4	-6	-11	-16	-15	-9	-12	
outside	ε		+9	+17	+12	+7	+1	-8	-12	-11	-13	-25	-12	-10	-15	
	ζ		+13	+7	+12	+4	+2	-6	-7	-12	-8	-17	-12	-20		
East.	η		-8	+8	+5	+4	+7	-5	-8	-13	-12	-10	-14	-15		

INSIDE COFFER

South end.								North end.						
		b	C	D	E	F	G	H	J	K	L	M	N	O
Top	*f*	+3	+1	+2	+7	+7	+7	+4	+2	+2	+3	-12	-1	+1
	e	-1	+1	+2	+4	+6	+7	+2	+4	+4	+4	+2	-1	-1
West	*d*	+1	+2	+4	+4	+3	-1	-6	-5	-4	+1	0	0	-2
inside	*c*	-1	+1	+3	+3	+5	+1	-7	-11	-11	-3	-3	-1	0
	b	+4	+1	+1	+2	+6	+10	-2	-12	-16	-9	-5	-2	-1
Base	*a*	+19	+3	+2	+1	+5	+10	-2	-10	-8	+3	+6	+5	+4

South end.								North end.						
		b	C	D	E	F	G	H	J	K	L	M	N	O
Top	*f*	-5	+1	+2	+7	+7	+7	+4	+2	+2	+3	-12	-1	+1
	e	-5	+1	+2	+4	+6	+7	+2	+4	+4	+4	+2	-1	-1
East	*d*	-4	+2	+4	+4	+3	-1	-6	-5	-4	+1	0	0	-2
inside	*c*	+-6	+1	+3	+3	+5	+1	-7	-11	-11	-3	-3	-1	0
	b	-6	+1	+1	+2	+6	+10	-2	-12	-16	-9	-5	-2	-1
Base	*a*	0	+3	+2	+1	+5	+10	-2	-10	-8	+3	+6	+5	+4

West side.			East side.			
		β.	γ.	δ.	ε.	ζ.
Top	**f**	0	-7	+1	+2	+4
	e	0	-8	-3	-6	-8
North	**d**	0	-2	0	-1	-5
inside	**c**	-3	-3	-1	+1	-1
	b	+1	+1	-1	-1	+2
Base	**a**	+20	+16	+18	+10	0

West side.			East side.			
		β.	γ.	δ.	ε.	ζ.
Top	**f**	+3	0	-1	-2	-10
	e	-5	-5	-4	-5	-9
South	**d**	-4	-3	-1	-1	-5
inside	**c**	+1	0	+2	+2	-4
	b	-5	+1	+4	+4	+2
Base	**a**	+11	+13	+24	+23	+17

South end.								North end.						
		b	C	D	E	F	G	H	J	K	L	M	N	O
West.	β	-1	-3	+5	0	-4	+1	+8	+5	+1	+10	+9	+11	+4
	γ	-8	-5	-3	-18	-5	0	-2	+1	-5	-2	+5	+1	0
Bottom inside.	δ	-5	-6	-4	-1	+2	+2	+2	0	-2	0	+1	-2	+7
	ε	+12	-9	+9	-6	+6	-13	-2	-1	-2	+1	0	-15	-12
East.	ζ	+2	+5	+3	+2	+5	+19?	+2	+1	+11	-4	+1	-5	0

TOP OF COFFER

South end.									North end.								
		A	b	C	D	E	F	G	H	J	K	L	M	N	O	P	Actual top.
West.	α		[0]	[+1]	[+4]	[+2]	[+4]	[+5]	[+4]	[+7]	[+6]	[+6]	[+5]	[+8]	[+8]		
	β	[-2]														[-1]	
	γ															[0]	
	δ															[+1]	
Top.	ε															[0]	
	ζ															[-3]	-1
	η									[-4]	[-4]	[-1]	[0]	[+4]	[0]	[-8]	
East.							act	ual	top		-4	-4		0	+1		-3

Offsets in brackets are from points on the cut out ledge, raised 1.70 inches, which is the mean level of the ledge below adjacent points of the remaining top; thus restoring the top as nearly as may be from the ledge. The actual top only remains at six points.

If; for example, the length of the E. side of the coffer is wanted, from the foregoing tables, at the level of *d*, half way up; on referring to " North outside" and "South outside" it will be seen that at *d* on East side the coffer is in excess of the mean length by + .02 on N. and + .37 on S.; adding these to the mean length (89.62 + .02 + .37) = 90.01 is the result for the E. outside of the coffer half way up. Similarly at 8 inches under the top on the same side, at *f* it is (89.62 + .18 + .34) = 90.14 in length; or at 4 inches above the bottom (which is about the lowest point uninjured) it is at α (89.62 + .13 + .54) = 90.29 in length. Or if the inside width is wanted, half way up the N. end, at *d*; referring to "West inside" and "East inside," at North end, *d* level, it is seen to be the mean inner width, 26.81, --12 on W., +.02 on E. = 26.71 ; the signs being, of course, reversed in adding internal offsets together. Similarly at the middle of the length of the coffer (H, *d*) the internal width is 26.81 + .06 + .05 = 26.92

If the thickness of the middle of the bottom is wanted, referring to "Bottom outside" and "Bottom inside," at H, *d* it is seen that the mean thickness 6.89 is changed by -- .04 and +.02, and it is therefore 6.87 thick at that point Or if the thickness of the middle of the N. end is wanted at d and *d* referring to "North outside" and "North inside," it is seen to be (5.67 -- .21 + 0) = 5.46 or the middle of the N. end at the top is (5.67 + .21 + .01) = 5.89 Thus the dimensions internal or external, or the thickness of any part, can be easily extracted from the tables by merely adding the corresponding offsets to the mean dimension.

Interior passageways and chambers ... sectional views

60. The thicknesses of the sides, however, are involved in the measurement of the cubic bulk of the coffer , and therefore need to be very accurately known, in order to test the theories on the subject. And by the above method the thickness is dependent on the combination of many separate measures, and is, therefore, subject to an accumulation of small errors. To avoid this uncertainty, the sides were independently calipered ; observing at every six inches, on the same spots on which the offsets were read. And it is to these caliperings which follow that I would mainly trust for determining the solid bulk of the coffer. The thickness is stated in hundredths of an inch.

South end.								**North end.**						
		b	C	D	E	F	G	H	J	K	L	M	N	O
Top	*f*	598	599	587	593	597	604	593	597	599	597	600	599	598
thickness	*e*	592	597	583	579	586	584	580	579	582	585	590	590	597
of	*d*	595	591	594	590	578	568	561	561	570	577	581	589	597
West side	*c*	596	589	592	588	576	561	555	553	559	571	579	591	596
Base	*b*	600	590	592	582	561	548	541	542	553	571	587	594	593
	a	617	613	602	582	576	557	548	576	586	602	607	619	610
Means		598	595	591	586	579	572	564	570	573	581	590	591	598

South end.								**North end.**						
		b	C	D	E	F	G	H	J	K	L	M	N	O
Top	*f*				592	594	594	594	594	596	597	582	600	597
thickness	*e*		583	587	589	593	594	593	579	595	596	596	594	595
of	*d*	575	585	588	589	597	587	586	586	591	594	597	596	596
East side	*c*	571	581	587	587	592	590	584	583	581	589	593	596	596
Base	*b*	572	583	586	590	591	597	591	579	577	586	591	595	596
	a	591	587	592	591	598	603	597	601	601	597	602	599	613
Means		575	585	588	590	594	593	590	589	589	593	592	596	597

West side.			**East side.**			
		β. €	γ.	δ.	ε.	ζ.
Top	*f*	596	583	589	589	595
thickness	*e*	574	561	564	560	571
of	*d*	569	548	549	552	559
North end	*c*	564	553	551	560	567
Base	*b*	567	561	553	563	572
	a	580	578	563	561	570
Means		574	563	561	564	573

West side.			East side.			
		β. €	γ.	δ.	ε.	ζ.
Top	*f*	591	595			
thickness	*e*	579	585	588	593	
of	*d*	567	575	572	587	600
South end	*c*	564	573	575	588	604
Base	*b*	562	570	576	587	609
	a	584	595	601	615	638
Means		574	581	584	594	609

From these caliperings the mean thickness of each of the sides, as compared with the results of the offsets, are thus :--

		By calipers	By Offsets	Difference
Thickness of	N.	5.67	5.67	0
	E.	5.90	5.87	-.03
	S.	5.88	5.89	+.01
	W.	5.84	5.82	-.02

Hence there appears to be a constant error of - .01 on an average, making the result of the thickness by the offsets to be less than the truth. This may be due to a tendency to read the offsets too large, or else possibly to a slight skewing of the calipers, as 3º skew would make this difference on 6 inches.

To compare in detail the results by calipers and offsets, over a small space, let us take the thickness of the N. end, along the lines C and d, which are near the mid height :--

		β € €	γ	δ	ε	ζ
At *d*	by offsets	5.65	5.51	5.46	5.51	5.56
	by calipers	5.69	5.48	5.49	5.52	5.59
At c	by offsets	5.66	5.54	5.49	5.59	5.64
	by calipers	5.64	5.53	5.51	5.60	5.67

Thus the mean difference between the thicknesses as ascertained by the two methods is .022, with a constant difference in one direction of .012 on an average. The spots observed on in the two methods were not always exactly identical; and so some difference may be due to waves of short length in the surface of the stone.

In stating the offsets on the top, the mean plane adopted is not the simple mean of all the offsets, but the mean of diagonally opposite pairs of offsets, so far as they can be taken. This is necessary in order to obtain a true result, as otherwise (the top being broken away all at one corner) any great tilt that it may have had, in relation to the base planes, would vitiate the result.

61. From the foregoing data the cubic quantities may be calculated of a simple rectilineal box, omitting all notice of the attachments for the lid, employing the mean planes :--

Contents-- 72,030; solid bulk = 70,500; volume over all, 142,530 cubic inches. Or by the caliper results, instead of the mean planes, the bulk is 1/580 more, and the contents probably about 1/1000 less; hence the quantities would be :--

Contents = 71,960; solid bulk = 70,630; volume over all, 142,590.

These quantities have a probable error of only about 60 cubic inches on contents and volume, and 100 inches on the bulk. The bulk of the bottom is = 23,830; and hence one side and end is on an average = 23,335. Bulk of bottom x 3 is then = 71,490; and 3/2 x bulk of sides and ends = 70,000, subject to about 100 cubic inches probable error.

62. The spaces, or "chambers of construction," as they have been called, which lie one over the other above the King's Chamber, are entered from a small passage which starts in the E. wall of the gallery, close under the roof. This is apparently an original passage, and leads into the lower chamber; the other four spaces above that can only be entered by the forced ascent cut by Col. Howard Vyse. This latter passage is not so easy to go up as it might be, as it is nearly all in one continuous height, so that a slip

at the top chamber means a fall of thirty feet; and as there are no foot-holes, and the shaft is wide, and narrows upwards, an Arab guide of Dr. Grant's refused to venture up it, alleging that he had a wife and family to think of. Ah Gabri, however, was quite equal to the business, and held a rope ladder to help me, which he and I together held for Dr. Grant.

The mouth of the passage out of the top of the gallery is 26.3 wide horizontally at top, 26.2 at base, the S. side of it being formed by the topmost lap of the S. end of the gallery. The top and base of the mouth follow the slope of the gallery, the top being the top of the gallery, and the base the bottom of the topmost overlapping; thus the mouth is 29.4 high, square with the gallery. The rough passage is 28½ wide, 32 inches high, and over 20 feet long.

All these chambers over the King's Chamber are floored with horizontal beams of granite, rough dressed on the under sides which form the ceilings, but wholly unwrought above. These successive floors are blocked apart along the N. and S. sides, by blocks of granite in the lower, and of limestone in the upper chambers, the blocks being two or three feet high, and forming the N. and S. sides of the chambers. On the E. and W. are two immense limestone walls wholly outside of; and independent of; all the granite floors and supporting blocks. Between these great walls all the chambers stand, unbonded, and capable of yielding freely to settlement. This is exactly the construction of the Pyramid of Pepi at Sakkara, where the end walls E. and W. of the sepulchral chamber are wholly clear of the sides, and also clear of the sloping roof-beams, which are laid three layers thick; thus these end walls extend with smooth surfaces far beyond the chamber, and even beyond all the walls and roofing of it, into the general masonry of the Pyramid.

The actual dimensions of these chambers are as follow :--

	N	E	S	W
Top	462 to 470	...	468.4	247
4th	481	196	467	198
3rd	479 ?	...	472	198
2nd	...	204.65	471.8	...
1st	460.8	205.8	464.6	205.9
Kings	412.8	206.4	412.5	206.1

But these dimensions are merely of the rough masonry; and some lengths could not be measured owing to the encumbrance of blocks of stone and rubbish left in the chambers from Vyse's excavations.

63. In the first chamber the S. wall has fallen outwards, dragging past some of the roof-beams, and breaking other beams at the S.E. corner. The E. and W. end walls have sunk, carrying down with them the plaster which had been daubed into the top angle, and which cracked freely off the granite roofing. On the E. end one block is dressed flat, but all the others are rough quarried.

In the second chamber are some bosses on the N. and S. wall stones; and several of the stones of the N. wall are smoothed, and one polished like those in the King's Chamber, seeming as if some spare blocks had been used up here. The S.E. corner shows cracks in the roof .52 wide. The masons' lines, drawn in red and black, are very remarkable in this and the upper chambers, as they show, to some extent, the methods of working. Some of the lines in this chamber, drawn in red on the S. wall blocks of granite, are over some of the plastering, but under other parts of the plaster. These lines, therefore, were drawn during the building, and while the plaster was being laid on, and slopped like whitewash into the joints. The red lines are always ill-defined and broad, about ¼ to 1½ inch; but, to give better definition, finer black lines were often used, either over the red or alone, about 1/10 inch wide. On the S. wall, starting from a drafted edge on the W. wall, 4 inches wide, there is a vertical mason's- line at 22.3, a very bad joint at 51.5, another line at 70.5, another at 435.8, and the E. wall at 471.8. Thus the two end lines are 413.5 apart, evidently intended for the length of the King's Chamber below them, and define the required limits of this upper space. On the E. wall is a vertical mid-line drawn, with a cross line and some signs; from this mid-line to a line at the S. end is 101.8, and to a line at the N. end of the wall is 102.85 ; total, 204.65, intended for King's Chamber width. There is a large cartouche of Khnumu-Khufu, nearly all broken away by Vyse's forced entrance; but this and other hieroglyphs need not be noticed here, as they have been already published, while the details of the masons' marks and lines of measurement have been neglected.

In the third chamber, the N. and S. sides are of granite as before; but they rest on pieces of limestone, put in to fill up hollows, and bn'ng them up to level: this showing, apparently, that the stock of granite supporting blocks had begun to run short at this stage of the building, and that any sort of pieces were used up, being eked out by limestone, which in the upper chambers supplied their places altogether. The flooring beams are very unequal in depth. and hence the sides of many of them are exposed, and show us the masons' marks. On the 1st beam from the E. end is a mid-line on the W. face at 98 from the S. On the 4th beam is a mid-line on the E. face, 102.8 to N., and 101 to S. On the 6th beam is a mid-line on W. face, 100 to N. and 101.5 to S.; these N. and S. ends being merely the rough sides of the chamber. There are two bosses on the S. side of the chamber. The chamber sides are much slopped over with liquid plaster. On the N. side is a vertical line on the western granite block, over the edge of a limestone block beneath it, apparently to show the builders where to place it. From the W. end of the chamber this line is at 10

inches, joints at 210 and 246, a red line at 260, chamber end at 479 (?), and end of granite blocks at 503.

In the fourth chamber the supporting blocks along the N. and S. sides are all of limestone, and are much cracked and flaked up by top pressure. The great end walls, between which all these chambers stand, have here sunk as much as 3 inches in relation to the floors and sides; as is shown by the ledges of plaster sticking to them, which have originally fitted into the edges of the ceiling. The roof-beam by the forced entrance has been plastered over, then coloured red, and after that accidentally splashed with some thin plastering. Along the N. wall, from the E. end of the floor as 0, there is a line at 37.8, another at 58.5 another at 450.6, and the W. end at 481 thus the extreme lines are 412.8 apart, with a supplemental line at 20.7 from one of them. This last was probably put on in case the end line should be effaced in building, so that the workmen would not need to remeasure the whole length. One stone, 65 inches long, has a mark on it of "3 cubits."
On the S. wall, from the E. end = 0, there is a line at 32.6, another at 384.7, another at 446.5, and the W. end at 467; here the extreme lines are 413.9 apart, with a supplemental line 61.8 (or 3 X 20.6) from one end. Along both sides of the chamber is a red line all the way, varying from 20.6 to 20.2 below the ceiling; with the vertical lines just described crossing it near each end. Remembering the Egyptian habit of building limestone courses in the rough, and marking a line to show to where they were to be trimmed down level, this line seems to have been put on to regulate the trimming down of these lime- stone sides; either as a supplemental line, like those one cubit from the true marks on tbe granite beams, or else placed a cubit lower than the trimming level, in order that it should not be effaced in the cutting. On the E. floor-beam is a line 98.6 from the S. end. On the third beam is a line 100 to N. and 96.2 to S. end. On the 4th beam a line 98.3 to N., and 100.6 to S. end. On the sixth beam a horizontal line running all along it, with a mid-line 98.0 to N. and 98.1 to S. end; and a supplemental line at 20.3 to 20.6 from S. end. On the other side of the beam a line is at 98.1 to N. and 96 to S. end. The rough tops of the floor-beams of this chamber show most interestingly the method of quarrying them; exactly as may be seen on the rough tops of the granite roofing inside the Third Pyramid. On the top of each stone is a hollow or sinking running along one edge; and branching from this, at right angles across the stone, are grooves 20 to 25 inches apart, about 4 wide, and 1½ deep. These seem to show that in cutting out a block of granite, a long groove was cut in the quarry to determine the trend or strike of the cleavage ; and then, from this, holes were roughly jumped about 4 inches diameter and 2 feet apart, to determine the dip of the cleavage plane. This method avoids any danger of skew fractures, and it has the true solidity and certainty of old Egyptian work.

In the fifth or top chamber, the width is quite undefined; and we can only say that between the points where the sloping roof-slabs appear is 247 inches. The roof-slabs have separated at the apex 1.55 at E. end, and I.0 at W. end. The end walls are very rough, being merely the masonry of the core. On the second floor-beam are two horizontal lines 20.6 to 20.7 apart, with three vertical lines across them, 103.1 and 103.5 apart. They have triangles drawn in black on both the vertical and horizontal lines, the triangle on the horizontal being 12.5 from the end vertical line, and therefore not apparently at any exact distance along it. On the fourth beam from the E. is a horizontal line on its W. side, with four vertical lines: these are a mid-line, others at 102.6 and 102.6 from it, and a supplemental line 20.0 from one of these. On the E. side of the same is a horizontal and three vertical lines; the two end ones 206.3 apart, and a supplemental line 2I.0 from one end. Both of these horizontal lines have a small black triangle, with one side on the line. The third beam from the E. has four verticals, with a triangle beyond the last. These are 103.3 and 103.25 from a mid-line, with a supplemental line 20.95 from one end. The E. beam has five verticals, 103.0 and 102.7 from the mid-line, with supplemental lines at 20.7 and 19.4 from the ends; it has also a horizontal line, with a large red triangle on the lower side of it, and a smaller black triangle inside the red. On the S. side is a line 29.3 from the W. end, apparently one terminal of the 412 -inch length. The roofing-beams are all numbered, beginning at the W. end of the N. side, going along to the E., turning to the S. side, and so back to the W. end. The numbers visible on the under-sides of the beams are 4, 18, 21, and 23 ; probably the numbers of the others are on the sides now covered.

From all these details of the lines, it seems that the roofing-blocks had usually a mid-line and two end lines marked on their sides as a guide in placing them; and, in case of obliteration, extra lines were provided, generally a cubit (20.6) from each end, but sometimes at other points. The horizontal lines were probably to guide the workman in cutting the straight under-sides of the beams; and it would be desirable to measure through some cracks to find their distances from the ceiling side. The flooring of the top chamber has large holes worked in it, evidently to hold the butt ends of beams which supported the sloping roof-blocks during the building.

64. General summary of the positions inside the Great Pyramid :---

	Horizontally		Vertically	
	From N. Base	From Centre	E. from Centre	Above Pavement
Beginning of entrance	**524.1 ± .3**	**N. 4010.0 ± .3**	**mid. 287.0 ± .8**	**+ 668.2 ± .1**
S. end of entrance passage	**4228.0 ± 2.**	**N. 306.0 ± 2.**	**mid. 286.4 ± 1.**	**- 1181.0 ± 1.**
S. end of N. subterranean passage	**4574.0 ± 2.**	**S. 40.0 ± 2.**	**mid. 286.3 ± 1.**	**- 1178.0 ± 1.**
Subterranean Chamber, centre	**4737.0 ± 2.**	**S. 203.0 ± 2.**	**mid. 25.9 ± 2.**	**- 1056.0 ± 2.**
N. end of S. subterranean passage	**4900.0 ± 2.**	**S. 366.0 ± 2.**	**mid. 284.9 ± 1.**	**- 1219.0 ± 1.5**
S. end of S. subterranean passage	**5546.0 ± 3.**	**S. 1012.0 ± .3**	**mid. 277.1**	**- 1213.0 ± 2.**
Beginning of Ascending passage	**1517.8 ± .3**	**N. 3016.3 ± .3**	**mid. 286.6 ± .8**	**+ 179.9 ± .2**
End of Ascending passage	**2907.3 ± .8**	**N. 1626.8 ± .8**	**mid. 287.0 ± 1.5**	**+ 852.6 ± .3**
Queen's Chamber, N.E. corner	**4402.1 ± .8**	**N. 102.0 ± .8**	**side 308.0 ± 3.**	**+ 834.4 ± .4**
Queen's Chamber, mid W. roof	**4533.8 ± .8**	**N. .3 ± .8**	**side 72.0 ± 3.**	**+ 1078.7 ± .6 roof**
Gallery, virtual S. end, floor	**4595.8 ± .9**	**S. 61.7 ± .9**	**mid. 284.4 ± 3.**	**+ 1689.0 ± .5**
Gallery, top of step face	**4534.5 ± .9**	**S. .4 ± .9**	**mid. 284.4 ± 3.**	**+ 1694.1 ± .7**
Antechamber, N. end, floor	**4647.8 ± .9**	**S. 113.7 ± .9**	**same ?**	**+ 1692.6 ± .6**
Antechamber S. end, roof	**4763.9 ± .9**	**S. 229.8 ± .9**	**same ?**	**+ 1841.5 ± .6 roof**
King's Chamber, floor	**4865.0 ± .9**	**S. 330.9 ± .9**	**mid. same**	**+ 1692.8 ± .6**
King's Chamber, N.E. wall base	**4864.7 ± .9**	**S. 330.6 ± .9**	**side 305.0 ± 3.**	**+ 1688.5 ± .6**
King's Chamber, roof				**+ 1921.6 ± .6 to + 1923.7 ± .6**

THE PYRAMIDS AND TEMPLES OF GIZEH.

BY

SIR W.F.M. FLINDERS PETRIE

Author of "Inductive Metrology," "Stonehenge," &c,

1883

LONDON;
FIELD & TUER, YE LEADENHALLE PRESSE; SIMPKIN, MARSHALL & CO., STATIONERS' HALL COURT; HAMILTON, ADAMS & CO., PATERNOSTER ROW.
NEW YORK: SCRIBNER & WELFORD, 743, BROADWAY.

PUBLISHED WITH THE ASSISTANCE OF A VOTE OF ONE HUNDRED POUNDS FROM THE GOVERNMENT-GRANT COMMITTEE OF THE ROYAL SOCIETY, 1883

NOTES

"The Great Pyramid has lent its name as a sort of by-word for paradoxes; and, as moths to a candle, so are theorisers attracted to it. The very fact that the subject was so generally familiar, and yet so little was accurately known about it, made it the more enticing; there were plenty of descriptions from which to choose, and yet most of them were so hazy that their support could be claimed for many varying theories." SIR FLINDERS PETRIE

Sir Flinders Petrie's 1880/82 survey of the Giza plateau which included the GREAT PYRAMID of KHUFU and the relatively unknown TRIAL SITE is probably the most detailed Egyptian study ever undertaken by a surveyor.

This is the original edition of 1883 which was sold out during the first few months. The second edition which summarized many of the tables into a few lines and omitted much of the technical work appeared in early 1885.

Petrie's approach to the 1880/82 survey is seen as something quite extraordinary and it warrants the remarks he sometimes made about the "rough and ready" character of those preceding him. For example when measuring the Great Pyramid's descending passageway Petrie refers to his encounter with screw-driver marks.

For those who have taken time to study some of the surveys conducted on the Giza plateau, Petrie's contribution stands head and shoulders above the rest. Whether he is right or wrong in all his readings is not the issue ... he just did things better.
After his extensive triangulation on the Giza plateau Petrie was somewhat taken back by what he uncovered and said of the Great pyramid "a triumph of skill. Its errors, both in length and in angles, could be covered by placing one's thumb on them."

Petrie measured everything in inches, a 10th of an inch, a 100th of an inch and occasionally a 1000th of an inch. It was acceptable then ... and it should still be acceptable now.
He went to Egypt as a professional surveyor but he also had experience as a mechanical engineer and his interest in metrology was written into a number of previous books.

Some of the book's type is sprinkled with dramatic dashes, words for example that appear as;---the Sphinx---and ---Mr Gill. They are not overdone and so have been retained more or less as they appear in the text. For appearance sake however, the book's italics has been converted to the alternate underline, although in some instances (where a reference has been made) this has not been necessary. Providing the fonts **MS Sans Serif** and **Arial** are both available the text shows little difference between browsers although IE5 probably gives the better reading . Additionally, some words of the book have come up poorly in the scan and might occasionally appear with ~ in place of a letter or letters, in particular (and with much annoyance) the decimal place or the "period" (for English speaking countries). Every effort has been made to correct them.

Also note that Petrie's comments which originally appeared in the margins or at the bottom of the page have been edited to appear closer to the text in question, that is to say immediately following it. In webpage format you also have the advantage of being able to click on a reference link, namely the illustration plates that Petrie included at the back of his book.

Petrie's 1880-1883 measurements for the Great pyramid are not the only ones available but they are the most reliable. Almost all serious investigations now quote Petrie. Sometimes the Egyptian government survey of 1925 is also quoted, as is the Cole survey of the same year. In the notes, where necessary, I have included the 1925 government measures for comparison.

Demy 8vo, cloth, 8s. 6d. With Diagrams and Tables of Results in Inches and Metres.

INDUCTIVE METROLOGY;

OR,

THE RECOVERY OF ANCIENT MEASURES FROM THE MONUMENTS.

BY

W. M. Flinders Petrie.

"The essay will be read with much interest and advantage by those persons who have given their attention to metrological science. It appears to be a valuable contribution to historical and ethnological literature, and to be a groundwork for further researches on the subject."—NATURE.

"This is a very useful and interesting book on the history of measures. . . . The work must be perused with care by all who wish to attain a definite conception of the mathematical ideas possessed by the builders of our megalithic monuments."—PALL MALL GAZETTE.

"The means of which Mr. Petrie makes use are the principles of the statistical, or, as a recent writer proposes to call it, the numerical method of inquiry. The general character of that method is familiar to everyone, and Mr. Petrie has shown in his thoughtful and excellent essay that it may be applied to the problem of the determination of the linear measures used in various countries in past times. The first part of the work deals with the methods required in this specific study, and gives examples of their working. . . . Mr. Petrie notes the principal sources of error to which metrological investigations are exposed, besides explaining the application of the theory of probable error to these investigations."—FINANCIAL OPINION.

"It is a very interesting and pregnant book, the result of much reading and patient research."—THE BUILDER.

"The work is full of fact and well-arranged arguments."—PUBLIC OPINION.

"On the whole, the work is a unique contribution to ethnologic science, and opens a wide field for future research. Not only are the methods and results original, but the whole conception is practically new to English-speaking ethnologists."—THE AMERICAN ANTIQUARIAN.

By the same author. Quarto, cloth, 3s. 6d.

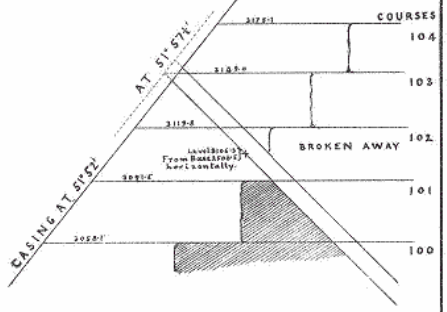
STONEHENGE:

PLANS, DESCRIPTION, AND THEORIES.

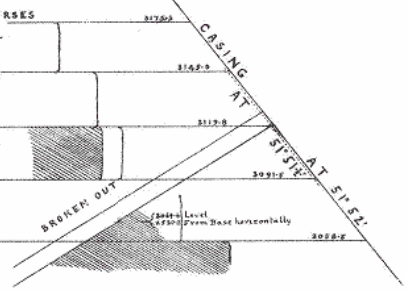
London: EDWARD STANFORD, 55, Charing Cross, S.W.

XI.

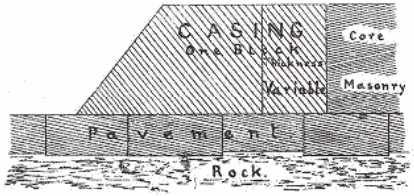
SOUTH AIR CHANNEL MOUTH
OF GREAT PYRAMID
(CASING RESTORED)



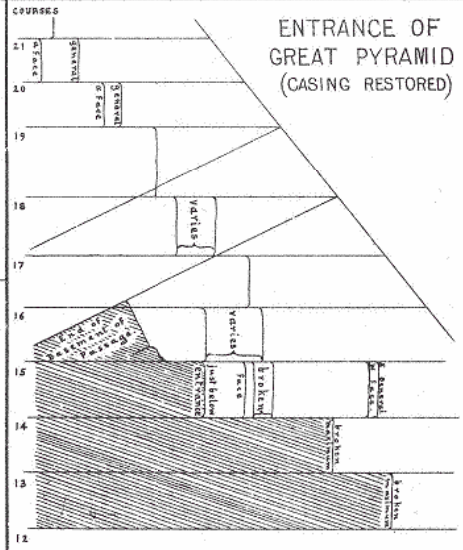
NORTH AIR CHANNEL MOUTH
OF GREAT PYRAMID
(CASING RESTORED)



EXISTING CASING ON NORTH SIDE
OF GREAT PYRAMID.

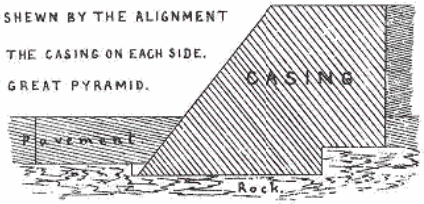


ENTRANCE OF
GREAT PYRAMID
(CASING RESTORED)

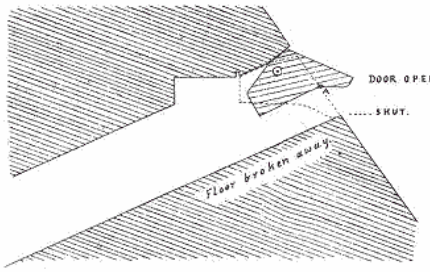


CASING-STONE IN AVERAGE CORNER-SOCKET.

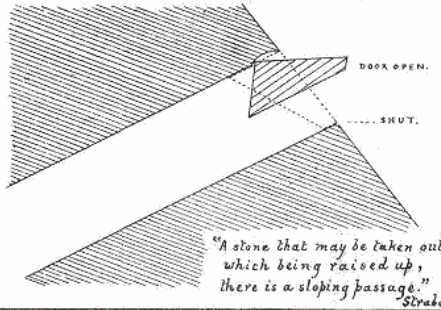
AS SHEWN BY THE ALIGNMENT
OF THE CASING ON EACH SIDE.
OF GREAT PYRAMID.



DOOR OF THE SOUTH PYRAMID OF DAHSHUR.
AS SHEWN BY THE EXISTING DOORWAY.



DOOR OF THE GREAT PYRAMID OF GIZEH
RESTORED FROM THE DOORWAY AT DAHSHUR.



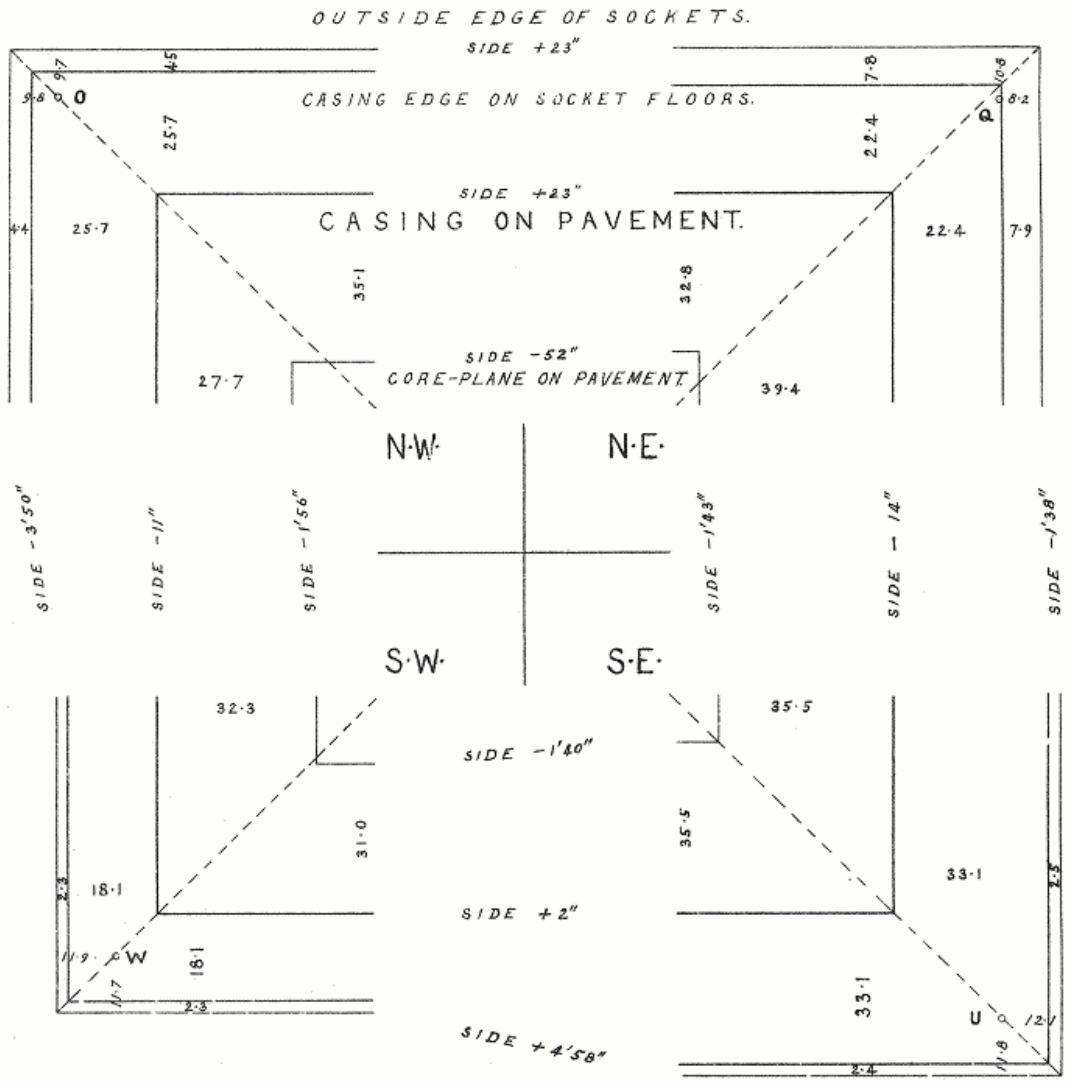
Thomas Kell & Son, Photolith.

SCALE $\frac{1}{100}$

W.M.F.P.ments. et del.

THE RELATIVE POSITION OF THE SOCKET-EDGES, CASING, AND CORE-MASONRY, AT THE CORNERS OF THE GREAT PYRAMID

SCALE $\frac{1}{50}$



The azimuths of the sides stated are from the mean azimuth of the casing on pavement, which is −3′43″, ie. W. of N. The station-marks O·Q·U·and W. are marked in position.

Plate 2.

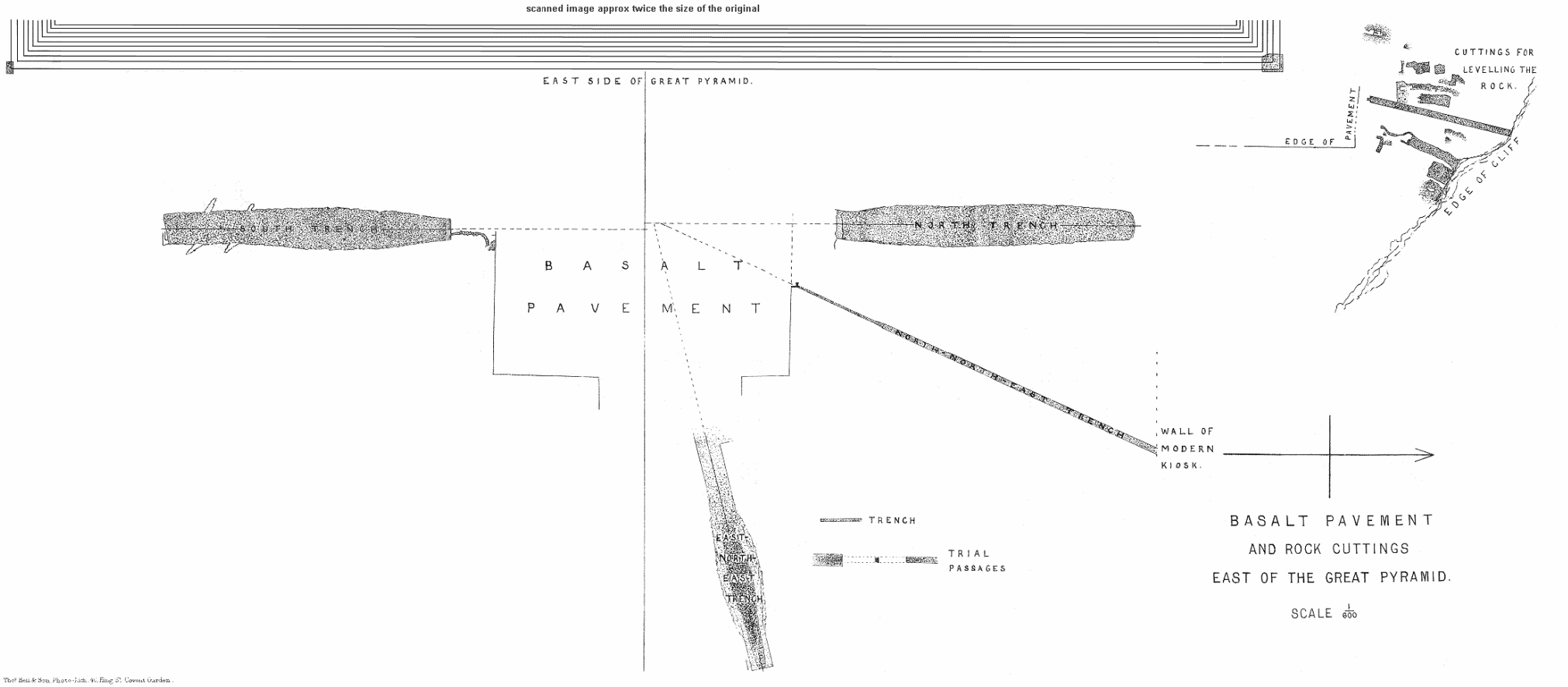

scanned image approx twice the size of the original
EAST SIDE OF GREAT PYRAMID.
SOUTH TRENCH
NORTH TRENCH
B A S A L T
P A V E M E N T
MODERN NORTH-EAST TRENCH
EAST-NORTH-EAST TRENCH
WALL OF MODERN KIOSK.
CUTTINGS FOR LEVELLING THE ROCK.
EDGE OF PAVEMENT
EDGE OF CLIFF
TRENCH
TRIAL PASSAGES
BASALT PAVEMENT
AND ROCK CUTTINGS
EAST OF THE GREAT PYRAMID.
SCALE 1/600
Thos Bell & Son, Photo-Lith. 46, King St. Covent Garden.

Plate 3a.

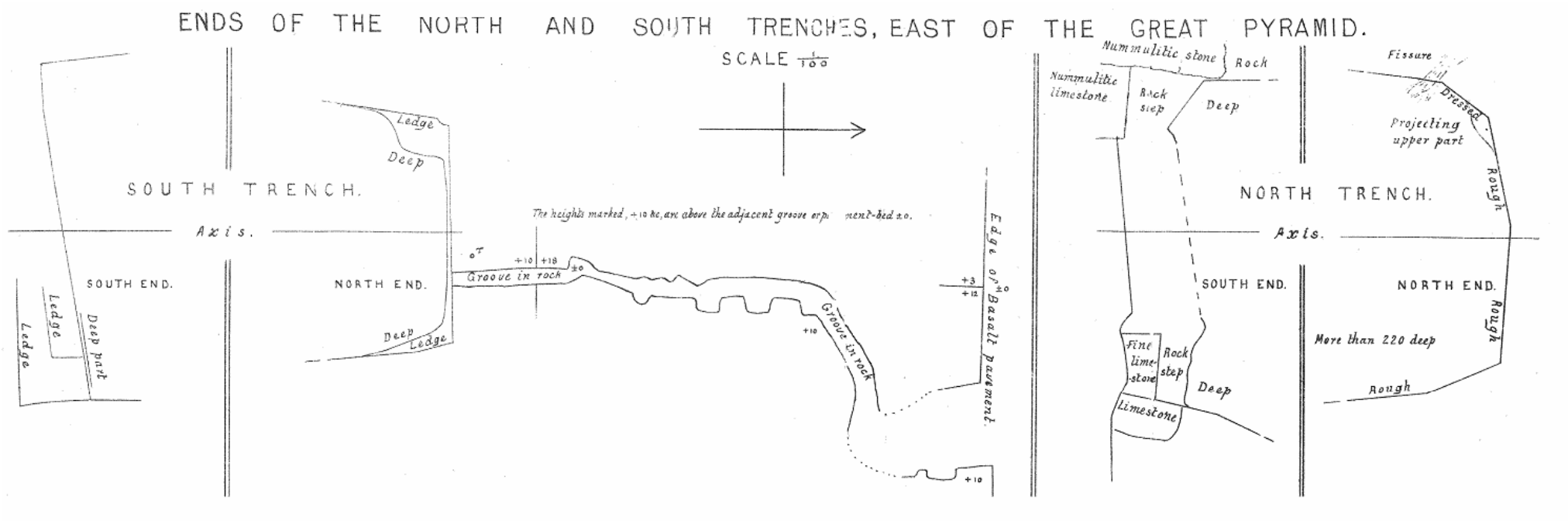
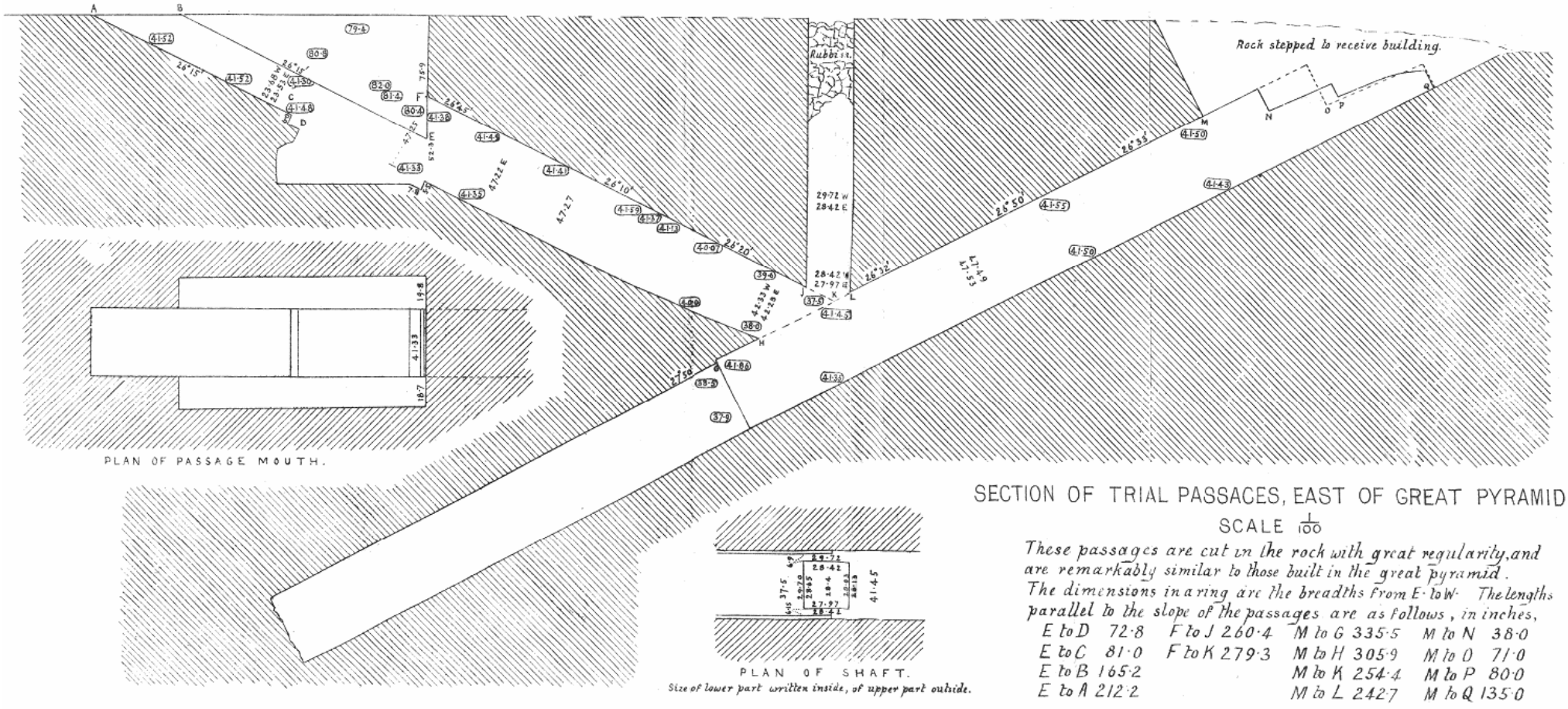

ENDS OF THE NORTH AND SOUTH TRENCHES, EAST OF THE GREAT PYRAMID.
SCALE 1/100
SOUTH TRENCH.
Axis.
SOUTH END.
NORTH END.
Ledge
Deep
Deep part
Ledge
Deep
Ledge
The heights marked, +10 &c, are above the adjacent groove or pavement-bed a.o.
Groove in rock
+10
+18
±0
Groove in rock
+10
Edge of Basalt pavement
+3
+12
+10
Nummulitic stone
Rock
Nummulitic limestone
Rock step
Deep
Fissure
Dressed
Projecting upper part
Rough
NORTH TRENCH.
Axis.
SOUTH END.
NORTH END.
Fine limestone
Rock step
Deep
Limestone
More than 220 deep
Rough
Rough

Plate 3b.



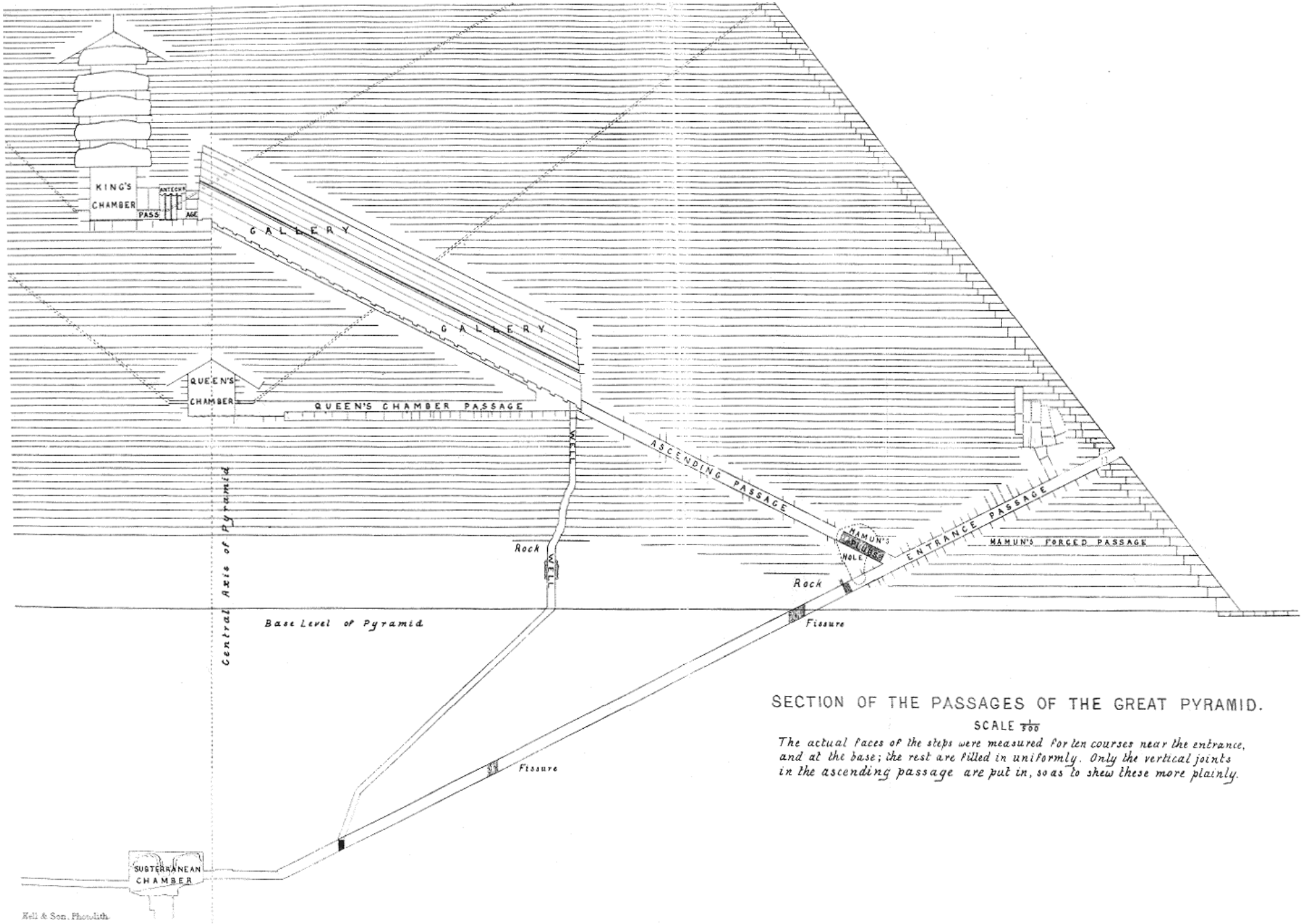
SECTION OF TRIAL PASSAGES, EAST OF GREAT PYRAMID.

SCALE 1/100

These passages are cut in the rock with great regularity, and are remarkably similar to those built in the great pyramid. The dimensions in a ring are the breadths from E. to W. The lengths parallel to the slope of the passages are as follows, in inches,

E to D 72·8	F to J 260·4	M to G 335·5	M to N 38·0
E to C 81·0	F to K 279·3	M to H 305·9	M to O 71·0
E to B 165·2		M to K 254·4	M to P 80·0
E to A 212·2		M to L 242·7	M to Q 135·0

Plate 9.

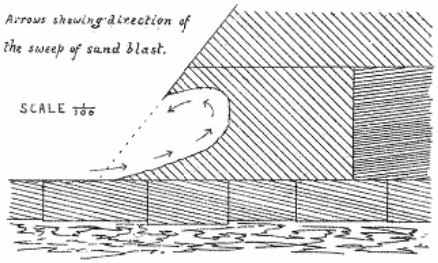


SECTION OF THE PASSAGES OF THE GREAT PYRAMID.

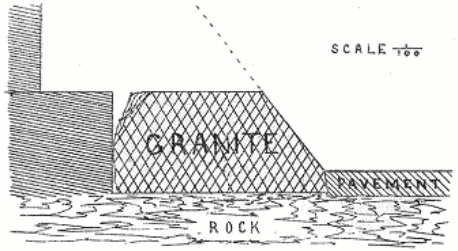
SCALE $\frac{1}{500}$

The actual faces of the steps were measured for ten courses near the entrance, and at the base; the rest are filled in uniformly. Only the vertical joints in the ascending passage are put in, so as to shew these more plainly.

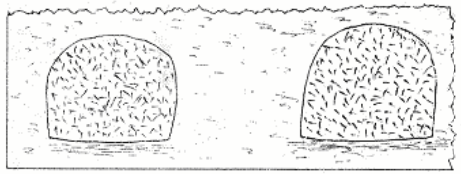
CASING OF GREAT PYRAMID
AS WEATHERED ON SOUTH SIDE.



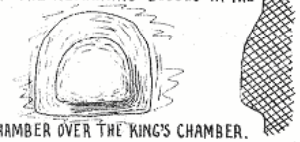
CASING OF SECOND PYRAMID.
WITH PAVEMENT ABUTTING ON THE FOOT.



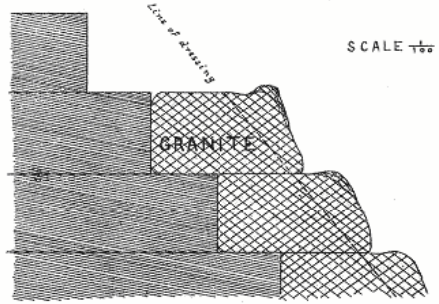
REMAINS OF TWO BOSSES DRESSED-OUT, IN KING'S CHAMBER.



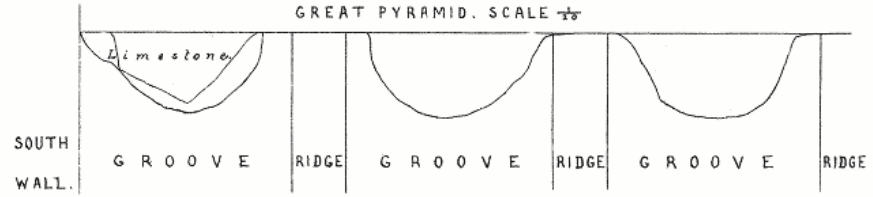
ONE OF THE REMAINING BOSSES IN THE SECOND CHAMBER OVER THE KING'S CHAMBER.



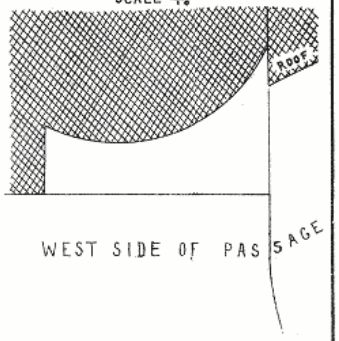
CASING OF THIRD PYRAMID.
WITH EXCESS REMAINING ON FACE NOT YET DRESSED.



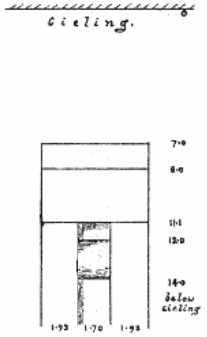
HOLLOWS IN THE TOP OF THE GRANITE WAINSCOT OF THE WEST WALL OF THE ANTECHAMBER.
GREAT PYRAMID. SCALE 1/10



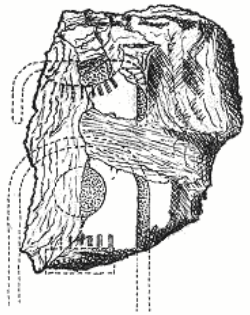
SECTION OF ROLL OVER BEGINNING OF HORIZONTAL PASSAGE, SECOND PYRAMID.
SCALE 1/10



TOP OF PANEL ORNAMENT ON CHAMBER WALLS, THIRD PYRAMID.
SCALE 1/10



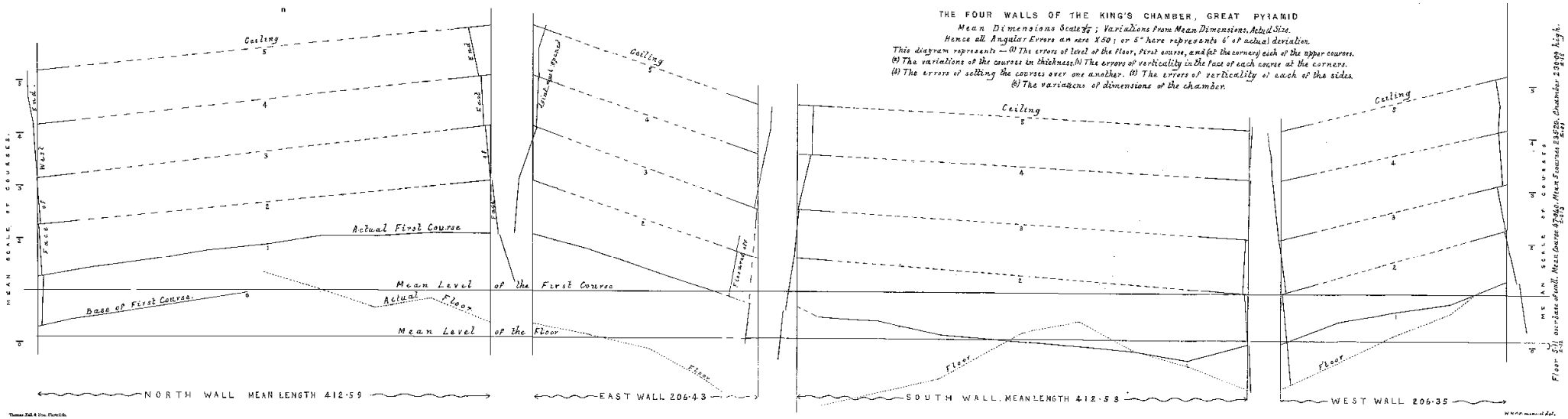
PIECE OF DIORITE STATUE OF MEN····RA, FOUND IN THE PYRAMID OF ABU-ROASH. SCALE 1/3

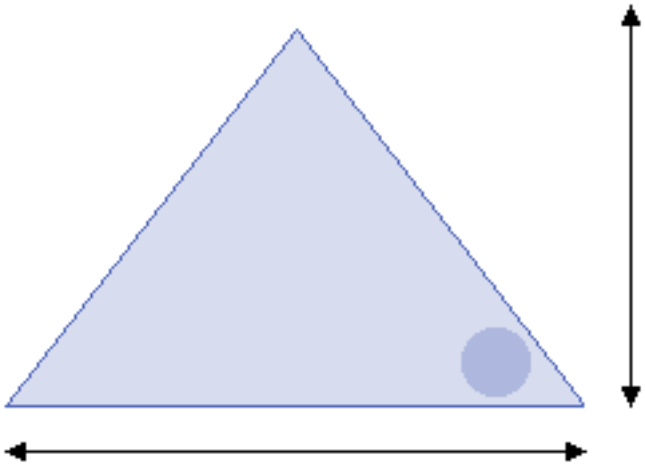


W.M.F.P. mens et del.

Thomas Kell & Son, Photozin.

Plate 13.


THE FOUR WALLS OF THE KING'S CHAMBER, GREAT PYRAMID
Mean Dimensions Scale 1/10; Variations from Mean Dimensions, Actual Size.
Hence all Angular Errors are x 50; or 5" here represents 6' of actual deviation.
This diagram represents — (1) The errors of level of the floor, first course, and (at the corners) each of the upper courses.
(2) The variations of the courses in thickness. (3) The errors of verticality in the face of each course at the corners.
(4) The errors of setting the courses over one another. (5) The errors of verticality of each of the sides.
(6) The variations of dimensions of the chamber.
MEAN SCALE OF COURSES.
Ceiling
Actual First Course
Mean Level of the First Course
Base of First Course
Actual Floor
Mean Level of the Floor
Floor
NORTH WALL MEAN LENGTH 412·59
EAST WALL 206·43
SOUTH WALL, MEAN LENGTH 412·53
WEST WALL 206·35



THE GREAT PYRAMID
outer measures

Base	9068.8 ± .5 inches = **755.69 - 755.78 ft.** (Egyptian Govt survey, 1925. **755.44 - 756.08 ft)** #	ref 1 ref 2
Height	**5776.0 ± 7.0 inches = 480.75 - 481.92 ft.** (Egyptian Govt survey, 1925. **481.4 ft**)	ref.
Seke slope	51º 52' ± 2' observations with goniometer 51º 48' - 51º 57', Casing stones "in situ", approx 51º 45' - 51º 49' ## (Egyptian Govt survey. 1925. 51º 52')	ref. ref.

Square base seen as uneven. (Egyptian Govt survey, 1925). It might have been measured that way in 1925 but if we listen to Petrie who praises Khufu's "quality of workmanship", it is most unlikely that the square base on the pavement would have originally been finished as anything but true.

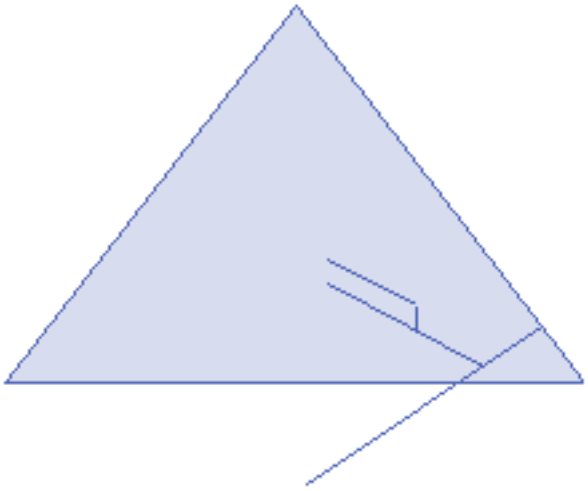
If Petrie slightly misread the true baseline or the true baseline level, as has often been suggested, then it is quite possible that the lesser angles offer a better estimate for the original slope; ie :
Casing stones in situ 51º 45' - 51º 49' (theodolite)

Note : The Great Pyramid has been in ruins for a very long time. When its outer casing fell to the ground all hope of recording its true dimensions ceased there and then. We really do not know its true baseline, hence its height and slope. At some time or other the pyramid was also hit by natural disasters (Petrie). A series of earthquakes would not seem an unreasonable assumption so our best estimates will now probably rely on the ability of future researchers to declare it a true geometric structure, one that responds to known proportions.

Related information :

Khufu, the Trial Site

Next page
Inside the Pyramid
Passageways angles



THE GREAT PYRAMID
inner measures

Descending passage	26º 31' 23" ± 5" ?	ref.
Ascending passage	Lower part (up to Gallery) 26º 02' 30"	ref.
	Upper part (Gallery) 26º 16' 40"	ref.
	Mean of whole 26º 12' 50"	ref.

With the ascending passage, we may well ask why the masons worked their way up to the beginning of the Gallery at approximately 26º 02' but then changed it noticeably for the Gallery itself. Did the masons stop at the Gallery to re-calculate after some concern was raised about the angle of the newly laid floor ?. Would it have missed its mark at King's chamber height ?. Perhaps the angle of the Gallery floor was then readjusted to bring it back in line with the planned angle. Petrie's data "Mean of whole" 26º 12' 50" may in fact reflect the planned angle closer than we think. This being the case we still have two different angles to contend with, the ascending about a 1/3 of a degree less than the descending. The question is ... why were the two angle planned this way and what was behind their geometry ? Of course if the descending passageway wasn't honed with incredible accuracy (a consistent altitude) we might not be asking these questions.

True scale : If drawing the Great pyramid to scale Section 64 is to be consulted for it has all the necessary measurement to correctly place the passageways and chambers.

Metrology

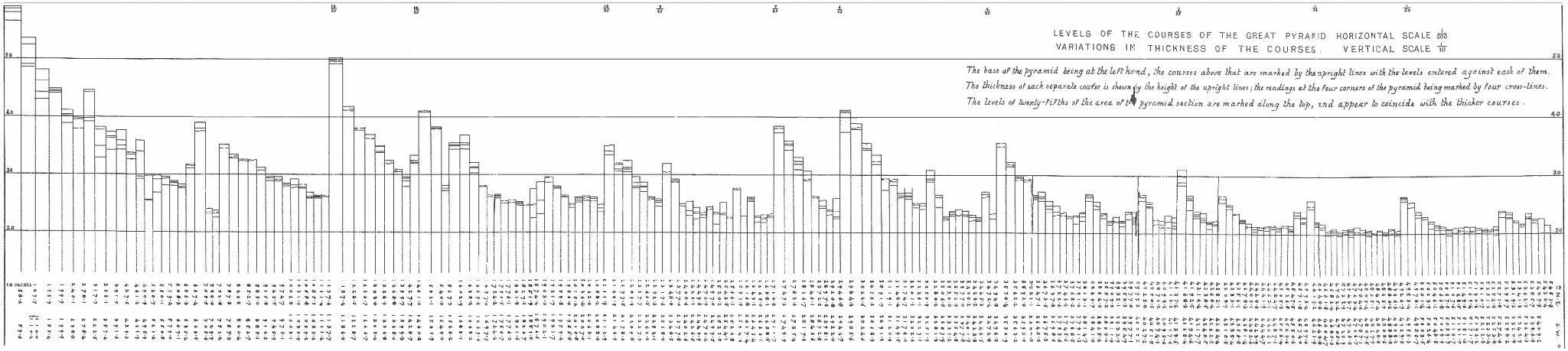
Royal cubit (base of King's chamber) **20.632 ± .004 inches** (523.95 - 524.15mm)	ref.
Royal cubit (summary King's chamber) **20.620 ± .005 inches** (523.62 - 523.87mm)	ref.
Digit (unit named by Petrie) ... **.727 ± .002 inches** (18.41 - 18.52mm)	ref.

Note : The royal cubit standard agreed upon for the 4th dynasty is generally quoted as the second measure, ie; **20.620 ± .005 inches** although as you can see there is but 1/3rd of a millimetre difference between them. The digit, so named by Petrie, is mainly from the 4th dynasty tombs he examined and it is consistently accurate to within 1/10th of a millimetre. It is by far the best indication we have for metrological proficiency during this period.

Plate 8a.

Courses of the Great Pyramid

From Petrie's explanation (to the right) we gather that the thicker the course the higher it is represented, ie; the first and second courses are the thickest. Course thirty five comes next and then course three.
On an additional illustration **Plate 8b** I have re-entered the course data, numbered each course and added the relevant information for thickness.



COURSE DATA and SITE COMMENTARY

Starting from the top of the pyramid and working down to the base (after Petrie). Two entries given for the progressive **top** of each course, ie; from the N.E. and S.W. corners above base. I have added the thicknesses for each course and the difference between the N.E. and S.W. readings, both in thickness and in level. There is also a column illustrating the **approximate** variation between the 4 corner thicknesses, corresponding to the 4 horizontal thickness bars on the previous illustration (**plate 8a**).

N.E. level	thickness	S.W. level	thickness	variation level	variation thickness	variation in thickness 4 corners	course
5451.8	21.4	-	--	--	--	--	203
5430.4	22.5	-	--	--	--	--	202
5407.9	22.2	5409.2	22.4	1.3	0.2	0.5	201
5385.7	22.8	5386.8	22.5	1.1	0.3	0.9	200
5362.9	21.6	5364.3	21.4	1.4	0.2	0.5	199
5341.3	22.1	5342.9	22.0	1.6	0.1	0.3	198
5319.2	23.5	5320.9	22.7	1.7	0.8	1.0	197
5295.7	23.9	5298.2	23.6	2.5	0.3	1.1	196
5271.8	19.8	5274.6	20.8	2.8	1.0	1.2	195
5252.0	20.7	5253.8	20.4	1.8	0.3	0.5	194
5231.3	20.6	5233.4	20.6	2.1	0	0.2	193
5210.7	20.1	5212.8	20.6	2.1	0.5	0.9	192
5190.6	21.2	5192.2	20.5	1.6	0.7	0.9	191
5169.4	20.4	5171.7	20.1	2.3	0.3	1.0	190
5149.0	20.5	5151.6	20.6	2.6	0.1	0.6	189
5128.5	20.9	5131.0	20.3	2.5	0.6	0.9	188
5107.6	19.7	5110.7	20.8	3.1	1.1	1.1	187
5087.9	21.1	5089.9	20.0	2.0	1.1	1.2	186
5066.8	20.7	5069.9	21.4	3.1	0.7	0.8	185
5046.1	22.2	5048.5	22.1	2.4	0.1	1.2	184
5023.9	22.5	5026.4	22.9	2.5	0.4	0.5	183
5001.4	23.3	5003.5	22.8	2.1	0.5	1.0	182
4978.1	24.7	4980.7	25.4	2.6	0.7	1.0	181
N.E. level	**thickness**	**S.W. level**	**thickness**	**variation level**	**variation thickness**	**variation in thickness 4 corners**	**course**
4953.4	26.5	4955.3	26.3	1.9	0.2	0.9	180
4926.9	20.6	4929.0	19.8	2.1	0.8	0.9	179
4906.3	20.1	4909.2	20.9	2.9	0.8	0.8	178
4886.2	20.3	4888.3	19.8	2.1	0.5	0.6	177
4865.9	20.5	4868.5	20.5	2.6	0	0.2	176
4845.4	20.3	4848.0	20.1	2.6	0.2	0.2	175
4825.1	19.7	4827.9	20.4	2.8	0.7	0.7	174
4805.4	20.8	4807.5	20.4	2.1	0.4	0.6	173
4784.6	21.2	4787.1	20.4	2.5	0.8	1.0	172
4763.4	19.7	4766.7	20.7	3.3	1.0	1.0	171
4743.7	20.8	4746.0	20.1	2.3	0.7	0.8	170
4722.9	20.5	4725.9	20.3	3.0	0.2	0.6	169
4702.4	20.0	4705.6	20.6	3.2	0.6	0.9	168
4682.4	20.6	4685.0	20.3	2.6	0.3	0.7	167
4661.8	21.2	4664.7	20.9	2.9	0.3	1.0	166
4640.6	21.4	4643.8	21.9	3.2	0.5	0.5	165
4619.2	25.8	4621.9	24.9	2.7	0,9	1.4	164
4593.4	22.1	4597.0	23.0	3.6	0.9	1.0	163
4571.3	23.8	4574.0	23.4	2.7	0.4	1.2	162
4547.5	20.7	4550.6	21.0	3.1	0.3	0.9	161
4526.8	21.5	4529.6	21.2	2.8	0.3	0.3	160
4505.3	20.6	4508.4	21.3	3.1	0.7	0.7	159
4484.7	21.6	4487.1	21.0	2.4	0.6	0.6	158
4463.1	21.2	4466.1	21.4	3.0	0.2	0.7	157
4441.9	21.3	4444.7	20.8	2.8	0.5	0.6	156
4420.6	20.5	4423.9	21.3	3.3	0.8	0.8	155
4400.1	21.8	4402.6	21.2	2.5	0.6	0.7	154
4378.3	22.2	4381.4	22.6	3.1	0.4	0.8	153
4356.1	23.0	4358.8	23.4	2.7	0.4	0.5	152
4333.1	24.4	4335.4	24.9	2.3	0.5	0.6	151

N.E. level	thickness	S.W. level	thickness	variation level	variation thickness	variation in thickness 4 corners	course
4308.7	26.6	4310.5	26.1	1.8	0.5	1.2	150
4282.1	21.7	4284.4	22.2	2.3	0.5	0.8	149
4260.4	21.9	4262.2	21.7	1.8	0.2	1.7	148
4238.5	22.1	4240.5	22.8	2.0	0.7	1.5	147
4216.4	23.9	4217.7	23.1	1.3	0.8	1.2	146
4192.5	24.2	4194.6	26.2	2.1	2.0	2.4	145
4168.3	31.1	4168.4	28.9	0.1	2.2	2.2	144
4137.2	20.9	4139,5	21.9	2.3	1.0	1.8	143
4116.3	23.1	4117.6	22.0	1.3	1.1	2.0	142
4093.2	21.0	4095.6	21.5	2.4	0.5	1.2	141
4072.2	21.7	4074.1	22.3	1.9	0.6	0.9	140
4050.5	25.5	4051.8	24.6	1.3	0.9	0.9	139
4025.0	25.7	4027.2	26.4	2.2	0.7	1.1	138
3999.3	22.3	4000.8	23.7	1.5	1.4	2.0	137
3977.0	23.7	3977.1	22.4	0.1	1.3	1.3	136
3953.3	21.2	3954.7	21.8	1.4	0.6	1.0	135
3932.1	22.8	3932.9	21.9	0.8	0,9	0.9	134
3909.3	21.5	3911.0	22.1	1.7	0.6	0.7	133
3887.8	23.2	3888.9	23.1	1.1	0.1	0.9	132
3864.6	24.9	3865.8	24.8	1.2	0.1	1.2	131
3839.7	26.6	3841.0	26.3	1.3	0.3	1.1	130
3813.1	22.1	3814.7	23.4	1.6	1.3	1.4	129
3791.0	22.8	3791.3	22.8	0.3	0	1.5	128
3768.2	22.6	3768.5	22.9	0.3	0.3	0.4	127
3745.6	23.0	3745.6	23.0	0	0	0.5	126
3722.6	24.8	3722.6	24.0	0	0.8	1.8	125
3697.8	24.3	3698.6	23.4	0.8	0.9	1.9	124
3673.5	26.4	3675.2	27.2	1.7	0.8	1.6	123
3647.1	26.0	3648.0	26.7	0.9	0.7	0.8	122
3621.1	29.1	3621.3	28.8	0.2	0.3	0.4	121
N.E. level	**thickness**	**S.W. level**	**thickness**	**variation level**	**variation thickness**	**variation in thickness 4 corners**	**course**
3592.0	29.8	3592.5	29.3	0.5	0.5	0.9	120
3562.2	31.8	3563.2	32.3	1.0	0.5	0.8	119
3530.4	35.6	3530.9	34.9	0.5	0.7	0.7	118
3494.8	22.4	3496.0	23.2	1.2	0.8	1.4	117
3472.4	27.1	3472.8	26.3	0.4	0.8	1.0	116
3445.3	22.1	3446.5	22.7	1.2	0.6	0.8	115
3423.2	23.0	3423.8	22.1	0.6	0.9	1.0	114
3400.2	23.2	3401.7	23.9	1.5	0.7	1.0	113
3377.0	24.1	3377.8	23.0	0.8	1.1	1.1	112
3352.9	22.9	3354.8	23.6	1.9	0.7	1.0	111
3330.0	23.2	3331.2	23.3	1.2	0.1	0.6	110
3306.8	26.6	3307.9	26.6	1.1	0	2.0	109
3280.2	29.3	3281.3	29.4	1.1	0.1	2.0	108
3250.9	24.8	3251.9	24.8	1.0	0	1.0	107
3226.1	25.0	3227.1	24.5	1.0	0.5	0.7	106
3201.1	26.4	3202.6	26.6	1.5	0.2	1.1	105
3174.7	26.3	3176.0	26.5	1.3	0,2	0.8	104
3148.4	29.3	3149.5	28.9	1.1	0.4	1.1	103
3119.1	27.4	3120.6	29.3	1.5	1.9	2.0	102
3091.7	33.5	3091.3	32.4	0.4	1.1	1.6	101
3058.2	35.6	3058.9	34.3	0.7	1.3	1.3	100
3022.6	38.3	3024.6	39.0	2.0	0.7	1.1	99
2984.3	37.5	2985.6	40.9	1.3	3.4	3.8	98
2946.8	26.0	2944.7	22.7	2.1	3.3	3.5	97
2920.8	23.0	2922.0	23.9	1.2	0.9	1.1	96
2897.8	25.6	2898.1	25.3	0.3	0.3	1.4	95
2872.2	26.1	2872.8	26.2	0.6	0.1	0.2	94
2846.1	29.4	2846.6	29.3	0.5	0.1	1.6	93
2816.7	33.1	2817.3	31.9	0.6	1.2	2.1	92
2783.6	34.3	2785.4	35.5	1.8	1.2	1.7	91

N.E. level	thickness	S.W. level	thickness	variation level	variation thickness	variation in thickness 4 corners	course
2749.3	38.5	2749.9	38.2	0.6	0.3	1.2	90
2710.8	22.7	2711.7	23.2	0.9	0.5	0.6	89
2688.1	23.1	2688.5	22.4	0.4	0.7	1.2	88
2665.0	21.9	2666.1	22.7	1.1	0.8	1.0	87
2643.1	26.3	2643.4	26.0	0.3	0.3	0.7	86
2616.8	22.9	2617.4	22.8	0.6	0.1	0.1	85
2593.9	27.8	2594.6	27.8	0.7	0	0.3	84
2566.1	22.6	2566.8	22.7	0.7	0.1	0.2	83
2543.5	23.3	2544.1	23.1	0.6	0.2	2.3	82
2520.2	23.2	2521.0	23.5	0.8	0.3	2.0	81
2497.0	24.1	2497.5	24.1	0.5	0	0.5	80
2472.9	23.1	2473.4	23.5	0.5	0.4	1.0	79
2449.8	23.7	2449.9	23.4	0.1	0.3	2.1	78
2426.1	25.5	2426.5	23.9	0.4	1.6	2.5	77
2400.6	23.6	2402.6	24.8	2.0	1.2	1.5	76
2377.0	29.0	2377.8	29.3	0.8	0.3	0.5	75
2348.0	30.4	2348,5	30.5	0,5	0.1	1.5	74
2317.6	25.3	2318.0	25.9	0.4	0.6	1.3	73
2292.3	25.8	2292.1	26.1	0.2	0.3	0.5	72
2266.5	28.8	2266.0	28.1	0.5	0.7	1.5	71
2237.7	27.8	2237.9	28.1	0.2	0.3	1.9	70
2209.9	32.4	2209.8	31.2	0.1	1.2	2.0	69
2177.5	30.6	2178.6	31.7	1.1	1.1	1.4	68
2146.9	35.0	2146.9	34.0	0	1.0	1.7	67
2111.9	23.7	2112.9	24.3	1.0	0.6	1.3	66
2088.2	26.2	2088.6	25.5	0.4	0.7	0.7	65
2062.0	25.6	2063.1	26.1	1.1	0.5	0.8	64
2036.4	26.0	2037.0	26.2	0.6	0.2	0.9	63
2010.4	24.4	2010.8	25.0	0.4	0.6	0.6	62
1986.0	26.2	1985.8	26.4	0.2	0.2	0.3	61
N.E. level	**thickness**	**S.W. level**	**thickness**	**variation level**	**variation thickness**	**variation in thickness 4 corners**	**course**
1959.8	28.1	1959.4	27.7	0.4	0.4	0.4	60
1931.7	28.7	1931.7	29.6	0	0.9	0.9	59
1903.0	28.6	1902.1	25.6	0.9	3.0	5.5	58
1874.4	22.5	1876.5	25.0	2.1	2.5	5.2	57
1851.9	24.8	1851.5	24.8	0.4	0	0.1	56
1827.1	25.3	1826.7	25.1	0.4	0.2	0.5	55
1801.8	25.7	1801.6	25.3	0.2	0.4	0.4	54
1776.1	25.6	1776.3	25.6	0.2	0	0.3	53
1750.5	26.3	1750.7	26.5	0.2	0.2	0.6	52
1724.2	26.6	1724.2	26.5	0	0.1	0.5	51
1697.6	28.0	1697.7	28.1	0.1	0.1	0.2	50
1669.6	31.2	1669.6	31.4	0	0.2	1.8	49
1638.4	35.5	1638.2	35.1	0.2	0.4	2.5	48
1602.9	35.6	1603.1	34.9	0.2	0.7	1.1	47
1567.3	27.3	1568.2	28.2	0.9	0.9	0.9	46
1540.0	37.9	1540.0	38.1	0	0.2	0.4	45
1502.1	41.1	1501.9	41.1	0.2	0	0.3	44
1461.0	33.3	1460.8	32.1	0.2	1.2	1.2	43
1427.7	28.0	1428.7	29.4	1.0	1.4	1.5	42
1399.7	30.9	1399.3	30.7	0.4	0.2	0.3	41
1368.8	31.9	1368.6	31.8	0.2	0.1	0.6	40
1336.9	33.9	1336.8	33.8	0.1	0.1	1.1	39
1303.0	36.3	1303.0	36.3	0	0	0.8	38
1266.7	38.2	1266.7	38.0	0	0.2	0.4	37
1228.5	41.1	1228.7	41.8	0.2	0.7	0.7	36
1187.4	49.8	1186.9	49.2	0.5	0.6	1.1	35
1137.6	26.2	1137.7	26.3	0.1	0.1	0.1	34
1111.4	26.3	1111.4	26.2	0	0.1	0.4	33
1085.1	26.3	1085.2	26.0	0.1	0.3	1.0	32
1058.8	27.8	1059.2	28.3	0.4	0.5	0.6	31

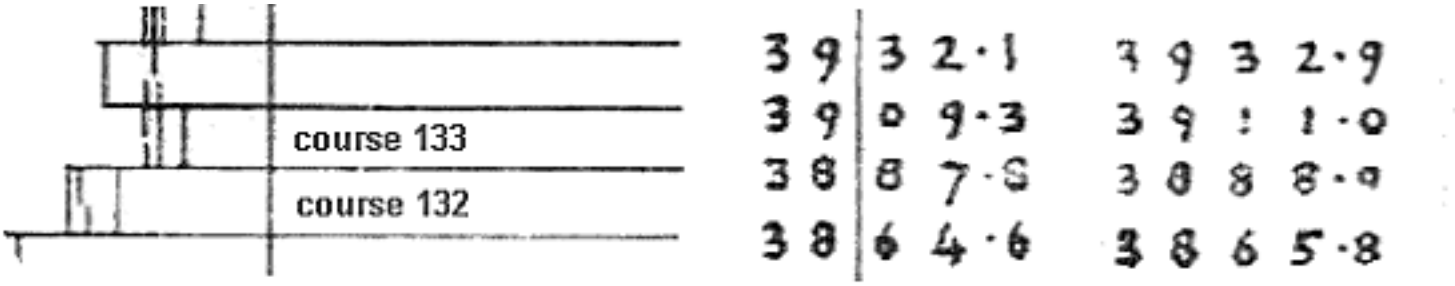
N.E. level	thickness	S.W. level	thickness	variation level	variation thickness	variation in thickness 4 corners	course
1031.0	28.2	1030.9	27.8	0.1	0.4	1.5	30
1002.8	28.1	1003.1	28.0	0.3	0.1	0.4	29
974.7	29.2	975.1	29.2	0.4	0	0.8	28
945.5	29.7	945.9	29.6	0.4	0.1	0.8	27
915.8	30.8	916.3	31.2	0.5	0.4	0.5	26
885.0	32.3	885.1	32.4	0.1	0.1	0.2	25
852.7	32.4	852.7	32.3	0	0.1	0.3	24
820.3	33.0	820.4	33.1	0.1	0.1	0.7	23
787.3	34.5	787.3	35.1	0	0.6	0.8	22
752.8	23.8	752.2	22.5	0.6	1.3	1.3	21
729.0	23.5	729.7	24.1	0.7	0.6	1.0	20
705.5	38.1	705.6	39.1	0.1	1.0	1.5	19
667.4	31.1	666.5	31.1	0.9	0	0.6	18
636.3	28.0	635.4	28.3	0.9	0.3	0.6	17
608.3	28.9	607.1	28.1	1.2	0.8	0.8	16
579.4	29.3	579.0	28.2	0.4	1.1	1.4	15
550.1	29.4	550.8	29.2	0.7	0.2	2.9	14
520.7	29.8	521.6	25.7	0.9	4.1	4.4	13
490.9	29.7	495.9	34.0	5.0	4.3	6.6	12
461.2	33.7	461.9	32.6	0.7	1.1	1.1	11
427.5	36.0	429.3	37.7	1.8	1.7	3.4	10
391.5	36.4	391.6	34.2	0.1	2.2	3.2	9
355.1	37.8	357.4	34.9	2.3	2.9	5.2	8
317.3	39.2	322.5	44.1	5.2	4.9	5.3	7
278.1	38.0	278.4	39.6	0.3	1.6	2.0	6
240.1	40.2	238.8	38.9	1.3	1.3	2.2	5
199.9	44.0	199.9	44.5	0	0.5	0.8	4
155.9	48.2	155.4	45.4	0.5	2.8	5.1	3
107.7	49.1	110.0	52.4	2.3	3.3	4.9	2
58.6	58.6	57.6	57.6	1.0	1.0	2.4	1

Continue

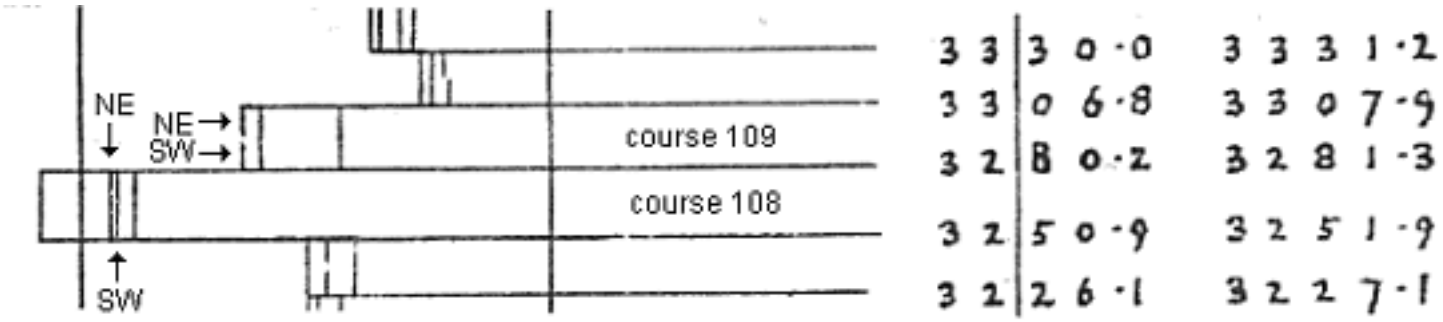
NOTES :

A. Petrie gave two levels for course 2. on the S.W. ie, 110.0 and 110.2. Only the first has been entered.

B. It was thought necessary to alter the S.W. level of course 132 from 3888.0 (as read by a number of investigators) to 3888.9 (illustrated below). The "level" data is for the top of each course. Petrie's thickness bars (to the left) for courses 132, 133 support the figure 3888.9, not 3888.0.

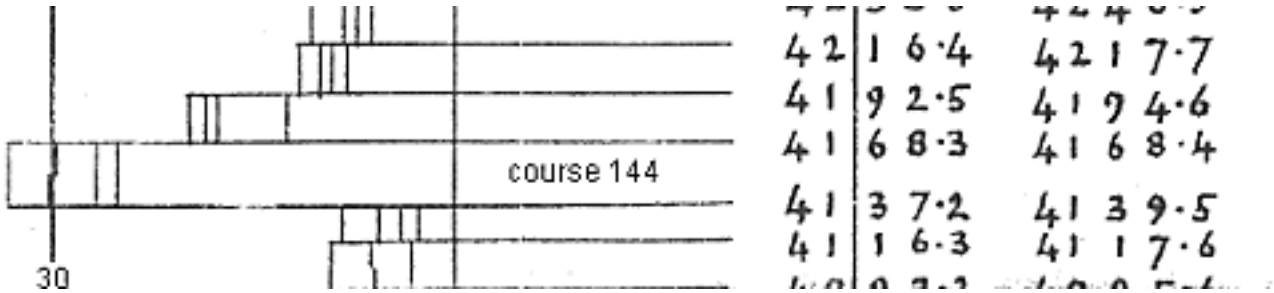


C. All of the horizontal thickness bars from the previous page have been re-measured and compared with Petrie' course levels, to see if, (1) they are correctly represented on the page, and, (2) to see if it can be found which bars relate to the NE and SW corners. As there is only one chance in six that Petrie's NE and SW data reflect the greatest thickness variation for each course most of the entries in the four corner column above will be greater than his. In some cases the total variation for individual courses far exceeds the data given by Petrie, courses 108 and 109 for example. In these two cases the NE and SW thicknesses have been identified as those represented by two bars very close together and greatly separated from at least one other.



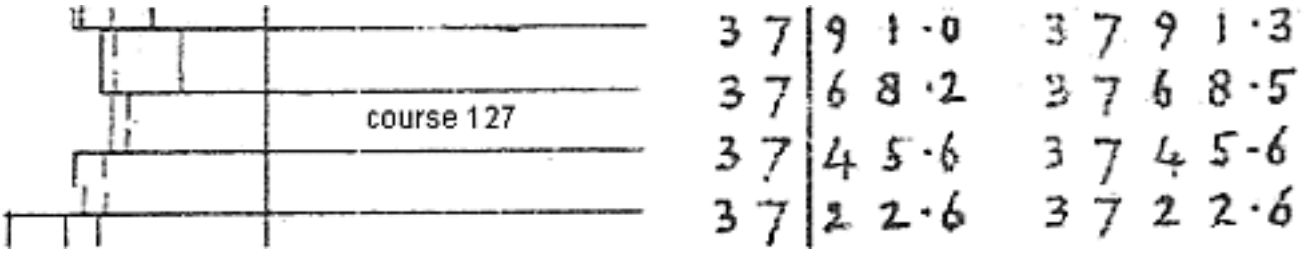
After looking at all the courses and their horizontal thickness bars the following was also found :

1. Course 144 has 5 corner entries marked in. The top bar (far left) is consistent with Petrie's NE reading and the bar second from the bottom the SW reading. Taking the bottom bar to be a correct entry the variation in thickness seems a little excessive (2.7 inches and the largest of the top 100 courses) so we suspect that this might be the odd one out. If not, then the other two corners of the pyramid are represented by the bottom bar and one of the two bars (?) hugging the 30 inch level.
Don't forget that the figures to the right of the illustration relate to level at the top of each course. Variation in thickness has to extracted, first, one over the other, and then across.

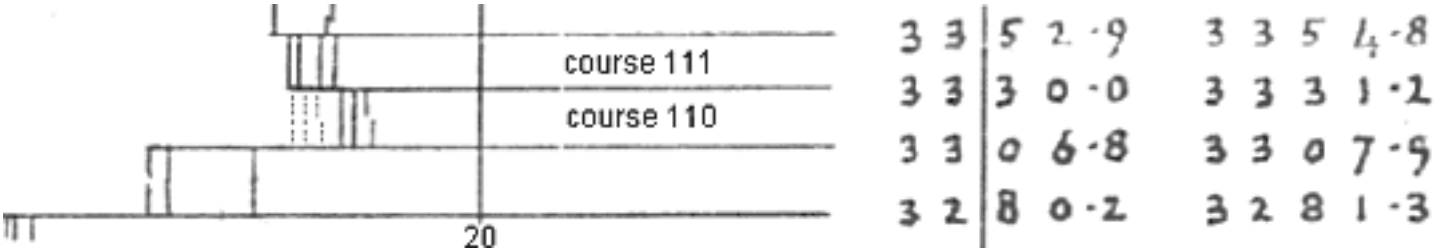


Continue

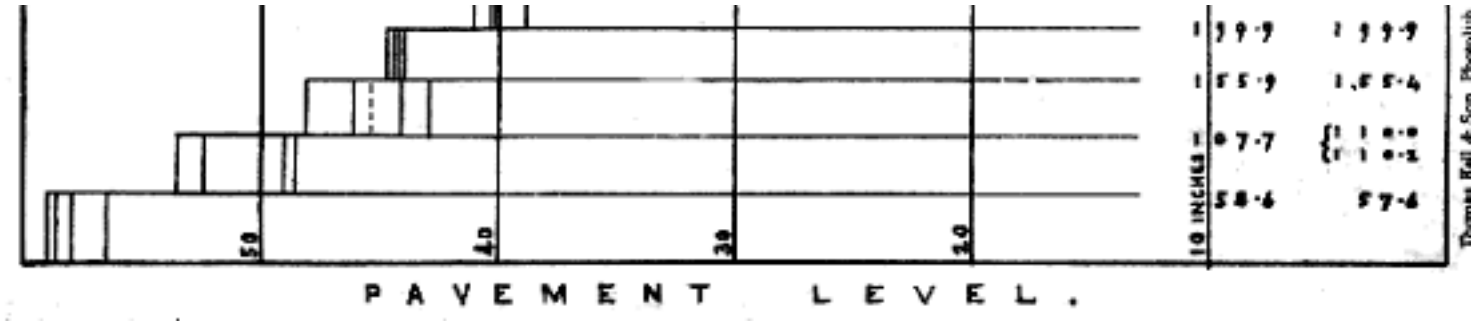
2. The missing bar for course 127 (Petrie's NE reading) should have been entered about midway between the bars illustrated



3. All the bars for course 110 have been wrongly placed. Petrie must have misread the distances 23.2 and 23.3 or 3,2 and 3.3 respectively above the 20 inch level. Our best guess is that all should be raised (as a block) to the dotted lines illustrated. It is presumed that the NE and SW thickness readings represent the two half bars 1/10th of an inch apart.



4. Course 3 ---- The top bar (far left) agrees with Petrie's level for the NE corner but the next bar underneath is wrong for the SW reading and should be lower as illustrated by the dotted line. The large variation in level across the platform (course 2) was corrected with course 3 (almost). Note the huge improvement with thickness when course 4 was laid.



The errors listed above are not the only ones. Minor bar placing discrepancies also occur for courses 124 and 125 and a number of other courses towards the base and it is here that we must realize the hazards of transforming columns and columns of data into illustrated bars.