Anglo-Saxon Timber Building Measurements: Recent Results

By P. J. HUGGINS

THE METHODS of analysis of Anglo-Saxon timber building plans and the use of the 5.03 m (16 ft. 6 in.) rod have been explored previously. The use of a shorter rod was identified tentatively at Thetford and now, at 4.65 m long, positively at Mucking. The use of both rods is discussed at Yeavering, Mucking, West Stow, Thirlings, Cowdery's Down, Northampton, Springfield Lyons, Wicken Bonhunt, Raunds, Bishopstone, Catholme and Cheddar. Nineteenth-century records in the Elbe-Weser region of Germany show rods, extant at that time, with an average length of 4.63 m. It is thus possible that the origin of the shorter Anglo-Saxon rod might be sought in the Germanic homeland of the Anglo-Saxons. The rods seem to have been divided into thirds and sixths, and the possible use of even smaller measures is considered. The implications of the widespread use of standard measures in Anglo-Saxon England are discussed. The awkwardness of the English medieval system of linear measurement may have been due to the amalgamation of elements of both of the two Anglo-Saxon systems.

The study is concerned with detecting what measuring system or systems may have been in use in Anglo-Saxon England for the setting out of timber buildings. F. Petrie[1] was the first to state the methods to be followed; these are to look for repeated dimensions in a series of buildings and to look for simple relations of the ratio length/width for a particular building. Petrie said, 'if laid out by a measure, the unit may generally be detected'. He also warned that 'it is fruitless to look for a precise norm of each standard', this means not trying to work to unwarranted precision, by for instance quoting results to too many significant figures; for example an estimated length of 11.8 m, meaning that it lies closer to 11.8 than 11.7 or 11.9 m or implying that it lies between 11.75 and 11.85 m, is preferable to quoting the length as 11.83 m, for this would mean that one was sure of its length on the ground to the nearest half centimetre and this precision is unattainable in practice.

The original study[2] began because W. J. and K. A. Rodwell at Rivenhall[3] and the author at Nazeingbury,[4] both in Essex, were simultaneously recognizing the recurrence of measurements approximating to 16 ft. 6 in. (5.03 m) between post centres in the ground plans of Anglo-Saxon buildings; moreover it was noted at both sites that the primary subdivision of this measurement appeared to be into thirds and it soon became clear that it was further divided into sixths. This measurement was the same as the medieval rod, pole or perch which survives historically as a

quarter of 'the acre's breadth' (4 rods × 1 furlong = 1 acre) and today as a quarter of the length of a cricket pitch. In the original publication the term 'Northern' was used for a measure of 5.03 m, this term was adopted by Petrie but it will not be used further; the term '5.03 m rod' now used has no geographical connotation.

The sole aim of the original study was to see if this rod measurement occurred in other published Anglo-Saxon building plans. The broader possibility to be explored is whether a complete and coherent system, or systems, of measurement can be detected in the building plans. In particular it is of interest to see how far backwards in time any system can be extrapolated. Particular results may be doubtful and interpretations uncertain, but the method as such can never be said to be 'void' as was claimed by M. Millett.[5]

The process is one of trying to determine the design size of a building from the pattern of post-holes or timber marks on a published plan. The study is based on the fact that some of these plans show a regular pattern of holes or timbers to indicate that the building was 'professionally' set out to a measured plan. The primary technique involves using a transparent rule so as to draw by eye the 'best' line to suit the centres of all the posts in a wall; this is equivalent to drawing a graph between a series of points all with an unknown amount of experimental error. The human eye is very efficient at achieving the best straight line and the process itself tends to cancel out many of the possible errors in planning, measuring, digging, excavating and recording; thus many of the uncertainties, which worry critics of the method, are effectively negated at the start of the analysis. The mean length and width of a building can then be measured between the appropriate wall lines as established above. There is no pre-supposition that the building is perfectly square.

It was not suggested that the 5.03 m rod was the sole measure used for building layout in Anglo-Saxon England; the study was purposely selective of those buildings which seemed to fit this measure. As work has progressed, in particular at Mucking, Essex, it became clear that a 4.65 m rod was also in use extensively for building measurements. Rods of this length were extant into the 19th century in N. Germany.

The study also suggests how, if it was clear that a particular measure was in use, a partial plan of a building can in some instances be extended to a full reconstructed plan. The two examples from Nazeingbury[6] are included to show such reconstructions which depended heavily on mathematical considerations. The example of Building 5 at Rivenhall[7] is a case where only 13 out of a possible 34 post-holes were considered sufficient to postulate a single substantial building. It is in the case of partial plans that consideration of measurements may be of special use in aiding the interpretation.

A secondary technique, for less regular plans, involves drawing a grid on transparent material; the grid is marked in rods, thirds and sixths of whatever measure is being tested. By offering it up to the plan, drawn to the same scale, it is often possible to achieve a reasonable register with the posts, or the centre of the post-holes, so as to suggest the design size of the building in question. In the case of a building set out of square the length and width have to be considered separately by skewing the grid around a little to suit the evidence of the plan.

PROBLEMS AND UNCERTAINTIES

When Millett wrote that the data used in the original work was very selective, he was possibly influenced by J. T. Smith[8] who, writing on the principles of inference, castigates excavators and others for offering three-dimensional reconstructions of buildings without using all the excavated evidence; this is clearly a valid criticism. This should not be extended to preclude analysis of particular building plans.

In considering partial plans, one may need very little evidence to reconstruct the whole plan. If there is evidence of a rectangular building, then one would know the size without any surviving corners; likewise two diagonal corners alone would suffice. It is a question of how little information one needs as a minimum, not how much.

James[9] was concerned about the effect of possible errors; we should talk of differences or uncertainties because we know nothing of 'true' values of length or width to which an error could apply. There is doubt about the standardization of the rods used over the whole country, the accuracy of their use, the precision of digging post-holes and of positioning posts. There is uncertainty that post-holes have been excavated properly, where a post was positioned in a hole or pit, that it has been recorded accurately and there is further uncertainty in measuring from the published or working plans. If we were measuring from one post to another, each of these uncertainties would affect the accuracy of the measurement, but the likelihood is that some uncertainties would cancel out others. Fortunately many doubts about particular post centre positions are negated in drawing the 'best' straight line through the post centres and then measuring the distance between the lines. The proposed techniques allow discrimination between the two systems discussed and identification of results which do not conform to either system.

The greatest danger is of systematic uncertainties or ones which are not randomly plus or minus, such as would arise from using a measuring rod with a broken end, or wrong published scales. Then the results will be wrong, but this would not apply for all time or over the whole country.

Perhaps the greatest problem in reconstructing units of measurement is knowing what dimensions were actually measured and why. This means understanding which are the basic design dimensions and excluding secondary dimensions which may not have been measured; for instance post spacings may be entirely dependent on the timbers which happened to be available, one would not therefore expect to find fossilized evidence of the measuring system in use from such dimensions.

In these analyses there is no need for complex statistical processes. Most of what is needed can be done graphically with some measure of central tendency, such as a mean value, and of dispersion with standard deviation. Graphical methods such as the histogram in Fig. 1 come into the realm of *descriptive statistics* which is concerned with the simple organization and presentation of data.[10] In the present work, where there is mixed data from two or more systems of measurement, this is the best approach. Attempts have been made by computer to detect 'modules' in numerical data from buildings where one measuring system was in use[11] but they were bound to fail because data other than the basic design measurements were included.[12]

Proving that a particular measuring system was in use is not possible. No hypothesis can be proved by experiment, it can be tested and verified at each test but never proved. The idea could only be proved in some other way such as the discovery of a calibrated and dated metal rod with a statement that it was used for building layout. That the 5.03 m and 4.65 m rods were in use for building measurement in Anglo-Saxon England will remain only an hypothesis. So far the idea has gained support as each new site has been analysed. The sites discussed below, with only one exception, lend support to the hypothesis. It is not suggested that the two rods above were used exclusively and there must be no pressure to force new data into either system. Also it is no detriment to the above systems if future data suggests other systems of measurement were in use as well. It is hoped that excavators will analyse sites for themselves using their data, if good enough, to detect their own standard measures; and if not to see if either of the two systems above appear to have been used.

RECENT RESULTS

Here entirely new results are given in detail and some results, published since the original essay, are summarized since they have relevance to the developing story.

YEAVERING, NORTHUMBERLAND

The buildings at Yeavering were analysed by Hope-Taylor[13] in terms of what he termed Yeavering-units. Later work[14] attempted to show that the 5.03 m rod was in use there and was evident in many of the plans. In particular, in the plans of the two A3 buildings, which to Hope-Taylor were anomalous because they 'did not lend themselves to detailed extension of this metrological enquiry'.

E. C. Fernie,[15] writing of 'the weakness of the Yeavering-unit', said, 'Any unit must be suspect which is restricted to one site and which has no independent existence, either in texts or among surviving measuring rods. The perch or rod which Huggins substitutes satisfies both these criteria, as it is known at a number of other sites, is attested in numerous documents and is, indeed, the modern perch of 5½ English yards'.

An interesting point about building A4 is that it was altered during construction to dimensions fitting the 5.03 m rod. Thus one measuring system was apparently being changed to another. There is just the hint here that the earlier system was based on a much shorter rod of 3.77 m; this possibility can be borne in mind in the north and possibly elsewhere.

MUCKING, ESSEX (Fig. 1)

Because of the crucial information from the building plans at Mucking, the results are presented again here. Although the Mucking excavation data is not fully processed, post-hole groups have been drawn to suggest at least 66 ground-level Anglo-Saxon post-hole buildings, though the final publishers may not accept so many. Four plans have been published;[16] three of these appeared to suit the 5.03 m rod but the other, although quite regular, definitely did not. Both the primary and secondary methods of analysis have been used here at different stages of the study.

The full group of 66 buildings includes many with partial plans, but 70 primary measurements of width and/or length were extracted and can be compared with the 5.03 m scale (Fig. 1 bottom). It can be seen that the largest column is of thirteen measurements in the range 4.6 to 4.7 m and these clearly do not relate to the 5.03 m scale; these are the repeated dimensions which Petrie knew were of special significance. By considering the whole sub-group of measurements between 4.5 and 4.8 m a mean value of 4.65 m is obtained with a standard error of the mean of 0.014 m; this can be used to infer that there is an 85% likelihood

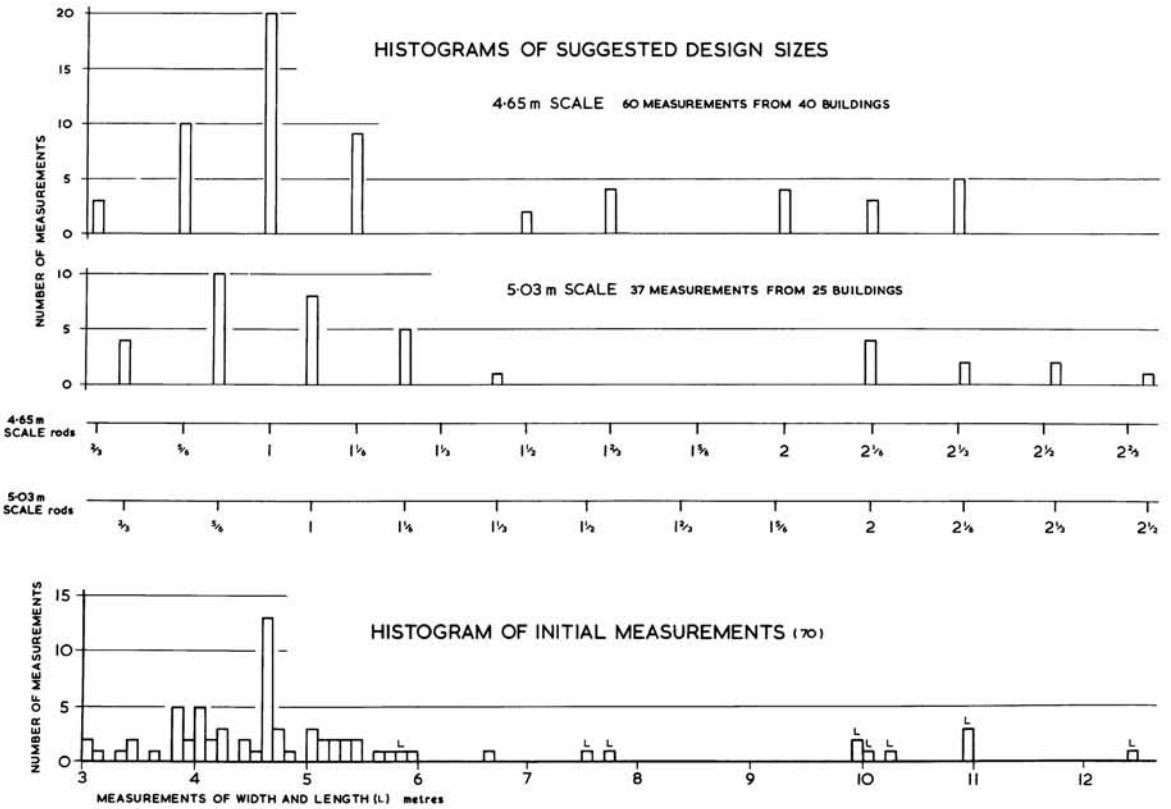

FIG. 1

Mucking building data. At bottom: histogram of raw initial measurements between centre lines of parallel rows of posts. Above is the 5.03 m scale, which many measurements do not fit, and the 4.65 m scale which was deduced from these latter measurements. At top: histograms of suggested design sizes of 65 buildings, these were obtained by offering up scaled grids of each measuring system to the post-hole groups; these histograms contain more data than was initially considered measurable for the bottom histogram

that the mean lies in the range 4.63 and 4.67 m. A 4.65 m rod was certainly in use and most of the buildings were designed using this; a 4.65 m scale is added to Fig. 1 with its thirds and sixths as before. At the higher end of the scales it is seen that measurements from the two systems tend to coincide but fortunately at the lower end the discrimination is good. Fortunately, with a length, there is usually an associated width so that the larger dimensions can also be apportioned to one scale or the other.

Using scaled grids it was possible to assign 65 of the 66 'buildings' to one unit or the other. Thus 40 buildings or 62% are judged to have been designed to the 4.65 m rod and 25 or 38% to the 5.03 m rod. Histograms of the suggested design measurements, obtained by using the grid method, are included at the top of Fig. 1. The top two histograms have not been derived from the raw measurements, but by the grid method. More measurements have been established by the grids than were measureable as raw data, thus augmenting the data base.

With the use of the grids, it is difficult to say what range of error is accepted. However, if one grid fits the other certainly does not. The interpretation will to some extent depend on the experience, confidence and honesty of the worker; fortunately all the work can be repeated by others.

Whether or not the use of the two systems implies a hiatus in occupation is not known. The two groups of buildings do not separate geographically on the site plan. Mucking, on the Thames estuary, is in the area of primary Anglo-Saxon settlement in England. See later for rods extant in the 19th century in the Germanic Elbe-Weser homeland with a mean value of 4.63 m.

WEST STOW, SUFFOLK

Three buildings were published in the interim report,[17] but it now appears that the metric scales added to the plans were in error so that the original analysis[18] must be ignored. The full publication[19] includes fourteen plans some of which are partial and confused. Possible design sizes can now be postulated for eight of the buildings with a possible width for another. The published plans are small so that they were enlarged reprographically and the grid method was used. The scales added are short so that even a width cannot be checked easily.

Building 1 is important because it is clearly a 2:1 building (length:width) and is equally clearly 1⅔ of the 4.65 m rod long and this shows that it must have been designed ⅚ rod wide (with the wrong scale it was judged to be the same dimensions but in the 5.03 m system). This was the first building analysed which indicated that rods were divided into sixths as well as thirds; this conclusion stands in spite of the scale problem. Building 5A, although of different form is another probable 2:1 building and, if so, is the same size. These two buildings alone show that the 4.65 m rod was in use at West Stow. It is confirmed by the post-holes of Building 7 which are set[20] at a pitch of 12 ft. 9 in., for this is ⅚ × 4.65 m to within 0.5%; there are five versions of this building,[21] but using just the posts shown, as in version 2, the building would measure 3⅓ × 1⅔ of the 4.65 m rod.

Building 2 is less amenable to analysis because there are groups of double posts. It certainly does not suit the 4.65 m rod. The mean width is ⅚ × 5.03 m but the length is a little less than 2 × 5.03 m. With regard to Building 4, if one was sure there were no further posts to the east or west this would class as 2 × 1 of the 4.65 m rod with the posts narrowing off somewhat on the N. side at the E. end. All the other buildings are smaller. Buildings 10, 11 and 13 seem consistent with the 4.65 m rod, the one-rod dimension occurring as the largest measurement of Buildings 11 and 13. Building 14 is a little structure which does not suit the 4.65 m rod, if there should be no more post-holes then it fits ⅚ × ½ of the 5.03 m rod quite well.

At West Stow the 4.65 m rod was certainly in use for most of the buildings. If it had not been known that this rod was used in Anglo-Saxon England it is unlikely that this site alone would have yielded this fact.

THIRLINGS, NORTHUMBERLAND (Fig. 2b)

Two of the Thirlings buildings have been published: A[22] and B[23] both had vertical posts in trenches linked by vertical plank filling. Of the total of seven buildings five are of this type and two of posts in holes.[24] It is difficult to decide how a post-in-trench, hereafter called trench-built, building was measured out. If the line of the wall was marked out it would be destroyed by digging the trench. Also measurements to the outside or inside of the trench might have been used. Building B gives a clue; the posts appear approximately to suit measurements of 2⅓ × 1⅙ of the 4.65 m rod but a grid of 2 × 1 of the 4.65 m rod can be fitted inside the building just free of the trenches. That this rectangle is in more basic numbers suggests that setting out may have been achieved by the use of such an inscribed shape. Once such a basic rectangle had been marked on the ground, perhaps with sand,[25] or set out with cords, then the wall trenches could be dug just outside the lines of the rectangle and then the posts could be erected and positioned by measuring from the line with some small carpenter's measure. The beauty of an inscribed rectangle (or rhombus, if the corners are not square) is that marking cords could be left in position during the trench digging and post erection without the cords being misplaced or tripped over by the builders.

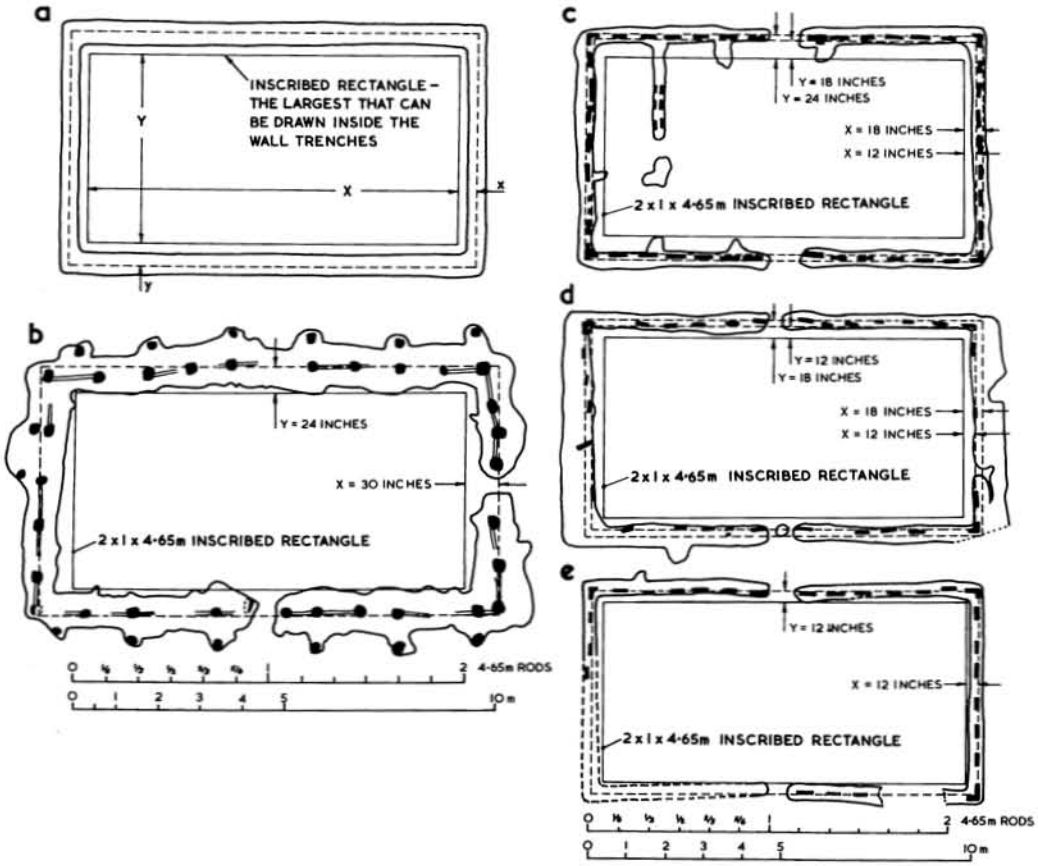

FIG. 2

Analysis of trench-built structures. *a*. Suggested method of using an inscribed rectangle for setting out; the basic X and Y measurements are shown with small offsets x and y for setting the timbers relative to the rectangle. *b*. Thirlings Building B showing the very basic 2 by 1 rod inscribed rectangle but with doubt about the small offsets. *c* to *e*. Cowdery's Down Buildings C9 to C11 respectively, again showing the very basic 2 by 1 rod inscribed rectangles with less certain offsets for positioning the timbers

At this stage the above hypothesis needs testing; testing here means seeing if the largest grid that can be fitted appears to be in basic rods and its subdivisions. The idea is illustrated in Fig. 2(a), the basic inscribed rectangle measures X by Y and the posts are set at offsets x and y from the rectangle. Thus the mean length and width become $X + 2x$ and $Y + 2y$, with the result that the building dimensions are not the primary measurements but can be called 'once-removed primary'; the word secondary has already been used differently.[26] If x and y are small measurements[27] in 'feet', or even smaller such as 'palms' and 'inches', then the overall building measurements may not be in the simple rod, thirds and sixths; also x and y do not need to be equal. Detailed analysis of all the Thirlings buildings cannot be given before the final publication of the site, but the application of the idea to the published Thirlings Building B is shown in Fig. 2(b).

The wall trenches of Building B, as excavated, are rather irregular and contravene the inscribed rectangle very slightly but one would assume the original trenches were dug without this irregularity. The x and y dimensions, in this case, may have been chosen by eye

as the posts wander. However, dashed lines have been included on Fig. 2(b) at positions where x = ⅙ rod (2½ 'feet', or 30 'inches') and y = 2 'feet' (or 24 'inches'). The result is that the overall length at 2 rods + 5 'feet' or 2⅓ rods is still a satisfactory number in the rods, thirds and sixths system whereas the width across the walls at 1 rod + 4 'feet' is not. Bearing in mind that if a building collapses post positions could be randomly misplaced, the fit of the dashed lines to the centres of the wall posts is not unreasonable.

The example of Building B is included here to illustrate the postulated method for the laying out of some, possibly most, trench-built structures. It illustrates the point that the basic design dimensions are to be found in the inscribed rectangle and not in the actual building size; the latter may not exhibit the basic measurements of rods, thirds and sixths. In applying this idea of a basic inscribed shape, no assumption is made that the building is squared up, it may be a slightly skewed rectangle (a rhombus) in plan.

Thirlings is seen to be yet another site where both the 4.65 m and 5.03 m rods were in use. Building B is one of spaced posts linked by vertical planking where the individual post centres may reasonably be considered to have needed to be kept in line; this contrasts with the Cowdery's Down buildings.

Cowdery's Down, Hampshire (Fig. 2c–e)

When the Anglo-Saxon buildings at Cowdery's Down were first studied[28] some years ago, no evidence of the 5.03 m rod could be found. This can now be quoted as a validation of the method in that buildings designed to one system are not, in general, confused with those designed to another; this can be cited in response to fears that many of the observed close fits are coincidence.[29] From ten buildings studied[30] none were judged a good fit to the 5.03 m rod although two near possibilities were listed.

With the discovery of the 4.65 m rod the position is quite different. Of fourteen measurable buildings, seven are of post-in-hole construction and seven are of post-in-trench, called trench-built, construction. Only two are judged to fit the 5.03 m rod, all the others seem to fit the 4.65 m rod.

Of the seven post-hole buildings, B4 is a splendid example[31] showing paired vertical planks in holes with square corner posts and outliers; other buildings with paired planks are thereafter called the B4 type. Building A1,[32] of B4 type, is a little uncertain at one end; it is 1⅓ of the 4.65 m rod wide and almost certainly 3 of the 4.65 m rod long with a square annexe at one end measuring 1 × 1 of the same rod, door post centres are close to ⅓ rod apart. Building A2 is represented by a part plan, it has B4-type holes but is particularly interesting, if the interpretative plan is correct,[33] in that it also shows the use of square posts, some to one side and some to the other side of the wall material itself, so that small and large holes are present for different types of posts in the same wall and, because of their different function, they are not quite in line; A2 is roughly 1⅙ of the 4.65 m rod wide and 2⅙ rod long if the doors are central. Only the opposite corners of Building A3, of B4 type, were seen;[34] the width is one 4.65 m rod, one end is probably an annexe 1 × 1 rod square. Building B4 itself is an almost perfect validation of the 4.65 m measuring system,[35] it measures 3 × 1⅓ rods and some post-holes, particularly the end ones, are at ⅓ rod pitch; it shows too how, in a fairly well-measured building, that some post-holes can be carelessly dug, as the pitch was not maintained, and ends can be out of square. It also shows, with paired vertical planks in holes, that the measurements to the centre of the paired group were the design measurements. Building B5 was represented by a few holes only, if the excavators opinion is correct it measured 1⅙ of the 4.65 m rod square.[36]

The plan of Building B6 is incomplete but there is enough to establish the size;[37] it does not fit the 4.65 m rod at all; the best fit to the centre of the post-holes is 3⅙ × 1½ rods of the 5.03 m system. If the one-sixth measurement appearing in the length of such a large building is considered strange, another possibility exists as discussed for Thirlings Building B, for trench-built structures, and this is that an inscribed rectangle was marked out and the post-holes dug by measuring offsets from it. This inscribed rectangle would be 3 × 1⅓ of the 5.03 m rod and is quite possibly the basic marked-out size. The offsets x and y each = 15

'inches'; however this method is not considered common for post-hole buildings. The last of the post-hole buildings, B/C15, with single planks in holes, is large, so that the measuring systems do not discriminate so well; however the best fit is $3\frac{1}{2} \times 1\frac{2}{3}$ rods of the 5.03 m system. The post-hole buildings demonstrate convincingly that the 4.65 m system was the predominant measuring system for these buildings.

The trench-built structures have previously been more difficult. The plans are not all complete and Building C8 has non-parallel sides and is considered unmeasurable.[38] The plans again show clear detail of the actual structural timbers, some have two rows of staggered vertical planks and others have discontinuous planks in single rows. Four of the buildings are large so that there is the problem of discriminating between the systems, but three, C9 to C11, are all small and superficially 2:1 in length:width. But C9 and possibly C10 are only exactly 2:1 buildings in terms of inscribed rectangles; both measuring systems were tried but in each case the largest rectangle measured 1×4.65 m wide and 2×4.65 m long. So the three buildings, which themselves are not quite the same size, suit this common identical inscribed rectangle. It is not easy to determine the offsets x and y from the inscribed rectangle to the timbers because one might measure from one side of a timber or the other or to the centre of a post position; however the possibilities for Buildings C9 to C11 are shown in Fig. 2(c) to (e).

The illustrations are from enlarged copies of the figures from Millett;[39] the timbers of C9 are clear, those of C10 and C11 are less clear with consequent difficulty in reproducing exact timber positions; outlying posts have been omitted and nothing is postulated about internal features. In each case the 2×1 inscribed rectangle of the 4.65 m rod is drawn inside the trenches. In the case of Building C9 (Fig. 2(c)) additional lines have been drawn at $x = 1$ 'foot' and $1\frac{1}{2}$ 'feet' (or 12 and 18 'inches') and at $y = 1\frac{1}{2}$ 'feet' and 2 'feet' (or 18 and 24 'inches'); most of the timbers lie between these lines, which are thus 6 'inches' apart whereas the timbers were recorded as about 4 in. thick. It is not possible to suggest whether measurements were made from the inscribed rectangle to the inside or to the outside of these timbers, so both possibilities remain. It does not seem likely that the mean, between the inside and outside dimensions, would be the measured dimension for these vertical planks.

For buildings C10 and C11 the positions are less clear. For C10 the side timbers are moderately distinct but a bit irregular. Offsets at $x = y = 1$ 'foot' and $1\frac{1}{2}$ 'feet' encompass some of the timbers, but not all, and from their skewed angle some have obviously been misplaced from their original position. For Building C11 there is less evidence of the timbers but the 2×1 inscribed rectangle fits once again but in the absence of many timbers, and because of the irregularity of those present, little else can be said.

From the published evidence of these three smaller, superficially similar, trench-built structures, the common element of the design is the 2×1 rod inscribed rectangle of the 4.65 m system. There is doubt, however, as to whether offset measurements were to the inside or outside of the timbers for these buildings.

It can be seen that this method of offsets and inscribed rectangle (or whatever shape is appropriate) is a very convenient way of setting out the main wall timbers of a trench-built structure and could be applied to post-hole structures as well, as mooted for Building B6 above.

For the larger buildings the size of the inscribed rectangles are judged to be: C7[40], $3 \times 1\frac{1}{3}$ of the 4.65 m rod; C12[41], could be either system, but suggest $4\frac{1}{2} \times 1\frac{2}{3}$ of the 4.65 m rod: C13[42], possibly $2\frac{1}{3} \times 1$ of the 4.65 m rod: C14[43]; suggest $4 \times 1\frac{1}{2}$ of the 4.65 m rod. Only in one case of these larger trench-built structures does the distance between the wall centre lines fit either of the scales in rods, thirds and sixths; this was C13 where the post centres suggest $2\frac{2}{3} \times 1\frac{1}{3}$ of the 4.65 m rod, this means that the offsets $x = y = \frac{1}{6}$ rod.

Of the total of 14 measurable Cowdery's Down buildings, 12 appear to fit the 4.65 m rod, some, including the three small trench-built structures, conclusively. The other two seem to fit the 5.03 m rod and, as at Mucking, this suggests that the two systems were in use on the same site. The analysis is particularly satisfactory because the published plans are of a large size.

NORTHAMPTON, NORTHAMPTONSHIRE (Fig. 3)

The 'palace' at Northampton is a rectangular trench-built structure with a smaller annexe at each end, there are fairly regularly spaced posts of possible square section. The middle Saxon timber building is beautifully published[44] on a loose sheet at a scale of 1:80. The figure given for the length of the hall, between post centres, is 16.7 m and for the width 8.35 m. These measurements are $3\frac{1}{3} \times 1\frac{2}{3}$ rods in the 5.03 m system to within less than 0.5%. In this case the inscribed rectangle, using the grid method, was found to be $3 \times 1\frac{1}{3}$ of the 5.03 m rod with offsets $x = y = \frac{1}{6}$ of the same rod. If there was a name for the $\frac{1}{3}$ rod measurement this hall would measure 10×5 of such measures to within 0.5% and thus, at 2:1 in length:width terms, could be considered more basic than the inscribed rectangle; this does not, of course, invalidate the idea of the inscribed rectangle which is well-supported elsewhere.

The excavators attempted a metrical analysis applicable specifically to this building.[45] The idea was based on the assumption that the individual posts were measured distances apart. However, the post spacings on the north side had a mean spacing of 622 mm with a standard deviation of 98 mm. At the 95% confidence level this means a possible uncertainty of ± 196 mm in 622 mm or ± 31%. The present author feels that with this degree of variation, there is little certainty that the individual posts were measured out; and, if they were, there is such carelessness evident that the mean measurement cannot be used as the basis of any analysis. The excavators stress the idea of regular spacing of the posts and note that the posts are paired or that there are the same number, apparently, on each side of the hall; this seems to be the case although several are missing. There are 27 spaces if, as the excavators suggest, one considers the doorway as two spaces wide. The doorway is slightly off centre so there are 12 spaces (13 posts) to the west of the doorway and 13 spaces (14 posts) to the east. Mr Williams[46] feels that these 27 spaces must be reconciled with the suggested $3\frac{1}{3}$ rod length (50 'feet') and feels that 30 would have been more logical if the posts had been positioned

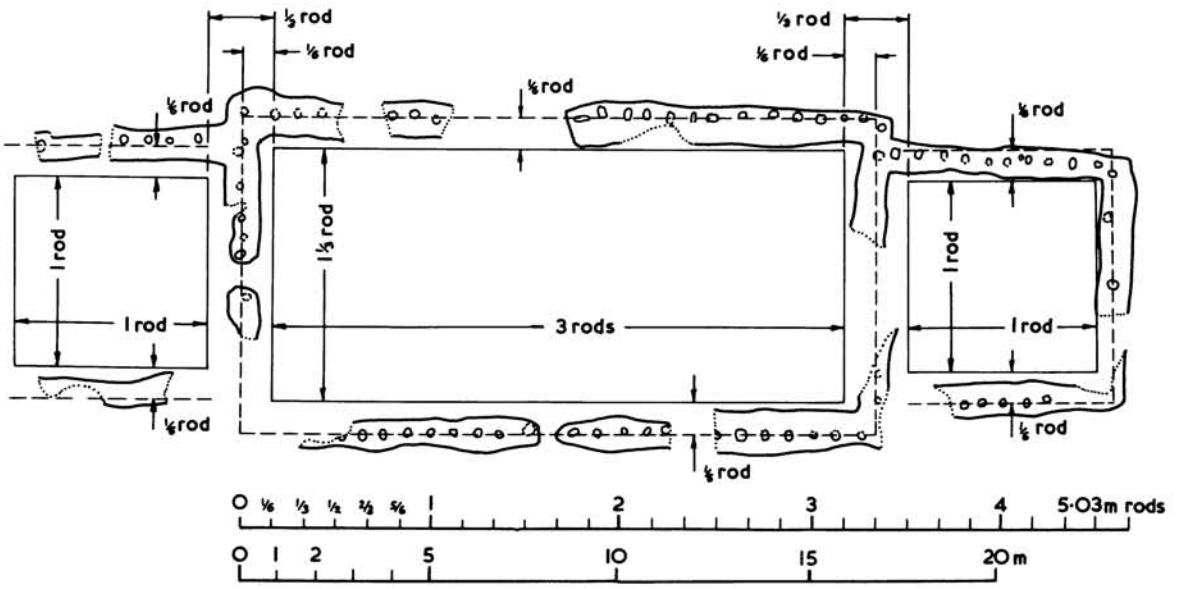

FIG. 3

Saxon palace at Northampton. Suggested use of measuring cords to form one rectangle and two squares for setting out. All the measurements, except for the end of the annexe, are the whole numbers of the 5.03 m rod, its thirds and sixths

according to the new ideas. Certainly the builders could have positioned the door centrally if they had desired or bothered so to do.

The excavators also stressed the importance of each fourth post because of the probable repair post set up at intervals as outlying shores to the structure; they took these supports to indicate the special significance of a four-post distance or a three-space length. Thus they arrived at a 'module' of 1.85 m which they applied to the length of the building but not the width. Neither the 'module' nor the post spacings seem to be related to the smaller divisions of the 5.03 m rod.

Only the eastern of the two annexes is well defined. The measurement for this is 6.35 m square so that the excavators' module does not relate easily to it. The annexe becomes meaningful in terms of an inscribed shape in the 5.03 m system, as it is just 1 rod square (see Fig. 3). The whole plan suggested here is of three separate inscribed shapes, a rectangle and two squares separated by a gap of $\frac{1}{3}$ rod.

SPRINGFIELD LYONS, NEAR CHELMSFORD, ESSEX

'Structures using a variety of construction techniques including earth-fast posts, post-in-trench and ground-beam forms of several phases' are reported.[47] The excavator has kindly supplied plans of the buildings and preliminary analysis suggests that both measuring systems were in use here but the 5.03 m rod was more common than the 4.65 m rod.

Parallel pairs of trenches here are more credible evidence of buildings because a rectangle 1 rod wide can be fitted between them. Measurements here should help the interpretation.

WICKEN BONHUNT, ESSEX

The settlement site of Wicken Bonhunt has evidence of at least 28 structures of middle Saxon date;[48] the author has kindly supplied plans of 21 of these, some very fragmentary. In the original analysis[49] six of these buildings were included as less-sure secondary evidence for the use of the 5.03 m rod, four were trench-built structures, B, C, F and H, with a little evidence of spaced posts, whereas N was a group of nine post-holes and M was the end of a post-hole building. The original results stand, but the 4.65 m rod and the use of inscribed rectangles for trench-built structures can also now be considered. For B, C and F inscribed rectangles of $1 \times \frac{5}{6}$, $\frac{5}{6} \times \frac{5}{6}$ and $2\frac{1}{3} \times 1$ rods respectively, all of the 5.03 m system, can be suggested.

There were only three well preserved trench-built plans, C and F above, and D. Building D did not fit the 5.03 m system but is a good fit to $2\frac{1}{2} \times 1\frac{1}{3}$ rods of the 4.65 m system and an inscribed rectangle of $2\frac{1}{3} \times 1\frac{1}{6}$ rods can just be fitted; this is a 2:1 rectangle. Six other structures, A, E, G, L, J and R, gave one or both dimensions which fit the 4.65 m rod.

When only searching for the 5.03 m rod six fits were found, but now seven fits are also suggested for the 4.65 m rod. Without the knowledge that the two rods were in use in Saxon England it is unlikely that Bonhunt would have provided this information.

RAUNDS, NORTHAMPTONSHIRE

A few building plans have been published from the complex site at Raunds;[50] the Anglo-Saxon evidence is divided into four groups. Buildings B and S are post-hole structures, many of the post-holes are very large and the precise line of the walls is not clear so no opinion is offered concerning the measuring system used. Trench-built structures F, G and H are shown on one drawing to a different scale: H has very wide trenches and again no opinion is offered. For F the trenches are somewhat irregular but wall dimensions fitting 2×1 rods of the 5.03 m system seem likely, an inscribed rectangle of $1\frac{2}{3} \times \frac{5}{6}$ of the same system may apply in which case the offsets are $x = 2y = \frac{1}{6}$ rod. The measurements are in a 2:1 ratio. Building G is small and square and its inscribed measurements may be $\frac{2}{3} \times \frac{2}{3}$ of the 5.03 m rod. The other plan has such a short scale that no measuring is justified. Here there is a little evidence for the use of the 5.03 m rod.

BISHOPSTONE, SUSSEX

This is a difficult site to analyse because most plans[51] are partial, several different scales are used and they are of inadequate length to measure even a width directly. In the original analysis[52] it was suggested that five measurements fitted the 5.03 m rod and that as many again fitted 'a shortened rod of about 4.6 m'; since then the 4.65 m rod has been defined.

Using the short scales, it is now suggested that only three measurements may fit the 5.03 m rod, buildings III, X and XI, with one dimension each. Four buildings are judged to suit the 4.65 m rod, I, XXVII, XXXIII and XXXV, the latter two with widths only. Building I, using minor posts for the east end, suits measurements of $2\frac{1}{2} \times 1$ of the 4.65 m rod fairly well, which makes it one of the 'double-square-excluding-door' category of plans; this is not the size considered to be the first phase of this building. Building XXVIII, a post-hole building, like all the others considered above, is not complete and contains difficult double holes, but ignoring two large holes at the east end which may represent an internal feature of the door, it measures 2×1 rods of the 4.65 m system. No opinions on the other buildings, including the only trench-built structure, can be given.

The results from this site are not very convincing but again seem to show that both measuring systems were in use. The last building mentioned, because of the 2:1 ratio, carries extra validity.

CATHOLME, STAFFORDSHIRE

At Catholme 66 buildings have been recognized;[53] less than half have been published. The largest plans are still very small[54] and they are drawn to several scales making the use of the grid method tedious. There are ten plans for which it may be possible to extract one or both design dimensions; these are Nos. 2, 3a, 3c, 3d, 13, 16, 17, 32, 34 and 36. No opinion is offered in the case of Nos. 34 and 36.

None of the buildings appear to have been designed to the 5.03 m rod. Three buildings fit the 4.65 m rod: trench-built No. 3c with a width of 1 rod; trench-built No. 2 with a width of $1\frac{1}{6}$ rod; and the post-hole structure No. 17 also with a width of $1\frac{1}{6}$ rod and a possible length of 2 rods. Smaller widths of postulated inscribed rectangles can be suggested for the trench-built buildings, 1 rod and $\frac{5}{6}$ rod for Nos. 2 and 3c respectively. This leaves two nearly complete plans, Nos. 13 and 16, both of post-hole construction; No. 32 of post-hole with trench; and Nos. 3a and 3d with partial plans of trench-built structures. In the original analysis[55] Building 16 was noted to be a 2:1 plan with dimensions which did not suit the 5.03 m scale, nor the more recently recognized 4.65 m scale, but rather indicated a local rod of 4.33 m. Using the grid method this has been taken further and the remaining five buildings seem to suit this latter measure. Building 13 measures $1\frac{2}{3} \times 1$ rods of 4.33 m closely; Building 16 measures $1\frac{2}{3} \times \frac{5}{6}$ rods quite well; Building 3a has a width of $1\frac{1}{6}$ rod; Building 3d has a width of $1\frac{1}{3}$ rod; and Building 32 has a width of $\frac{5}{6}$ rod.

This is the first site at which a measure other than the 5.03 or 4.65 m rods has been suggested, and so it remains tentative. The dimensions given by the excavator are often slightly larger than the measures extracted from the plans using the scales provided; it is not clear if this is because the excavator's measurements are external ones or because some of the scales were in error. When the remainder of the plans are available, hopefully larger and all to the same scale, it will be interesting to see if the position is changed.

CHEDDAR, SOMERSET (Fig. 4)

The main buildings at Cheddar were considered crucial to the identification[56] of the 5.03 m rod. The study of Cheddar can now be taken further using inscribed rectangles. As before, West Hall I, of posts in pits, measures $3\frac{1}{3} \times 1\frac{2}{3}$ rods of the 5.03 m system.[57] There are seven unequal 'bays' and these do not divide in a meaningful way. In 'feet' West Hall I measures 50×25. East Hall I, also of posts in pits, is an aisled hall with independently-structured aisles with presumed lean-to roofs; the aisles being unequal, the overall width is difficult to interpret. However the central 'nave', as before, measures $6\frac{2}{3} \times 1\frac{2}{3}$ rods of the

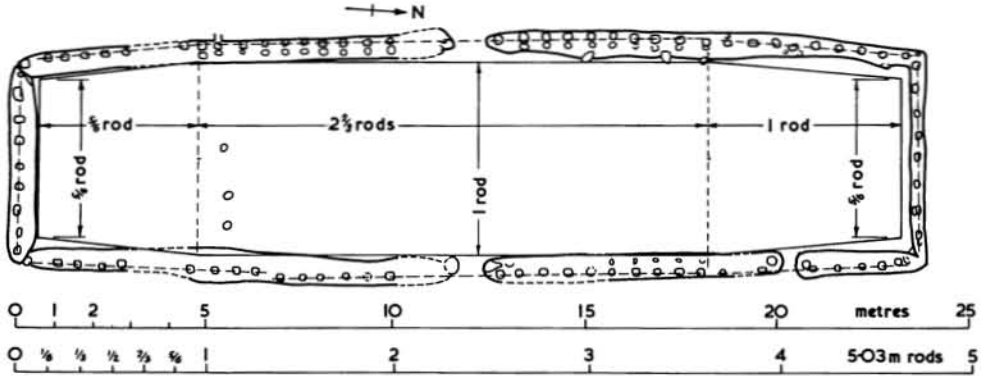

FIG. 4

Long Hall, Cheddar. Tentative suggestion for the use of measuring cords for setting out a re-interpreted form with a rectangular central part and tapered ends

5.03 m system or 100 × 25 'feet'.[58] Also the 'arcades' are of 10 bays so that the average bay length is a ⅔ rod or 10 'feet'. Therefore these two buildings suit the 5.03 m rod very well indeed. Two smaller buildings, both trench-built, suit the same rod in terms of inscribed rectangles; Building P accommodates an inscribed rectangle 1⅓ × 1 rods and Building S suits such a rectangle 1⅓ × ⅔ rods.[59] The wall lines of the small post-hole Building N are probably too uncertain to be measured;[60] the same applies to Building Z where the walls are not parallel.

The Long Hall did not fit the 5.03 m system so well as the other larger buildings, the mid-width, as it was originally called, being assessed, in the early work, as unacceptably 2% larger than 1⅙ × 5.03 m. There is no site evidence for the 4.65 m rod so the use of the 5.03 m rod can still be assumed. The overall length is fairly close to 4⅔ × 5.03 m (70 'feet'), but, being a trench-built structure, the use of inscribed shapes (compare Northampton above) must now be considered as a possible setting-out aid.

The Long Hall was classed as a bow-sided building with a first floor over the whole length;[61] this idea incorporated inner inward-sloping posts over the whole length although evidence of them was only found over the central part of the hall (see Fig. 4). The inner posts were considered to have supported an upper story as required by the evidence of fallen hearth material just to the S. of centre.

When straight lines are drawn between series of main wall posts it seems that the central part could be seen as made up of carelessly set straight elements (Fig. 4), with tapering ends beyond. If this idea is valid then the suggestion that the Long Hall was bow-sided can be set aside. The bow-sided appearance seems to depend on the form of the wall trenches themselves more than on the posts set in the trenches. Along the S. part of the E. wall the tapering, indicated by four posts, starts too soon; however, the trench was dug wide enough to accommodate the posts along their proper line, this extra width of trench, narrowing to the S. gives support to the re-interpretation here discussed.

The Long Hall has been re-interpreted as a 'double-annexed two-square' type of building.[62] This means a central rectangular hall previously called 'double-square-without-door' and with slightly narrower, but not apparently tapering, annexes at each end.

There was a variation in the quality of the evidence remaining but it may be right to accept the evidence of the excavation, certainly on the W. side, and to consider that the inner posts were present only over the central part where they were detected and were not present over the tapering ends where they were not detected; there is a difficulty here because trench widening on the inner side, associated with the inner sloping posts, also occurs at several places in the end annexes. However, the evidence of the tapered ends, taken alone, or

together with the absence there of inner posts, may suggest the ends were of different form to the central 'hall' and the new idea of 'annexes' at each end of a two-storey hall bears consideration. But the suggestion of James *et al.* of a central part of 'double-square-without-door' form does not take full account of the evidence of the length of the straight sides or of the less satisfactory evidence of the inner posts.

If, however, we do take account of the above evidence of the straight sides and the tapered ends, with the additional evidence of the inner sloping posts on the more complete W. side, and this means not continuing them under the S. chapel wall (where details are absent at the S.), then we have a central length of $2\frac{2}{3} \times 5.03$ m or 40 'feet' almost exactly, this out of a total length of $4\frac{2}{3} \times 5.03$ m or 70 'feet'. The data would be more convincing if the spare 2 rods were divided equally between the two tapering ends, but this is not quite so, the N. end being noticeably longer than the S. one. Asymmetry of the Long Hall is also evident in the non-central position of the side doors so perhaps it is not surprising that the ends are of different lengths; perhaps they had different functions.

At Goltho a 'bow-sided' building is possibly also not bow-sided, certainly the south side looks very straight over a central length of at least 13.5 m, possibly more, beyond that an end tapers in clearly.[63] This means there is no need to compare the Goltho hall, or the Cheddar Long Hall, with the buildings at Fyrkat and Trelleborg;[64] these Danish buildings are clearly circular-arc sided and the English buildings are certainly not so shaped.[65]

End 'annexes' are known at several other sites; such as Northampton, already discussed. But here in the case of the Long Hall the great difference is the apparant lack of end walls or partitions between the central rectangular part and the tapering ends. Three internal features, possibly post-holes, are included in Fig. 4; although roughly in line across the building, the holes are of different, and relatively shallow, depths and do not look credible as an indication of primary structural timber posts. The re-interpretation of the Cheddar building by James *et al.* in respect of the plan shape is interesting (they do seem to take account of the three possible post-holes mentioned above), but they do not take account of all the evidence, including that of measurements.[66]

Being trench-built, the Long Hall may have been set out with inscribed shapes laid out with cords or sand on the ground. A central rectangle $2\frac{2}{3} \times 5.03$ m long, to suit the 'straight' length (with the inner posts), is a starting point (see Fig. 4). A width of 1 rod just fouls the inside edges of the side trenches and this fact makes us consider if the inner sloping posts are primary to the design; the excavator certainly wondered if they were.[67] The inner sides of the wall-trenches showed partial sloping sides with well-defined vertical sides of a narrower trench below,[68] also the sloping posts bottomed at mid-trench depth so that overall they leave much doubt that they were primary to the design; in which case the wall-trenches would originally have been straight-sided and narrower so that the 1 rod wide inscribed rectangle can indeed be fitted in. Even if the inner posts were original they need not have been erected until the main wall posts were set up, thus the 1 rod wide rectangle could still have been used for setting the vertical timbers relative to the marking out cords which could then have been removed for the widening of the trenches for the setting of the inner posts. So a basic inscribed rectangle $2\frac{2}{3} \times 1$ rods of the 5.03 m system for the main straight-sided central part of the hall is feasible; the wall posts could have been set with smaller measures so that the overall width does not fit the 'round' number divisions of the 5.03 m rod. The y-offset from the sides of the inscribed rectangle to the wall centre lines is about 20 'inches' so that the overall width would be 1 rod + 2y or 1 rod + 40 'inches' which is just over $1\frac{1}{6}$ rods as stated at the outset. The rest of the possible inscribed shape layout shown in Fig. 4 is very tentative as nothing with trapezoidal shapes has been suggested before for other buildings; however the tapering wall lines follow the shape quite well with the y-offset being about 20 'inches as for the straight walls. The fact that the trapezia are different sizes could be due to a surveyor's error, after all it would be a fairly difficult exercise to lay out such a shape on the ground and the over riding consideration may have been to stick to a client-builder contract for a building of 70 'foot' length. Alternatively the N. end with the door and the possible staircase may have been made purposely longer for functional reasons.

The posts of the E. wall are not directly opposite those of the W. wall as instanced by the fact that the ends, shown dashed, of the inscribed rectangle do not relate squarely with the W. wall posts. Rather they suggest a slight skew, but maintaining a right angle was often a problem.

This is an interesting case study because, if the arguments are even partly valid, it can be seen that the study of the measurements makes one think about aspects which might not otherwise come to mind. In particular, and trying to avoid circular argument, this study may just tip the balance in favour of the inner sloping posts of the Long Hall being considered as a secondary emergency response to instability. This in its turn might lead to a re-consideration of the suggested use of individual tranverse frames in the reconstruction. The ends can hardly be seen as single storey due to the absence of partition walls (compare Northampton, Fig. 3 here) between them and the central two-storey 'hall' and so should probably not be called 'annexes' in this instance. We are left, in plan, with a hall having a rectangular central part with tapered ends. Cheddar dates from before the 10th century (the Long Hall) to the 12th century.

THE SMALLER MEASURES

Both the 5.03 and the 4.65 m rods have been shown to have been divided into thirds and sixths. These fractional parts of the rod have been called 'round' number measures because they are the largest basic divisions of the whole rod.

It has been implied that smaller units would have been needed to measure from the inscribed rectangles, postulated to have been used in the laying out of trench-built structures, to the wall posts. They may also have been used for the squared timbers of some of the buildings. However there is no certainty as to what these smaller measures might have been.

The conservatism of communities with regard to the retention of ancient measures is well known. It is also known that two measuring systems can be in use at the same time; the Roman Agrimensores recorded such among the Tungri, near Liège, in present-day Belgium.[69] There was the *decempeda* of 10 feet of 12 Roman inches each and there was the perch of 12 feet of 13½ Roman inches each. The larger foot was measured *ad manus* — by hand. So there was the standard Roman *pes monetalis*, related in some way to the foot we stand on and the larger local *pes Drusianus* measured by hand and of length about 13.1 modern inches. Grierson presents a recent discussion of these measures.[70] This example shows that an existing measure can survive in contact with an introduced measure, even one having a supporting bureaucracy.

One of the most awkward equalities found in measuring systems is in the 13th-century Statute for Measuring Land,[71] viz.:

$$5\tfrac{1}{2} \text{ elnes} = 1 \text{ perch (or rod)}$$

where the elne or ulna (later yard) is the new 'iron elne, of our lord the king'. This awkward equation can only have arisen because of the need to fit together two well-established units of measurement. This means combining the elne of 3 feet of one system with the perch or rod of the other. So it is possible that the two systems were being combined in the interests of standardization and the result is the system that survived, in Britain, into the 20th century (see Appendix).

The 5½ elne measure of 16½ modern feet is the 5.03 m rod which was the first to be detected in the Anglo-Saxon building plans. Now the 4.65 m rod is equally well

established from the plans. The analyses of the building plans shows that both rods were divided primarily into thirds. Therefore, if there is a relationship used by Anglo-Saxon builders, the number of feet in a rod ought to be a multiple of 3, so it would appear logical that there would be 15 contemporary feet in the Anglo-Saxon rod, or some other multiple of 3, and not 16 or 20 for instance. This would presumably apply to both rods. We have two rods and two sorts of feet so it would be logical to relate the longest feet, the manupes, measured by hand, to the longest rod. If 15 manupes = 1 rod of 5.03 m. then the manupes measures 13.2 modern inches or 335 mm; so we arrive at a reasonable comparison to the measure recorded in Belgium of 13.1 modern inches, in fact the record of the Agrimensores would probably only have been given to the nearest half Roman inch, so we may see the precise equivalent. There can hardly have been enough difference in the manupes measurement in England and Belgium to postulate 12 or 18 manupes to the rod. It is this evidence of the manupes, at about 13 modern inches long, which is taken to support the division of the 5.03 m rod into 15 manupes or feet (or 30 shaftments if the manupes was not used).

The manupes is first recorded in England in the 12th century but its half measure, the shaftment, goes back at least to the 10th century and at Rheims to the early 9th century, so it is permissible to consider the relationship of the manupes to the longest Anglo-Saxon rod.[72] The shaftment mentioned here is the measure of the width of the hand with the outstretched thumb, so that a timber could be measured by gripping it with the thumb outstretched and passing one hand over the other along the timber; this is a measure suited to the needs of carpenters and builders and may contrast with the needs of land measurement where stepping out with the feet may be more appropriate.

The division of the third of a rod measurement into the sixth can be achieved in two ways. Both hinged and sliding measures would be suitable. It is interesting that the Latin word *pertica* means both measure and flail and the latter is a leather-hinged implement. Such instruments can be compared with the hinged surveyors rod which was in common use before metrication, which was 5 feet long.

We have to keep an open mind on whether complete systems of measurement actually existed. Fernie feels that although feet and perches are mentioned in the same description of a piece of land in a 10th-century charter, this does not necessarily infer the existence of a system relating the two. He concludes by stating 'it is, then possible to say that the Anglo-Saxons used fingerbreadths, inches, feet, ells, perches . . . but there is no way of knowing in what way, if at all, they were related to each other'.[73] To this list could be added shaftments but whether the two-shaftment measure was called a manupes or was termed a foot is not of great concern.[74] The idea of the relationship of the hand measurement to this 5.03 m rod is not affected.

It is evident from excavations over the last 20 years that the Anglo-Saxon carpenter was very expert. The achievement in maintaining standard rods over hundreds of miles shows the need for standardization. It is hardly credible that the need did not also arise, for builders at least, to standardize the number of feet in these rods. It may also be likely that the extent of the king's peace 'to wit three miles and three furlongs and three (or nine) acre's breadths and nine feet and nine shaftments

and nine barleycorns' is listing the names in a system.[75] Relative to miles there is no point in mentioning barleycorns (three to the inch, which itself is not mentioned) for their own sake or even the shaftments; so as a real measurement the total is silly and the passage is perhaps seen as a poetic way of listing related measures. However Fernie has pointed out (see Acknowledgements) that measurements based on anatomical features are likely to be unrelated; this is almost certainly true as originally used or defined. What is probably important is that they would vary from person to person and this would supply the need for standardization, and some sort of calibrated measuring stick would develop with, eventually, an overseer with the duty and authority to see the standards were adhered to.

It is felt that the discussion above, together with the data in the Appendix, may be sufficient to demonstrate that some at least of the various measures were originally related in two separate systems and were later combined into one system with a little consequent adjustment. As a result of the suggested compromise some relic of each Anglo-Saxon system may have come down to us into the 20th century; the foot and the yard from the shorter 4.65 m rod and the 5.03 m rod itself. In what units the rods were originally calibrated, smaller than the sixth of a rod, is not known. However, at some time a consistent set of smaller measures did develop and remained in use into our present era.

Postscript: William of Malmesbury, writing *c.* 1125, records that, *c.* 700 A.D., Aldhelm brought back an altar stone from Rome which measured 4 ft. by 1½ ft. (*sesqui pedali*) by 3 palms (*trium palmorum*) thick. So the thickness is clearly less than a foot and this surely confirms that in William's mind there were 4 palms to a foot (information from F. Bottomly and K. N. Bascombe: see Rolls Series 52, 1870).

ORIGIN OF THE 4.65 m ROD

The measures used in Germany, including the Anglo-Saxon homeland, have been recorded by Meitzen.[76] He lists 38 examples of rods extant in the 19th century, varying in length from 2.5 to 4.97 m. If the data are considered geographically and numerically they fall mostly into four groups. There is a S. German group ranging from 2.5 to 3 m, a Thuringian group from 3.93 to 4.33 m, a western, Rhineland, group from 3.39 to 3.99 m. The largest group, widespread over NW. and central Germany ranges from 4.48 to 4.97 m; these have a mean of 4.63 m. Of this last group there are ten examples in the Elbe-Weser region of the Anglo-Saxon homeland (see Fig. 5): Bremen, 4.63 m; Brunswick, 4.57 m; Hamburg, 4.59 m; Hannover, 4.67 m; Heilingenstadt, 4.71 m; Hildesheim, 4.48 m; Kalenberg, 4.67 m; Lippe, 4.63 m; Schaumberg, 4.64 m and Schleswig, 4.66 m; to those can be added a more northerly example at Ostfriesland, 4.71 m. If the mean of all these is taken the value obtained is again 4.63 m, the range is 4.48 to 4.71, and more than half the values are within ±0.04 m, of the mean, or within less than 1%. This mean value is of course within 0.5% of the commonest rod extracted from the excavation plans at Mucking which is one of the primary settlement areas of the Anglo-Saxon peoples on the Thames estuary.

Since we know the use of the 5.03 m rod lasted from the Anglo-Saxon period to the 20th century it is equally possible that the use of the 4.65 m rod had lasted an

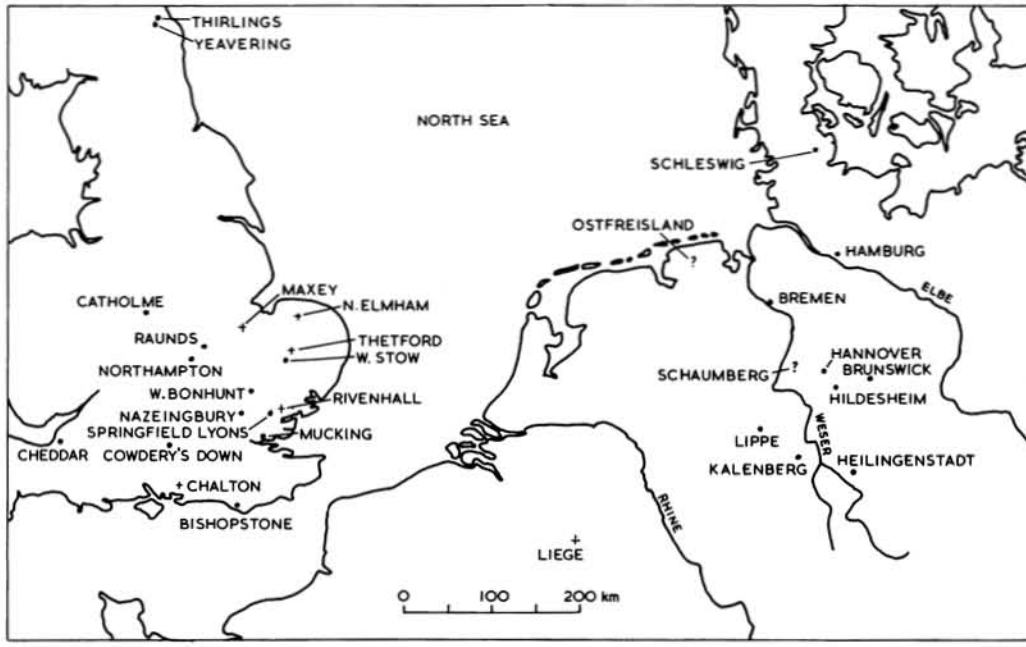

FIG. 5

Map of Northern Europe. Black dots in England mark sites discussed in this paper; crosses mark sites only discussed in the original paper (Huggins *et al.* 1982). Black dots in the Elbe-Weser region of the Germanic homeland indicate places where 19th-century rods averaged 4.63 m length; a cross marks Liège, whereabouts the Agrimensores recorded the local rod measured *ad manus*

equivalent length of time in Old Saxony. The suggestion is that the origin of the 4.65 m rod, found to have been used in England in the Anglo-Saxon period, can reasonably be sought in the Saxon homeland.

Verdenhalven has listed German measures in greater detail.[77] Seven of his examples have rods divided into 15 feet, although 16 is more common. In Anglo-Saxon England the division into 15 feet is suggested with the later compromise producing the 'rounding up' to 16½.

IMPLICATIONS

Since both the 4.65 and the 5.03 m rods have been found to apply over so much of England and have generally prevailed for building planning, it may be that the construction of major buildings was in the hands of a relatively small, closely knit, group of craftsmen with common working practices like the later medieval guilds. Alternatively it may have been that the local kings were able to exercise the necessary control over local builders; the responsibility for maintaining standard measures was later in the hands of the borough authorities and the church.

The situation may have parallels in the 16th-century Austrian Tyrol, where mining was supervised by officials called *schiner* who used the surviving measure called the *klafter* made from two pieces of squared timber which extended in brass

slides to twice the closed length;[78] extended this was the third of the 5.03 m rod to within 0.2%. This instrument was employed by a specialist class of overseers and would have been a 'staff of office'. It is possible there was a specialist class of carpenters or builders who controlled major building in Anglo-Saxon England.

The use of these standard measures tends to minimize the significance of any do-it-yourself element in major Anglo-Saxon building. In the cases of prestigious works as at Yeavering and Cheddar there can be no doubt that the work was controlled by professionals. This implies a builder–client relationship where the client would stipulate the design size of the buildings required so that careful measurement would have to be adhered to.

Since the 4.65 m rod has been detected in the Anglo-Saxon homeland, it is likely that this is the one which was brought over by the first settlers; it is the commonest measure at Mucking. As to the 5.03 m rod, one can postulate that it was the indigenous rod which was maintained in use. Since it was this larger rod which was still in use into the late Saxon period at Cheddar, and for the best, and presumably latest, buildings at Mucking, it must, in general, have gained the ascendency over the 4.65 m rod for building purposes; being related to the shaftment, it is clearly the builders' or carpenters' measure. As a rod it is the one which survived into the 20th century.

However, the smaller units of the 4.65 m rod may have become well established for other purposes so that, although the 4.65 m rod was superseded, the foot had to be incorporated into the compromise 13th-century Statute. No doubt, the carpenters or builders would have continued to use the measure best suited to their trade, the shaftment. Its definition in the 17th century is a testament to its continued use and usefulness.[79]

Whether or not the change of use of one rod to another, at a particular site, indicates a hiatus in Anglo-Saxon affairs is not known. At the large site of Mucking there was no geographical separation in the use of the two measuring systems. Perhaps all that is seen is the introduction of one measure into the land of another with both continuing in use side by side, and each having its own individual applications with the best measurement for timber gaining the ascendency for building.

Under this heading we can mention the implications for students of the Burghal Hidage. This early 9th-century record of fortifications and defence obligations in southern England effectively gives a record of the lengths of the fortifications.[80] The data are the areas in hides which supplied men to defend the ramparts. There were four men to the perch or rod length of fortification and each hide of land had to supply one man. Therefore Winchester at 2,400 hides supplied 2,400 men so that the length of fortifications should be 600 perches. Excavations have shown that the length of fortifications was 3,034 m, this gives the length of one perch as 3,034 ÷ 600 or 5.06 m. This, bearing in mind the nature of the problem, is unbelievably close to the rod of 5.03 m. For Wareham the resultant rod length is 4.98 m, again very close to 5.03 m. However, at Wallingford, where the manned length was also 600 perches and the measured length of fortifications is 2,769 m, the perch or rod length works out at 4.62 m;[81] this is so close to the shorter Anglo-Saxon rod of 4.65 m as to make

one wonder if both rods were used in the Burghal Hidage assessments. This is a matter for Burghal Hidage students.

CONCLUSIONS

The hypotheses, that rods of 5.03 and 4.65 m were used for setting out Anglo-Saxon timber buildings, are not universal like physical laws. They cannot be dismissed because there are buildings, or even whole sites, where these rods do not apply. Likewise they cannot be proved. They can only be tested on data, old and new. Workers may accept the propositions as reasonable or not. If accepted it will be on the basis of how often the 'round number' measurements appear in the results.

However, it is an undoubted fact that the consideration of measurements is a valuable aid in the interpretation of often confusing excavation plans and it is surely now obligatory to attempt it. We came back continually to Smith's principle of archaeological inference that all the evidence of a building must be considered in its study.[82]

There are several important sites being prepared for publication for which a study of measurements is relevant. For this work to be extended and replicated draughtsmen and editors must ensure that building plans are published at a decent size with scales of sufficient length to measure the longest dimension portrayed; representative fractions are unhelpful as they rely on precise reductions in printing. Comparable plans should be printed to exactly the same scale.

APPENDIX

Notes on the numerical data and units of measurement used

The 5.03 m rod is that in use to the present day (in the length of the cricket pitch: 4 rods = 1 chain = 66 ft.) and was the first detected from the analysis of Anglo-Saxon building plans. The 4.65 m rod was determined from Mucking building plans after being tentatively suggested for Thetford. It is also close to the average of a group of 19th-century rods from the Elbe-Weser region of Germany.

The basic division of both rods into thirds and sixths was determined from plans of excavated buildings. The further division of the 5.03 m rod into 15 feet or manupes is inferred from the documented continental length of the manupes.[83] The division of the 4.65 m rod into 15 shorter feet is assumed by comparison with the 5.03 m rod because both rods also have the third and sixth subdivisions in common. The further division of the feet into 4 palms is possible although there is no evidence. A shorter Welsh foot was made up of 3 palms in the 10th century; the Welsh documents record a whole system of related units.[84]

The division of the feet into 12 inches is assumed, remembering the 12 thumb-inches mentioned by Asser;[85] nothing can be said about the fingerbreadth or the ell.

The yard or elne of 3 feet is not included in the tables below, and perhaps it only applies in the 4.65 m rod system, as it does not relate sequentially to the other units. Perhaps it was derived for the measurement of a particular commodity. It must have been of special importance to have been retained as the non-conforming element of the 13th-century Statute.

The reader may be concerned with the mixture of decimal and fractional quantities in some statements such as 'the building measured $3\frac{1}{3} \times 1\frac{2}{3}$ rods of the 5.03 m system'. The mixture is intentional. The 5.03 m figure implies this measurement is 5.03 rather than 5.02 or 5.04. To write the number of these rods as decimals would require saying 3.33×1.67 or 3.333×1.667 and one would lose sight of the fact that these are numbers rather than

measurements. Since the rods are judged to have been divided into fractions this needs to remain clear.

The following tables of equivalences with metric measures (m and mm) and with English statute measures (ft. and in.) are given on the understanding that some of the 'Anglo-Saxon' units may not have existed. The listing of all possibilities is thought to be worthwhile since names from the Anglo-Saxon literature may, as a result, be recognized; in particular names for the third and sixth subdivisions of the rod would be valuable.

In the lists below there is no attempt to suggest that one inch of the 5.03 m rod was known to a tenth of a millimetre, this is just the way the equivalences work out. The number of significant figures quoted depends on accepted modern equivalents such as one modern inch = 25.4 mm and one modern foot = 305 mm.

5.03 m ROD

1 inch	= 27.9 mm or 1.10 in.
1 palm = 3 inches	= 83.8 mm or 3.30 in.
1 shaftment = 2 palms = 6 inches	= 168 mm or 6.60 in.
1 foot or manupes = 2 shaftments = 4 palms = 12 inches	= 335 mm or 13.2 in.
⅙ rod = 2½ feet = 5 shaftments = 10 palms = 30 inches	= 838 mm or 33 in.
⅓ rod = 5 feet = 10 shaftments = 20 palms = 60 inches	= 1.68 m or 5 ft. 6 in.
1 rod = 15 feet	= 5.03 m or 16 ft. 6 in.

The 'round number' appearance of the ⅙ rod and the ⅓ rod measures is noted in terms of shaftments, palms and inches.

4.65 m ROD

1 inch	= 25.8 mm or 1.02 in.
1 palm = 3 inches	= 77.5 mm or 3.05 in.
1 foot = 4 palms = 12 inches	= 310 mm or 12.2 in.
⅙ rod = 2½ feet = 10 palms = 30 inches	= 775 mm or 30.5 in.
⅓ rod = 5 feet = 20 palms = 60 inches	= 1.55 m or 5 ft. 1 in.
1 rod = 15 feet	= 4.65 m or 15 ft. 3 in.

If the idea of the amalgamation of the two systems is seen in the fitting of the shorter foot, and thus yard or elne, into the longer rod, then:

$$\text{Length of rod} \div \text{length of yard} = 5.03 \div (3 \times 0.31) = 5.41 \text{ yards}$$

and it is entirely reasonable to see this rounded up to 5½ yards per rod or perch. Thus the 16½ ft. rod of the 13th-century Statute for Measuring Land may have resulted as a compromise between the two early systems.

Grierson says, 'There seems to be no contemporary evidence for the length of the Anglo-Saxon rod — it is more usually called the "gyrd", from the yardstick with which it was measured — but there seems every reason to believe that the unit of about 16 feet was brought over at the time of the original settlements'.[86] He went on 'there may have been some rounding off to the nearest half foot . . . in the 12th century'. He gave no reason for these beliefs but overall presents a fair picture of what is here suggested to have happened.

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NOTES

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[7] See Huggins *et al.*, op. cit. in note 2, fig. 2.3.
[8] J. T. Smith, 'The validity of inference from archaeological evidence', in Drury, op. cit. in note 2, 7.
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[21] Ibid., 2, fig. 20.
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[23] L. E. Webster and J. Cherry, 'Medieval Britain in 1974', entry for Thirlings, *Medieval Archaeol.*, 19 (1975), fig. 90.
[24] Colm O'Brien, pers. comm., 1984.
[25] This technique is used today in engineering works.
[26] Huggins *et al.*, op. cit., in note 2, 43.
[27] We cannot be sure all these units existed but the assumed relationship, discussed later, is 3 'inches' = 1 'palm'; 4 'palms' = 12 'inches' = 1 'foot'; 15 'feet' = 1 rod.
[28] Using M. Millett, *Excavations at Cowdery's Down, Basingstoke: interim report* (Basingstoke and Deane Borough Council, 1980); with extra plans supplied by the author.
[29] James, op. cit. in note 9, 396.
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[38] Ibid., fig. 39.
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[57] P. Rahtz, *The Saxon and medieval palaces at Cheddar*, British Archaeol. Rep. Brit. Ser., 65 (1979); using a calibrated grid on fig. 47.
[58] Using the grid method on ibid., fig. 60 and following the interpretative plan fig. 61.
[59] Using the grid method on ibid., figs. 35 and 48 of slightly different scales.
[60] Ibid., fig. 34.
[61] Ibid., fig. 32.
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[64] Ibid., 115.
[65] Huggins *et al.*, op. cit. in note 2, figs. 2.9 to 2.11.
[66] James *et al.*, op. cit. in note 62, fig. 14.
[67] Evidence for the west side prepared from Rahtz, op. cit. in note 57, fig. 30.
[68] Rahtz, op. cit. in note 57, fig. 68. section CH3.
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[72] Ibid., 36.
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[86] Ibid., 22.

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