necessary in all surveys, was the measurement of the base line, namely, the length and breadth of the building. This was done with steel tubular measures compared, at the time of measurement, with the thermometer, from which also long deal rods were graduated for the measurement of the heights, and for general purposes. The iron rods were carefully compared by Mr. Simms, both before and after my return, with his standard, and I give the results as delivered at Athens. They are still subject to a very minute correction, but not worth troubling you with at present.

As soon as the weather allowed, and the requisite permission was obtained from the local authorities, I proceeded to hoist a scaffolding at the east-end, of which I made an entire circuit, beginning with the three columns which are standing on the north side, and ending with the south-east angle column.

In this examination we plumbed every column, measured every stone of the architrave, the capital, and upper and lower stones of each column, in every direction; took careful measurements of all the cracks which have in any way modified the original form, and obtained levels of all the lines of the entablature at fixed points; and finally examined the entasis of five different columns, taking several sections of each.

We then migrated to the west-end, where I contented myself with making an exact examination only of the two angular columns, which positions enabled me to obtain the levels of the upper members of the western part. I also took all such measurements in the western part as my examination of the eastern part had pointed out to me as necessary to arrive at the exact original state. I then proceeded to examine the upper members of the Posticum, and the arrangement of the Tympanum, which has some peculiarities worth notice connected with the support of the statues. Then the roofing, the ceiling, and lastly, the original painting, engaged our attention.

This work in the upper part of the building was naturally very much exposed to wind, &c. It often happened that while it was impossible to do any accurate work on the scaffolding, we might be employed profitably below. But frequently it was altogether out of the question to go up to the Acropolis at all. The pavement was of course levelled in every part and several times over, until the whole system worked perfectly together, and I could satisfy myself that I had got the exact curve in every instance, or at least within one or two thousandths. We also took such measures as sufficed for the accurate position and proportions of the cella, with the arrangement of columns within it. This sums up our proceedings at the Parthenon, which occupied nearly five months. The Propylæa occupied a considerable share of attention, and I searched the Temple of Theseus to find how far it was analogous to the Parthenon.

Last, but not least, we ascended the Temple of Jupiter Olympius, from which we obtained various measurements and drawings. I have now nothing to do but actually to mention the measurements obtained, and I shall venture to hint at their intentions, where I have been able to form any thing like a theory on the subject.

The measurements of the breadth of the temple on the upper step, at the east and west ends, I found to be, respectively 101·341 and 101·361,—north and south, 228·141 and 228·154 respectively. This exceedingly small difference in measures which were certainly intended to be equal, points out the limit of error, which can be attributed solely to inaccuracy of measurement in other dimensions, namely, about 1 in 5,000. I may just observe that I found my wooden measures, notwithstanding they had been previously saturated in oil, subject to a fluctuation in various states of the atmosphere rather greater than this amount. So that, had the eastern front of the Parthenon been set out with deal rods on a dry day, and the western on a moist day, we should have had as great a difference between them as actually exists. I simply mention this to point out that the equality of the two ends is as great as wooden measures, under certain circumstances, could ensure.

It follows that all quantities which tend to proportionality must be looked at with great suspicion, in which varieties exist sensibly greater than this small admissible error.

I will take as my example the proportion between the fronts and flank, measured on the upper step. I prefer adopting the measure from the eastern end, on account of the greater religious importance of the first.

This is very nearly in the proportion of 9 to 4 or $3^2:2^2$. Had it been only 228·017, it would have been exactly so; instead, we have 228·147, if we adopt a mean between the measurements of north flank and south, and which gives a difference of ·130 between the probably intended proportion and the actual measurement. Again, the proportions of the cella, also measured on upper step, are 193·739 and 71·331. This suggests the proportion of 19 to 7, which would have held exactly, had the length of the cella step been only 193·612. The flank is, therefore, exactly as much too long as in the other case of the upper step of the peristyle, supposing the two assumptions of proportion to be correct.

These two tendencies towards a mark, and missing by exactly the same small quantity and in the same direction, strongly confirm the hypothesis that the mark was aimed at in both these cases, and that they were both deflected by the same cause. I think I could point out what the cause was, but I have already, I fear, exhausted your patience on a point of comparatively small importance. I will just point out the way in which the position of the cella seems to have been determined. My proof that it was so rests in the exactness of the proportions by which I have worked it out, and that it seems a very simple and natural method.

To bring a case of a proportion that may be admitted at once without any cavil, I will take the interior dimensions of the Naos, 98·04, 63·01; had it been 98·016, it had been exactly in proportion of 14 to 9: the difference here is only ·024 or $\frac{1}{4000}$. And again, the interior of the opisthodomus, or treasury, which is between walls, 63·01 by 43·767. Had it been 43·750, I would have had the exact proportion of 36 to 25, or $6^2:5^2$, the difference in this case being $\frac{1}{2500}$. This may be fairly admitted, particularly as it is a geometrical ratio. I will now mention an approximate proportion, which I am not so ready to entertain.

The breadth of the Temple of Theseus is 45·011, and its length is 104·23. The former is almost exactly in proportion of $\frac{4}{9}$ths of the breadth of the Parthenon: this, I think, was intended.

But a difficulty occurs if we attempt to proportion the front with the flank on the upper step. It has been suggested to try the equilateral triangle. That, however, notwithstanding its being near enough the mark to suggest the trial, leaves a quantity = ·282 unaccounted for at the end; and, besides, I do not find that in the Parthenon there are any affinities whatever to that figure.

I very much prefer to descend from the upper step, and try the proportions on the second. By this addition, the flank becomes 106·63, and the front 47·41.

We now obtain a proportion of 9 to 4, differing from exactitude by so small a quantity as to be fairly admissible.

It is somewhat remarkable that the quantity 1·066 is found frequently in the measures of the Erectheum.

The proportion of solids to voids is 4522 to 1000, nearly as 9 to 2.

I have now stated the principal larger proportions: I will state a few others, which are the more important secondary ones. A very happy artifice is the walls of Pronaos and Posticum being thicker than the cella walls.

The height of the columns of Parthenon is exactly $\frac{3}{20}$ length of temple on upper step, the breadth of the abacus of six of the eastern columns is exactly $\frac{1}{15}$ breadth of temple; they are not all equal, but I have given the dimensions of those at the eastern end, which always gives the key to the main proportions.

In the Temple of Theseus, the column is exactly $\frac{18}{100}$th of length of temple on the lower step, and the abacus $\frac{1}{12}$th of the breadth on the upper step. In both, this member appears to be the unit of measure for all the details.

The whole building is most accurately proportioned in every part, and I think it not unlikely that it will be possible to find a standard which shall express every dimension without any incommensurable fractions.*

F. C. PENROSE.

* The remainder in our next.

USE OF CEMENT IN CONSTRUCTION.

SIR,—What I am about to say is founded on several years' experience in the almost exclusive and extensive use of cement; and I can prove its efficiency, when properly used, in building columns, as at Euston-square station. If columns are built with good cement, hard bricks, and properly bonded, they are capable of sustaining as much weight as ordinary building stones; and the entablatures (if built in cement properly, with bricks, all stretchers, and iron-hoop bond) may be made as strong, or stronger, with proper iron bearers, than a stone entablature; but the way in which irons are put in make them frequently causes of defects in entablatures, and often useless. It is not necessary to use iron over small openings; but over wide openings, where they are used, they should camber and have tension rods to them, and be made to take the abutment of the brickwork. The way in which brickwork in cement is *generally* done is very bad indeed; for I say, and can prove it, that not one bricklayer in a hundred understands or uses cement properly; and many of the builders themselves, not being practical men in this department, know less, especially in this matter. The chief cause is the degenerated state of brickwork, brought on by ruinous competition; and yet many architects encourage it, by accepting tenders, however low. Instead of accepting the lowest, if the medium price were adopted it might be considered the most fair price, and low enough, too, for it is certain that when a man takes a job so very low, every possible advantage is and will be taken, frequently bringing trouble and discredit on the architect, who, not always being on the spot, cannot see or know what is going on; even if there is a clerk of the works, he is not competent to understand every branch, particularly if he is by trade a carpenter, as most of them are. The system is to go in and win; and every advantage is afterwards taken of plans and specifications to make extras. The quality of the work is not considered,—the quantity is the chief thing required of the workmen; and he that can pack the bricks in a wall the quickest is generally esteemed the best workmen; and the railway works have made many that go merely by the name of bricklayers not worth half their wages, and not noticed in a crowd at large jobs.

I have known brick and cement work tendered at 14*l.* per rod, and brick in mortar at 10*l.* per rod, prime cost; and I am sure that brick and cement work cannot be done properly in any case for less than 15*l.* per rod prime cost; and in most cases where cement is used for strength, not so little as that; and if it is not done tolerably well, good mortar may as well be used, and in some cases better: for good mortar will harden, and spoiled or bad cement will not. It is a general practice where brickwork is to be cemented, that bad bricks are used with the idea that any sort will do to put cement on; but it requires good hard bricks, and where bricks are intended to be used in cement, they should be washed clean, and for particular works one by one; but what is generally done is to throw a few pails of water over a heap, and that neither soaks nor cleans them, and then the cement will not adhere to them. In particular jobs, every cask or at least every load of cement should be tried before using, for most of the cement that is made so cheap is very bad and unfit for anything. This precaution is necessary even where a better price is given for it, as it sometimes happens that it is stale or injured by damp, and in order to test the abilities of a workman in the use of cement, let him stick up some bricks flat against the face of a wall, and if he can bring out seventeen with the ends upwards, or twelve with the edges upwards, he may be considered an efficient workman; although I can shew twenty-two end upwards, and fifteen edge upwards, stuck up within the last ten days, without any other support than their adhesion to the wall, and in *Roman* cement (*not* obtained for the purpose).

Much has been said about bond, to which I wish to add a little, and recommend it to be 1-16th inch thick, and $1\frac{1}{2}$ inch wide, and one layer to each half-brick thick, viz., three to a brick-and-half wall: when laid in two or three courses of bricks, all stretchers, well cleaned and wetted,