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Modular Planning in First-Century A.D. Romano-British Auxiliary Forts

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It is just over a century since John Ward suggested[1] that the Trajanic fort at Gellygaer was set out in units of five and ten Roman feet. His view was accepted and applied without question, it seems, by later excavators, e.g. by I.A. Richmond at Fendoch[2] and by A.H.A. Hogg at Pen Llystyn,[3] and remains the norm in recent studies.[4] The purpose of this paper is to argue that a re-appraisal is long overdue, to propose that at least one other modular unit was extensively used in the planning of Roman auxiliary forts during the first and early second centuries A.D., and to explore some interesting implications for Roman military design in general.

What evidence is there for the conventional view? The belief in 5 and 10 ft measurements apparently derived from the Polybian camp set out on the basis of 50 and 100 ft spacings, some of them forming the widths of streets.[5] But statements by Roman military writers show that 5 and 10 ft measurements were by no means always adopted in practice. In discussing the stationary camp (*castra stativa*), Vegetius points out that defensive ditches might be 9, 11, 13, or 17 ft wide depending on circumstances ('it is usual to keep to uneven numbers'), despite being checked by centurions with ten-foot rods (*decempeda*).[6] Procedures followed in digging ditches around campaign bases should not, of course, be transferred uncritically to permanent forts, though later parts of this paper will suggest that in planning terms the links may be closer than often supposed, an idea which receives strong support from Alan Richardson's recent work on Roman camps.[7] Richardson has also argued that permanent forts, following the Hyginian model, were set out using fractions of the *actus* (120 *pedes Monetales*, hereafter *p.M.*), and there is some evidence in favour of this, as we shall find. On the other hand, the *actus* proves a rather blunt instrument for evaluating Roman fort planning at the detailed level, and it may well be that fractions and multiples of 12 *p.M.* provide a more flexible and practical approach to the problem, though the two are obviously related.

As for the archaeological record, detailed discussion below and reference to Appendix, Table F will reveal that 5 and 10 ft measurements are less than ubiquitous even on the 'type-site' of Gellygaer. The sort of difficulties which can arise from automatic acceptance of their use is apparent from Hogg's analysis of the built-up area of Pen Llystyn.[8] Having rightly stressed the precision of the overall layout, he is obliged by his reliance on 10 ft multiples to propose

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1 Ward 1903, 22–4 and fig. 2.
2 Richmond and Mcintyre 1939, 125, 131.
3 Hogg 1968, 119.
4 e.g. Johnson 1983, 42.
5 Polybius, *Histories* 6.27–31.
6 *Epitoma Rei Militaris* 3.8 (Milner 1993, 77–8).
7 Richardson 2000; 2002.
8 Hogg 1968, 118–20.

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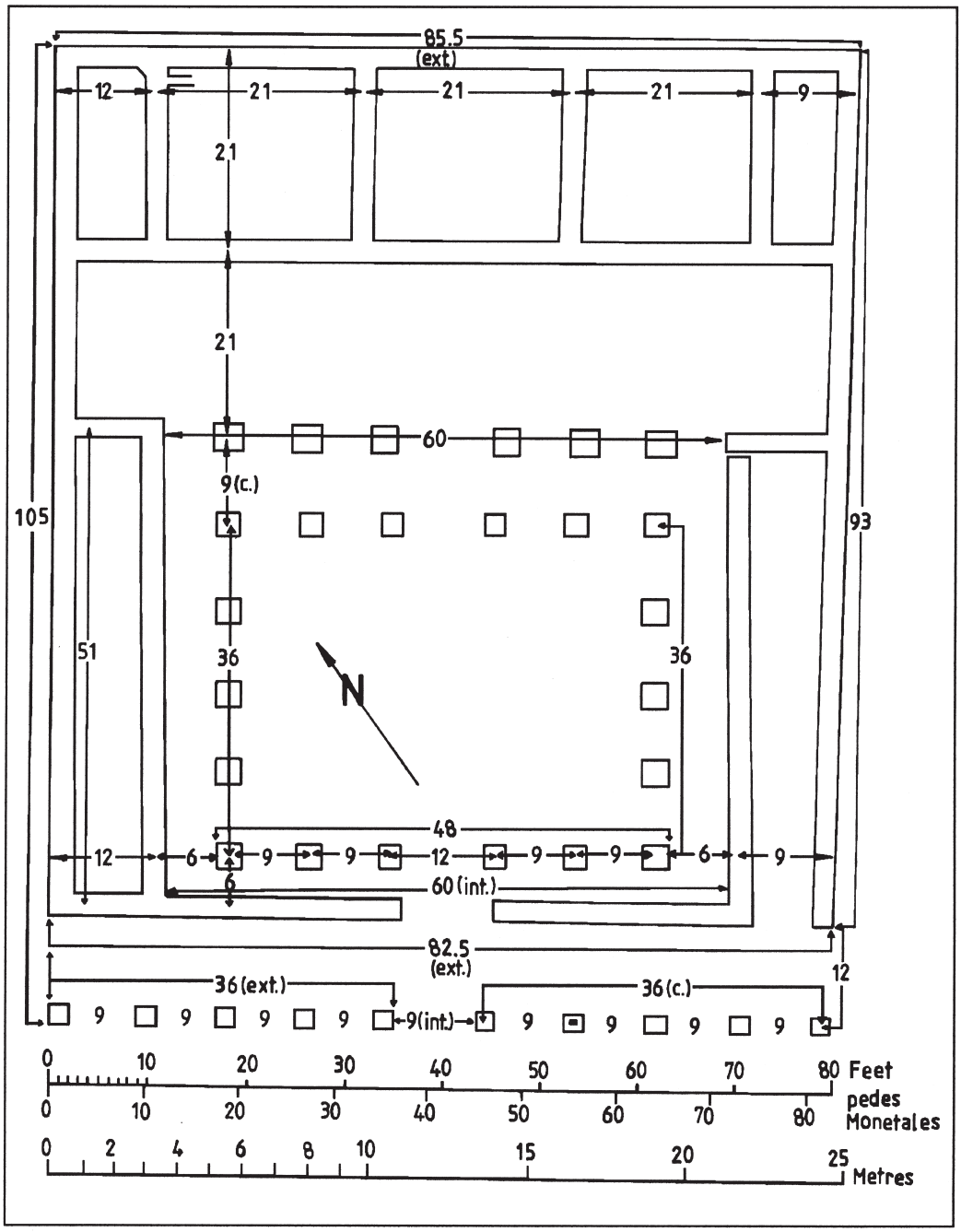


FIG. 1. Fendoch *principia* after Richmond and McIntyre 1939, 123, fig. 6. Dimensions in *pedes Monetales*.

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an unlikely local foot equivalent to 1.034 modern feet, which proves ill-fitting in practice and undermines the claim to precision itself![9] The claim is undoubtedly justified, but can be validated only by interpreting the published dimensions in terms of a different module.

Analyses of individual buildings within forts can also run into trouble if based upon preconceived notions. Richmond's conclusion[10] that the plan of the Fendoch *principia* (FIG. 1 and Appendix, Table E) was 'a manifest drawing-office product, such as the engineers of a *praefectus fabrum* might well have produced' has much to commend it and a number of headquarters buildings which virtually replicate each other's measurements will be considered later. But the inference that the Fendoch design 'was conceived in units of tens and fives, reflected in the dimensions of the whole building, its rooms and colonnades and the intercolumniations of the cross-hall' seems to have limited basis in fact. Richmond's own dimensions, e.g. courtyard 41 by 31 ft ; cross-hall 77 by 17 ft, with a frontage of 57 ft, hardly support the assessment, and the blanket application of 20 and 10 ft (?internal) measurements to the rooms of the rear range does not fit the detailed plan.[11] Interpretations such as these take insufficient account of the discrepancy between the modern foot and the *pes Monetalis* (11.65 in; 0.29617 m),[12] especially in the context of large-scale buildings, and Richmond's judgement[13] that the Fendoch granaries (see Appendix, Table E) were 'planned in units of fives and tens' seems equally difficult to sustain.

But if the conventional view is to be challenged, what alternative approaches may be offered to the question of recurring dimensions in fort planning? As part of a recent analysis of civilian and military basilicas,[14] it was suggested that the Hod Hill *principia* (FIG. 2)[15] was set out on the basis of 11 *p.M.* measurements and that other (legionary) headquarters buildings fall into the same category, along with several civil basilicas (Caerwent, Caistor-by-Norwich, and Silchester) which show strong military affinities.[16] Earlier studies had detected an 11 *p.M.* module in the planning of legionary defences at Exeter, Gloucester, Wroxeter, and Chester,[17] which might be extended to auxiliary forts, judging by the 22 *p.M.* wide East Gate at The Lunt (Appendix, Table B). It is perhaps unwise, though, to assume that the same module was necessarily used for defences and internal planning, and the writer would now admit to unease about his earlier assessment of the Hod Hill *principia*, especially in the light of Richardson's papers. A revised interpretation is, therefore, offered as FIG. 3, based upon a 12 *p.M.* module which seems to make better sense of the available information, but does not alter the fact that even as simple a plan as Hod Hill's observes that principle of basilica design whereby the sum of the length and width of the 'nave' as originally set out (33 + 21 *p.M.*) equals the overall length of the building (54 *p.M.* at the east end).

The modified picture of the *principia* may now be set in the context of the fort as a whole (FIG. 4).[18] The distance measured from the outer face of the south rampart to the north side of the built-up area (Stable 1) proves to be 570 *p.M.*, or ten times the planned width of the *principia* at its west end. The 84½ ft/87 *p.M.* length of the building represents almost exactly a sixth of the

9 'Within this parallelogram, the precision of the work seems to have fallen off'.
10 Richmond and McIntyre 1939, 125.
11 Richmond and McIntyre 1939, 123, fig. 6.
12 The writer would agree with Pamment Salvatore 1996, 31 'that the *pes Monetalis* would have been the official and designated unit of measurement of a Roman army despatched from Rome', though the use of other measurements in the North-West provinces cannot be excluded: see Walthew 1981, 15–35.
13 Richmond and McIntyre 1939, 131.
14 Walthew 2002, 185–9 and fig. 29A and B.
15 Richmond 1968, 74–6 and fig. 42B.
16 Walthew 2002, 201–30.
17 Henderson 1991, 73–5 and fig. 13.7–8; Mason 2001, 130.
18 Richmond 1968, 66–7: for details see Appendix, Table A.

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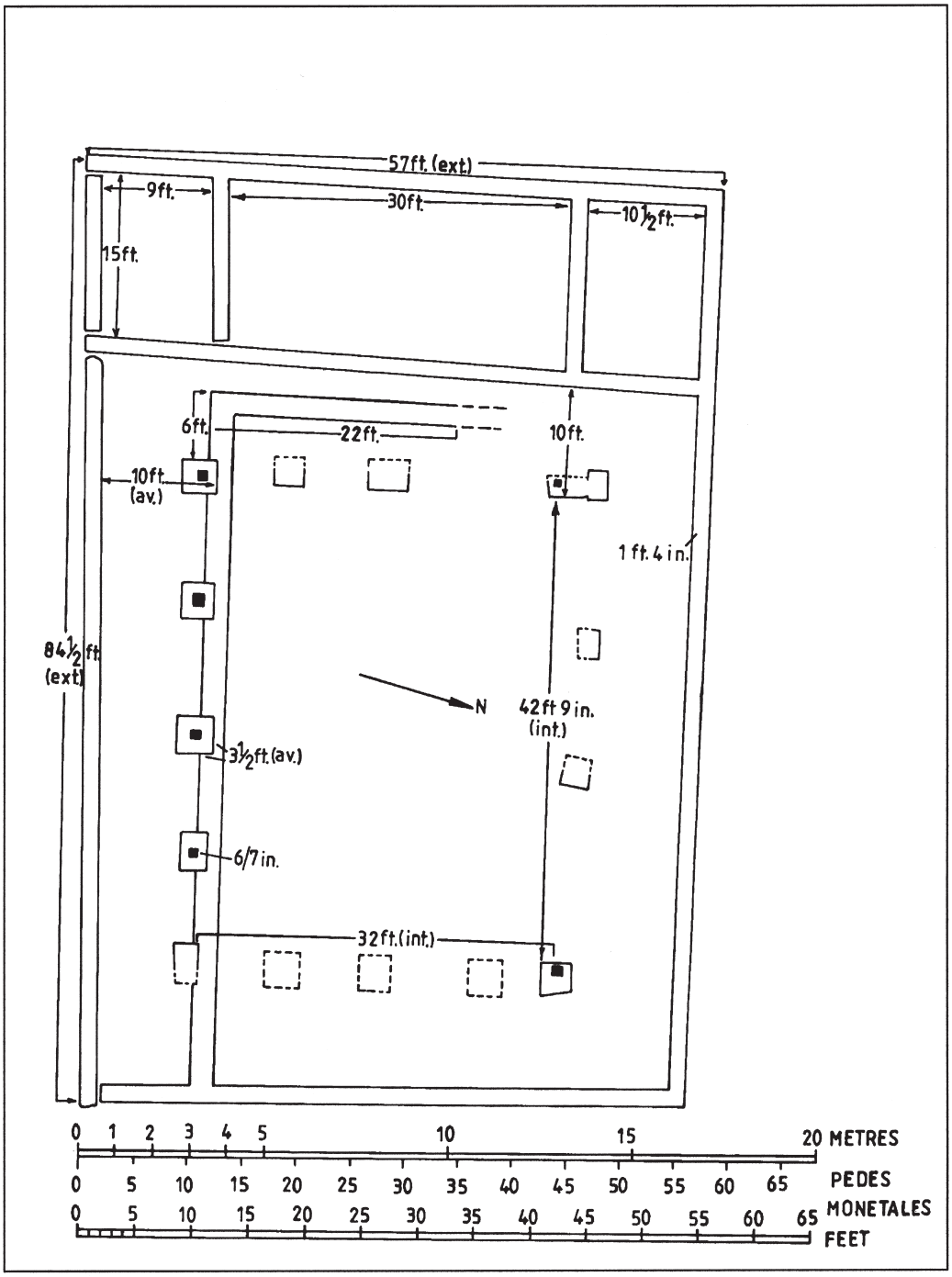


FIG. 2. Hod Hill *principia* after Richmond 1968, fig. 42B. Dimensions in Imperial feet.
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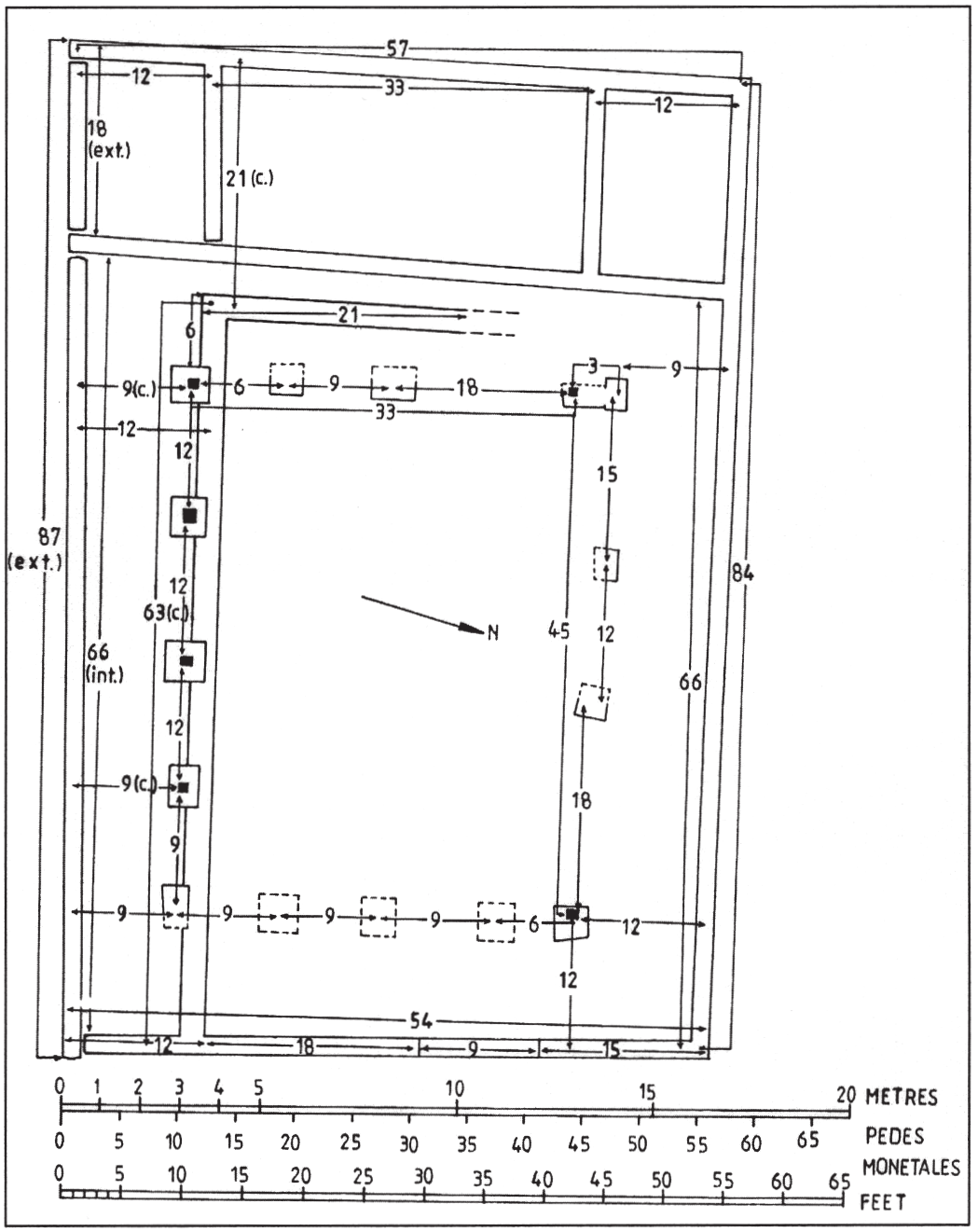


FIG. 3. Hod Hill *principia* after Richmond 1968, fig. 42B. Dimensions in *pedes Monetales*.

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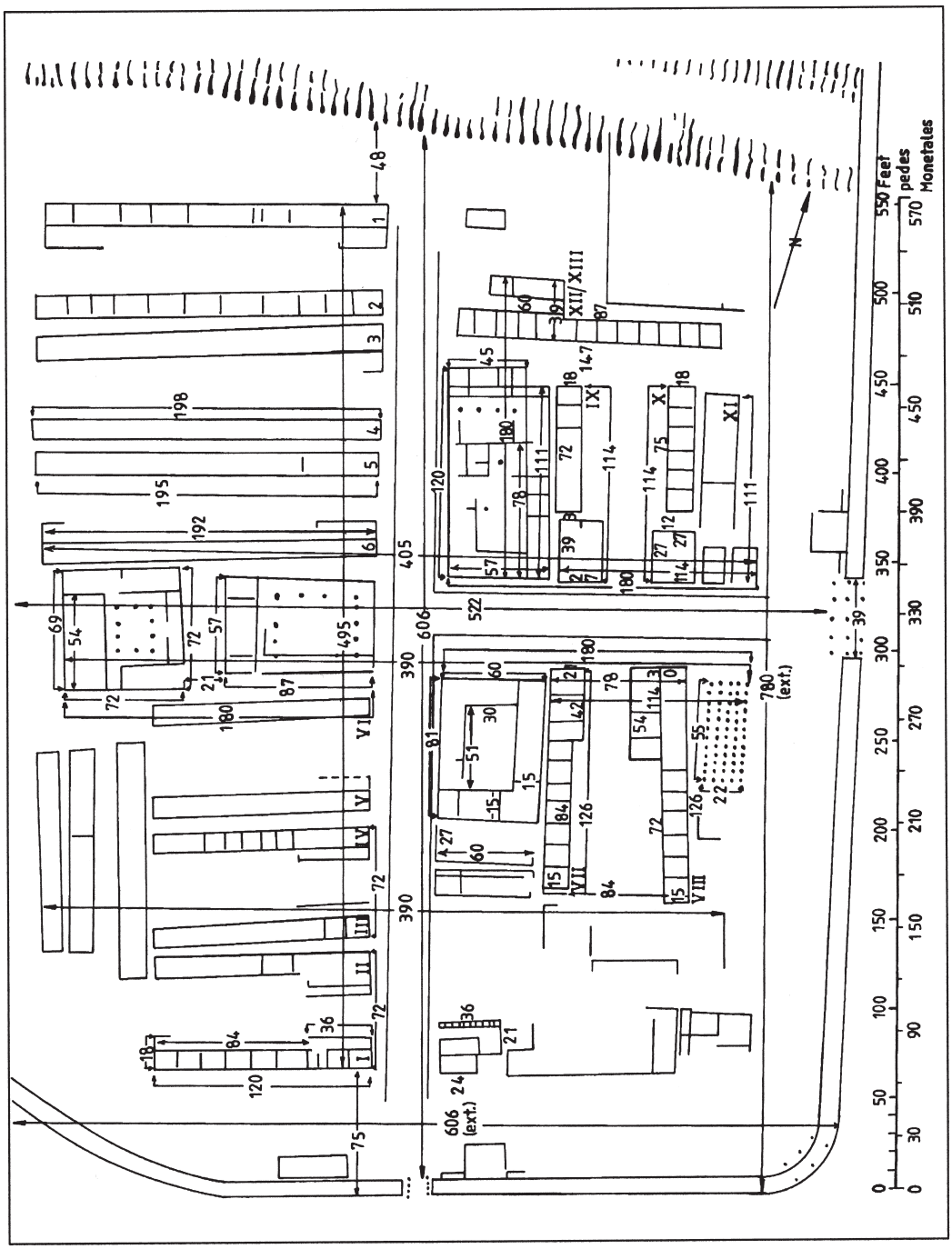


FIG. 4. Hod Hill fort plan after Richmond 1968, fig. 62. Dimensions in *pedes Monetales*.

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fort's 508 ft/523.26 *p.M.* internal axial width (east–west), for which a projected 522 *p.M.* (43½ times 12 *p.M.*) might reasonably be suggested. The two multiples in question (10 and 6) seem more characteristic of a legionary than an auxiliary base (cf. Haltern and Inchtuthil, 10 times the widths of their respective *principia*), and perhaps indicate that Hod Hill was set out by legionary surveyors.[19]

It is striking that the lengths of the Hod Hill stables, ranging from 192 to 195, 198, and 201 *p.M.*, all multiples of 12 *p.M.* (×16, 16¼, 16½, and 16¾ respectively), represent the full depth of the *latera praetorii* plus *retentura* and that the built-up area of the fort measures between 390 and 405 *p.M.* east–west, dimensions close to those of a range of later auxiliary forts,[20] in which the 192 *p.M.* measurement was to play a prominent role, as we shall see. Such comparisons prompt the question whether sets of guide-lines on fort sizes, at least partly based on the 12 *p.M.* module, were beginning to emerge in the Claudian period, perhaps in the form of a manual, which could be adapted even to the inconvenient surroundings of an Iron Age hill fort?

Such a manual might be expected to cover major internal buildings in addition to the *principia*, and *Praetoria* I and II at Hod Hill, recently subjected to proportional analysis,[21] are relevant here. *Praetorium* II (FIG. 5 and Appendix, Table A) was evidently set out as a square of 72 *p.M.* (70 ft), in which it was to be followed closely by the Gellygaer *praetorium*, 66 by 69 *p.M.*, as Richmond notes.[22] Evans' division of the Hod Hill plan into five units north–south and six units east–west is in broad agreement with the proposed application of 12 *p.M.* measurements. What is probably the main reception and dining room on the west side of the house measures 54 *p.M.* long by 24 *p.M.* wide between the centre-lines of walls and the central courtyard 36 *p.M.* wide by 42 *p.M.* long. The six west–east units may thus be seen to correspond to 24 + 36 + 12 *p.M.*, though the five north–south units sit less easily with the 15 + 42 + 15 *p.M.* subdivision of the east side of the building. But from these figures it clearly does not follow that 'neither the base module nor the larger units would have been whole numbers of feet'[23] and so far from obscuring the 'subtleties of planning' the measurements enhance them in precisely the sort of partnership which Vitruvius envisages.[24]

Praetorium I (FIG. 6) measures 119 ft long by 56 ft wide, plausibly interpreted as 120 by 57 *p.M.* As Evans rightly recognises, the core of the building is a narrower rectangle, 120 *p.M.* long by 45 *p.M.* wide, shorn of the east range, itself measuring 111 by 12 *p.M.* The core comprises an approximate northern square 42 by 45 *p.M.* ('dining-room' area), corresponding to 9 by 9 of Evans' modules, which on her reckoning of 4.88 *p.M.* per module yields 43.92 *p.M.*, and a southern rectangle of 78 by 45 *p.M.* ('courtyard' area), for the length of which 16 modules produce 78.08 *p.M.* The north range fronting the courtyard measures 21 *p.M.* deep between the centre-lines of front and rear walls and Evans' 5 module/24.4 *p.M.* width for the 'dining-room' nearly replicates the 24 *p.M.* measurable between the centre-lines of the north and south walls. Once again proportion and measurement are shown to be inextricably linked.[25]

[19] This is without prejudice to the debate whether Hod Hill was garrisoned by a mixed unit of legionaries and auxiliaries or by auxiliaries alone, on which see Frere and St Joseph 1983, 89–90; Maxfield 1986, 60 and 65.

[20] Compare built-up long axes of 384 *p.M.* at Pen Llystyn, Strageath (390 *p.M.* here also), and Caerhun and of 405 and 411 *p.M.* at The Lunt, Baginton, an overall length of 390/3 *p.M.* at Gellygaer measured between the centre-lines of the ramparts, and an internal width (north–south) of 384 *p.M.* at Strageath. At Hod Hill the axial 390 *p.M.* falls into 180 *p.M.* apiece for *praetentura* and *retentura*, separated by the 30 *p.M.* width of the *via principalis*.

[21] Evans 1994, 159–61 and figs 4–5.

[22] Richmond 1968, 78: see Appendix, Table A.

[23] Evans 1994, 161.

[24] Vitruvius, *De Architectura* 5.1.6. The 12 *p.M.* module obviates the need for 'a separate setting-out system' for the columns in the courtyard, as FIG. 5 shows.

[25] As before, the 12 *p.M.* module renders 'a new scheme' for the interior of the 'dining room' unnecessary, as FIG. 6 and Evans' own analysis (1994, 160) make clear!

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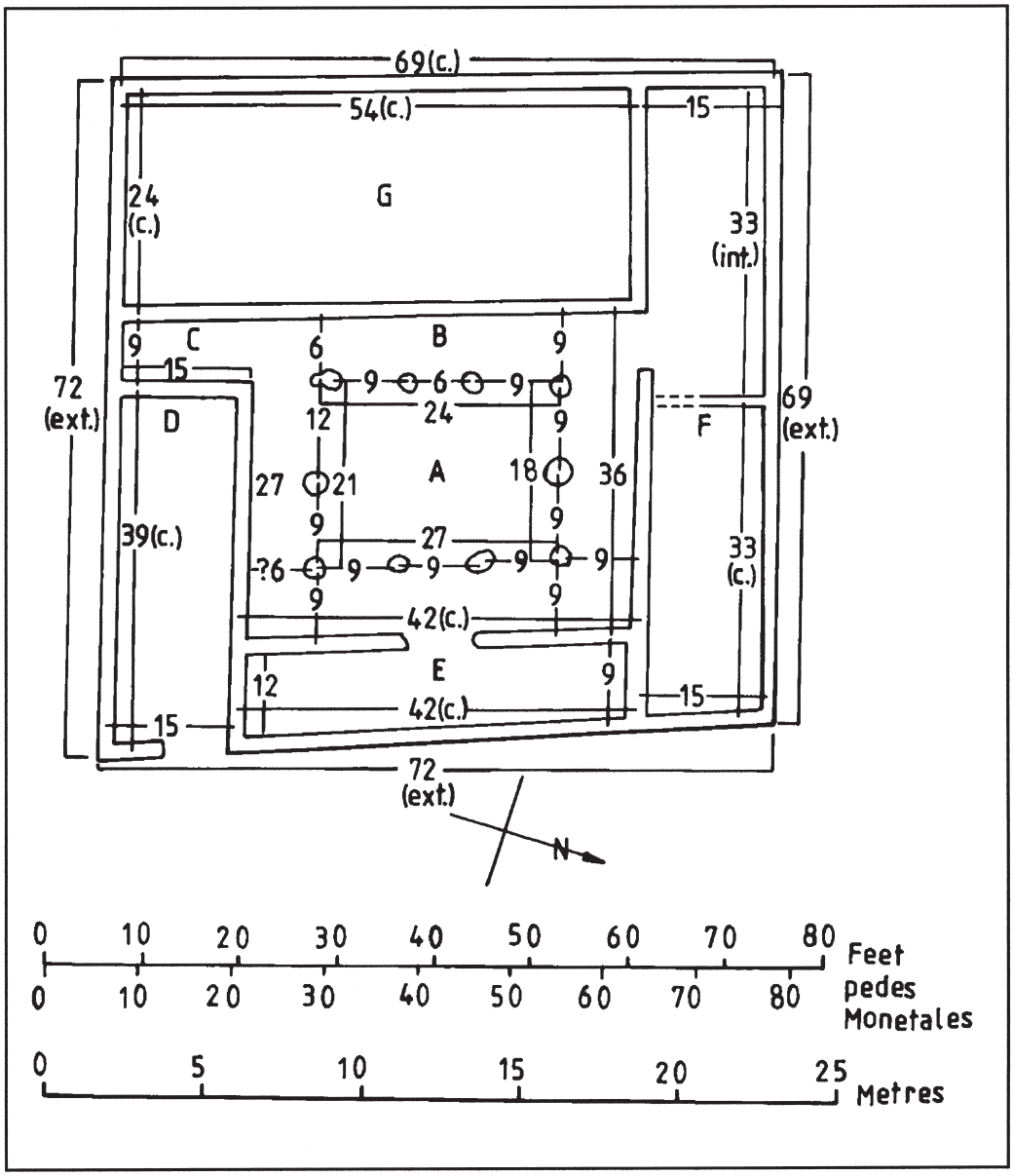


FIG. 5. Hod Hill *Praetorium* II after Richmond 1968, fig. 44. Dimensions in *pedes Monetales*.

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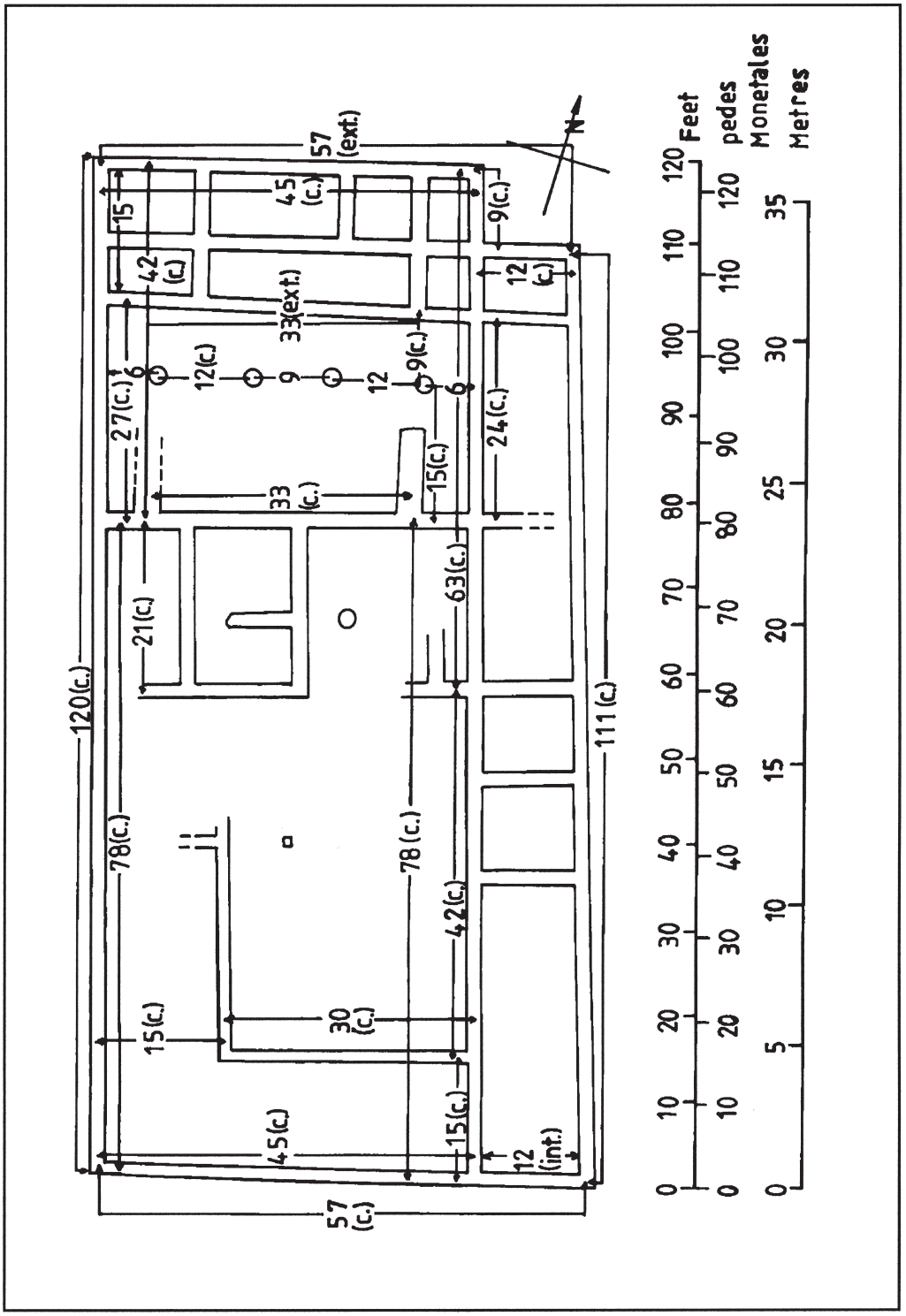


FIG. 6. Hod Hill *Praetorium* I after Richmond 1968, fig. 43. Dimensions in *pedes Monetales*.

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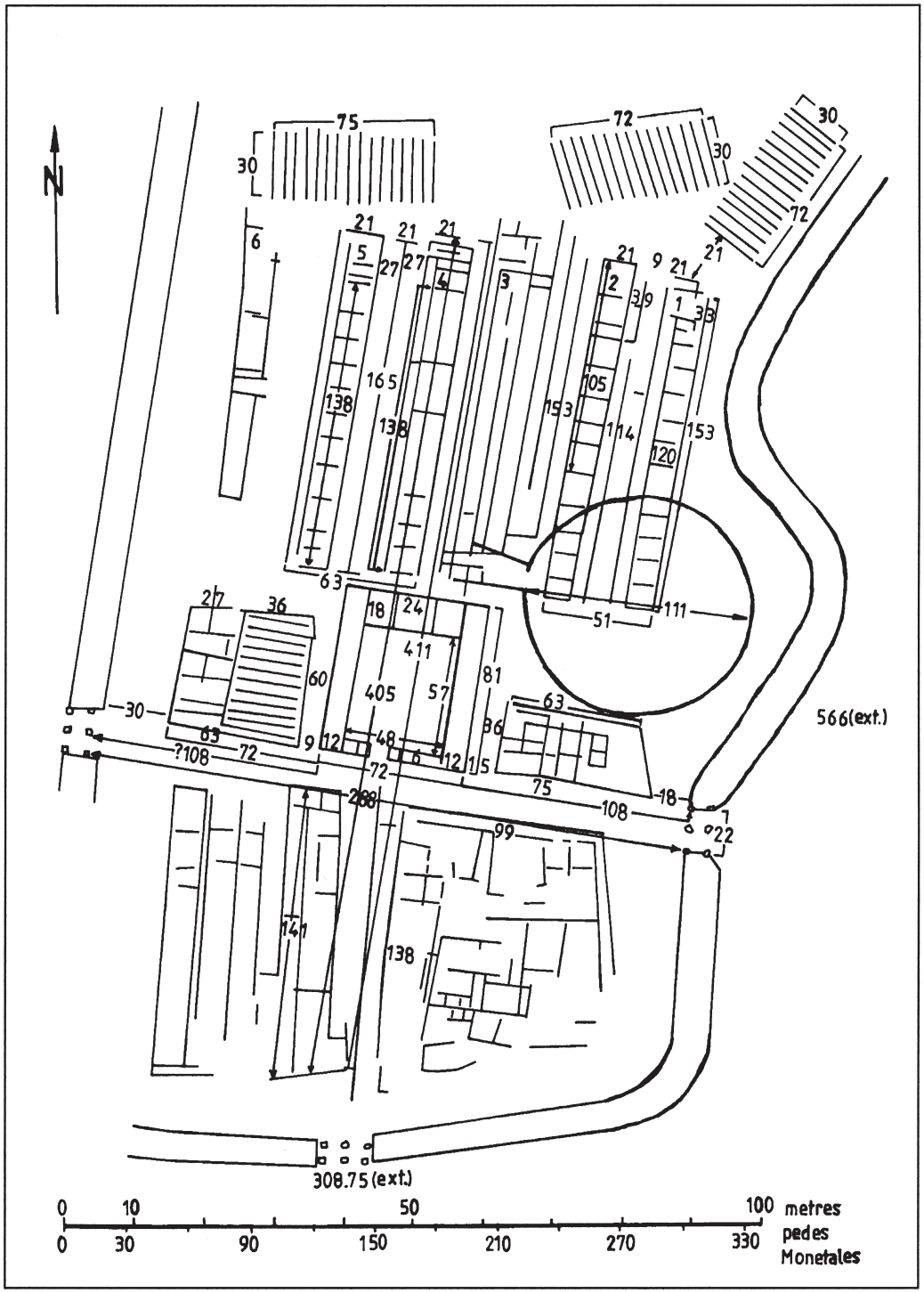


FIG. 7. Baginton fort plan after Hobley 1975, fig. 1. Dimensions in *pedes Monetales*.

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If Hod Hill may be seen to offer an emerging pattern for fort planning in Britain, The Lunt fort at Baginton, occupied *c.* A.D. 60–80, takes the development a stage further, perhaps surprisingly.[26] In the first place, clear signs of 12 *p.M.* measurements may be detected in the layout of many, if not most, of the internal buildings (FIG. 7). The *principia* was planned as a rectangle *c.* 21.28 m/72 *p.M.* wide by 24 m/81 *p.M.* long, which was to be virtually reproduced by the Gellygaer and Strageath headquarters buildings. 72 *p.M.* (21.33 and 21.28 m respectively) was also the length of Baginton's eastern and central granaries (the latter of Period 1), 75 *p.M.* the probable length of the western granary.[27] The training ring (*gyrus*) measured 111 *p.M.* (*c.* 32.77 m) in diameter.[28] Most telling are the *retentura* barracks, Nos 1 and 2 being 45.32 m/153 *p.M.* long (between centre-lines of walls) by 21 *p.M.* wide in Period 1 and Nos 4 and 5 48.76 m/165 *p.M.* long by the same width in both main periods. The varying lengths of officers' quarters and *contubernia* ranges are also amenable to convincing interpretation in multiples of 12 *p.M.*, as Appendix, Table B shows.

The unusual location and arrangement of The Lunt's northern granaries and the undulating course of the eastern defences, partly caused by the incorporation of the *gyrus*, should not be allowed to obscure the presence of an otherwise fairly conventional fort plan. Thus the 72 *p.M.* width of the *principia*, which is located *c.* 31.92 m/108 *p.M.* west of the East Gate (measured between post-centres) may be inferred to occupy a quarter of the fort's 85.12 m/288 *p.M.* internal width on the line of the *via principalis*. Less equivocal results may be achieved for the built-up area's long (north–south) axis based on the published dimensions (Appendix, Table B). Including the width of the western granary these produce a measured total of 134 m/452.44 *p.M.*; discounting the width of the granary and the street separating it from the adjacent barracks, the total falls to 121.84 m/411.38 *p.M.*, just 6 *p.M.* more than the precise figure (405 *p.M.*) which represents five times the 24 m/81 *p.M.* length of the *principia*.[29]

The next vital stage in the development of fort planning, *c.* A.D. 80–90, is reached with Hogg's 'parallelogram' at Pen Llystyn (FIG. 8), his designation for the fort's meticulously surveyed built-up area.[30] Measuring *c.* 373 ft long by 332 ft wide, it is most plausibly interpreted as 384 by 342 *p.M.* or 32 by 28½ times 12 *p.M.* What was very probably a ritual deposit was discovered on the line of the front wall of the *principia* cross-hall 'almost exactly 1 ft south of the true mid-point of the … parallelogram', thus close to 192 *p.M.* from either end. This figure recalls the depth of the left *latus praetorii/retentura* at Hod Hill and anticipates the significance of 192 *p.M.* measurements on the long axes of Strageath and Caerhun.

All the buildings in the central range at Pen Llystyn show signs of the 12 *p.M.* module, though not without some ambiguity (for full details see Appendix, Table C). The 75 ft external width of the *principia* is reasonably construed as 78 *p.M.*, its 92 ft depth less certainly as 93 *p.M.*, though this seems corroborated by the 91 ft depth of the *praetorium*. It is clear from the published plan[31] that the latter's frontage on the *via principalis* and that of the granaries (including loading bays) were set out to a common length, most likely 120 *p.M.*, the 120 ft published length of the

[26] Hobley 1969, 81–4; 1973, 19–32; 1975, 3–16 and fig. 1; for details see Appendix, Table B.

[27] Published length 22.80 m, interpreted as 75 *p.M.* by Manning 1975, 110, Chart 3. Cf. the 22.71 m external length of the two Caerhun masonry granaries: Baillie Reynolds 1929, 81.

[28] Clearly not 34.06 m as stated by Hobley 1973, 30; the 102.96 m/348 *p.M.* circumference also favours a diameter of 111 *p.M.* According to the excavator (ibid., 19), there is no doubt that the eastern defences were set out in relation to the *gyrus*.

[29] And, in fact, the general plan shows the distance from the north end of Barrack 4 to the slanting south wall of the more easterly of the Period 1 barracks in the right *praetentura* to measure *c.* 120 m/405 *p.M.* It should also be noted that the 167.64 m/566 *p.M.* external length of the fort is almost exactly seven times the length of the *principia*.

[30] Hogg 1968, 119.

[31] Hogg 1968, fig. 19.

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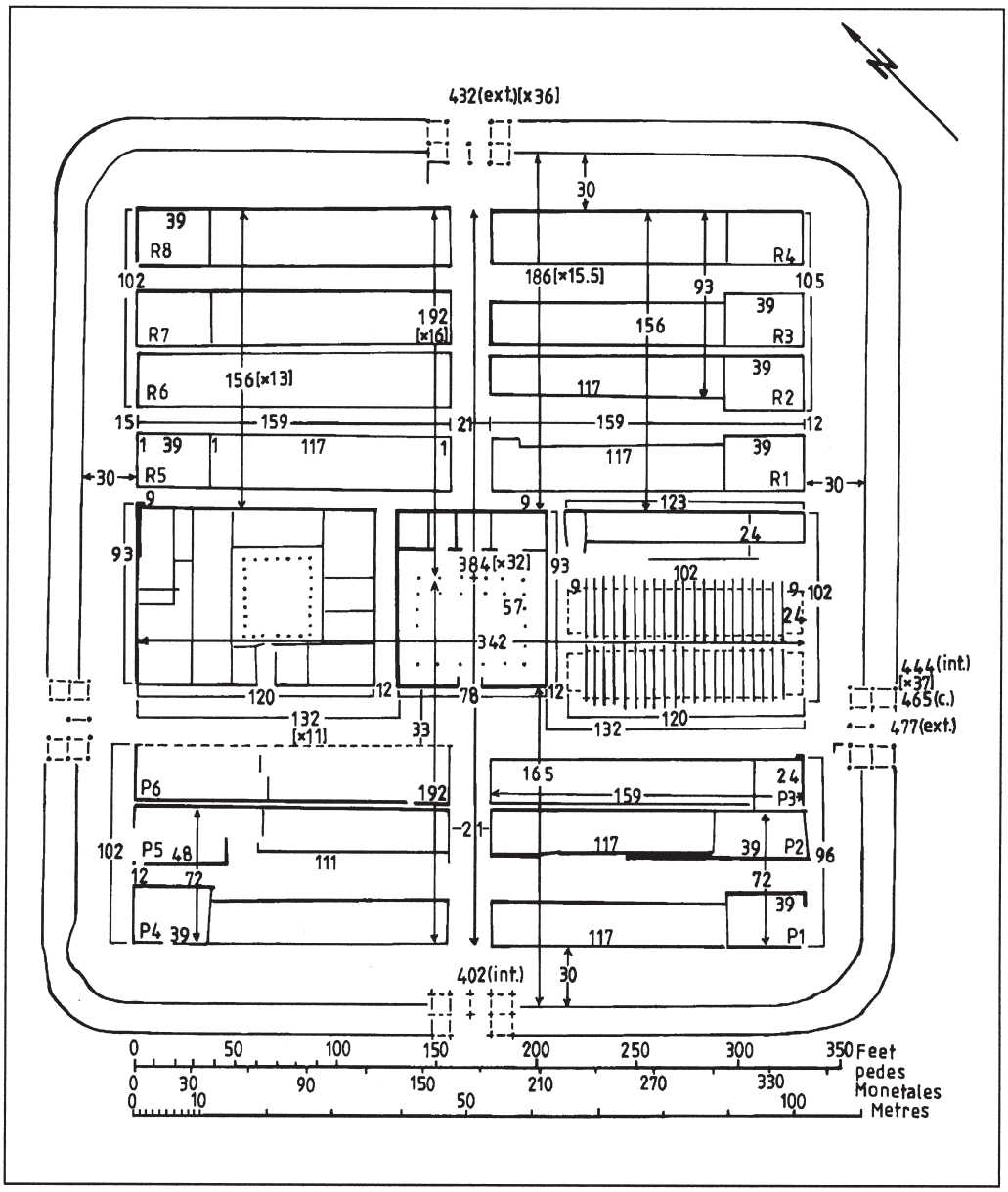


FIG. 8. Pen Llystyn fort plan after Hogg 1968, 112, fig. 5. Dimensions in *pedes Monetales*; multiples of 12 *p.M.*

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putative hospital suggesting slightly more, namely 123 *p.M.* If these tentative suggestions prove correct, the buildings on the north-east side of the *via principalis* may be supposed to have been set out as follows:

praetorium		street		*principia*		street		granary		
120	+	12	+	78	+	12	+	120	=	342 *p.M.*

The prominence of 120 *p.M.* measurements on this frontage is strikingly reminiscent of Caerhun (FIG. 12)[32] and the location of the *principia* 132 *p.M.* from either edge of the built-up area is fully replicated at Strageath, and partially so at Caerhun.

The disposition envisaged for the central range at Pen Llystyn finds support throughout the fort. The length of all barrack blocks is stated[33] to have been 155 ft by slightly less than 30 ft wide, comprising officers' quarters 40 ft long (with the exception of P5: 46 ft) and *contubernia* ranges 115 ft long. The likeliest interpretation of the overall figures, 159 by 30 *p.M.*, may seem strange (why not 160 *p.M.*?), but is readily explained. Given three wall-trenches *c.*1 *p.M.* wide, the centurions' quarters will have been set out over a length of 39 *p.M.* (48 *p.M.* in P5) and the *contubernia* ranges over 117 *p.M.* In other words, there was a ratio of 3 : 1 between them and a combined total (less the intervening partition) of 156 *p.M.* or 13 by 12 *p.M.* If correct, this analysis provides a significant pointer to the interpretation of barrack lengths at Strageath and Fendoch also. For Pen Llystyn it offers a persuasive model of barrack distribution *per scamna* at both front and rear of the fort:

praetentura/retentura

barrack		width of *via praetoria/decumana*		barrack	
159	+	21	+	159	= 339 *p.M.*

— the resulting total falling 3 *p.M.* short of the width of the central range and exceeding the built-up width (north–south) of Strageath by the same amount.

The Flavian fort at Strageath benefited from painstaking modern excavation, the results of which have been published in such detail as to make metrological analysis perfectly feasible (FIG. 9).[34] Indeed, the report contains so many measurements that only the more significant can be discussed here and the reader is referred to Appendix, Table D for further information. Of prime importance are the dimensions of the fort's built-up area, 384 *p.M.* on the long axis (east–west) and 336 *p.M.* on the short axis (north–south), in other words virtually identical to those of Hogg's 'parallelogram' at Pen Llystyn, the first figure also reproducing the length of the built-up east–west axis at Caerhun (FIG. 12). Taking the short axis first, the total width of the central range between the northern and southern *via sagularis* (effectively the cumulative lengths of the buildings lining the western side of the *via quintana* and the intervals separating them) proves to be 98.72 m/333.32 *p.M.* Close examination of the buildings in question will show 336 *p.M.* to have been the surveyors' probable target, and this is supported by Davison's figures,[35] which yield a built-up width for the *praetentura* of 99.50 m/335.95 *p.M.*, and by the measured width (north–south) of the *retentura*, comprising the lengths of Buildings II and X and the width of the *via decumana*, which amounts to 99.52 m/336.02 *p.M.*

[32] Where the built-up width of the fort on the line of the *via principalis* measures 351 *p.M.*, strikingly close to Pen Llystyn's 342 *p.M.* and Strageath's 336 *p.M.* The combined lengths of Buildings XVIII and XIX in the Caerhun *retentura* and the width of the *via decumana* separating them (168 + 15 + 170 ft) total 353 ft/363.60 *p.M.*, showing that the planned width of the built-up area at the rear (west end) of the fort was 12 *p.M.* greater than in the central range: see Baillie Reynolds 1927, 299–309 and fig. 5; 1929, 86–92 and fig. 20.

[33] Hogg 1968, 134.

[34] Frere and Wilkes 1989.

[35] Davison 1989, iii, 847 and 860.

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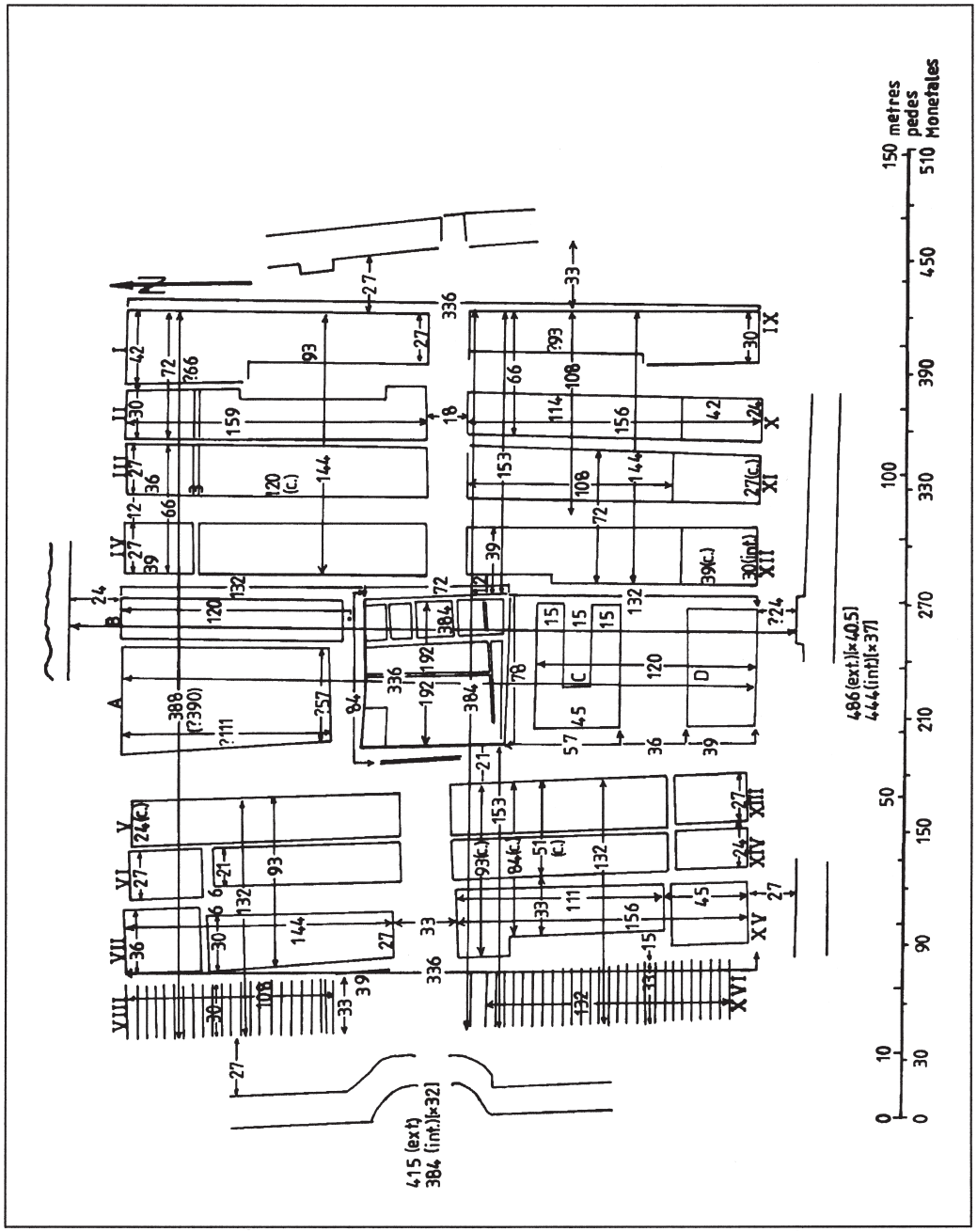


FIG. 9. Strageath Flavian fort plan after Frere and Wilkes 1989, fig. 66. Dimensions in *pedes Monetales*; multiples of 12 *p.M.*

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So how exactly was the 336 *p.M.* planned width of the central range subdivided? The measured distance from the northern *via sagularis* to the north-eastern corner of the *principia* totals 39.09 m, clearly 132 *p.M.* as at Pen Llystyn, most of that distance occupied by Building B, probably the hospital, the 36.04 m/120 *p.M.* length of which (including a possible southern portico) falls *c.* 2 *p.M.* short of Pen Llystyn's, suggesting that one *actus* was the target.[36] Between the *principia* and the southern *via sagularis*, buildings (and intervals) cover a measured distance of 38.33 m/129.42 *p.M.*, though it seems reasonable to assume that the surveyors were aiming at a symmetrical 132 *p.M.*, as in the corresponding position at Caerhun (FIG. 12).[37] The 21.3 m/72 *p.M.* width of the *principia* itself harks back to The Lunt and looks forward to Gellygaer, where the maximum width of the *principia* is a few inches less than 72 *p.M.*

Here it is convenient to turn to the *principia*'s long (east–west) axis and that of the fort itself. The 22.9 m length of the *principia* should signify a planned 78 *p.M.*, or 6½ times 12 *p.M.*, and the key role of this module in the design may be confirmed by room-by-room examination of the plan (FIG. 13). The dimensions thus reinforce the building's close relationship with its counterparts at The Lunt and Gellygaer. Most strikingly of all, the 22.9 m length represents almost exactly a fifth of the the fort's 114.96 m built-up length measured over the right *praetentura* and *retentura*, perhaps suggesting a projected 390 *p.M.* in the northern half of the fort. On the central axis, by contrast, the front wall of the cross-hall falls precisely at the mid-point, 192 *p.M.* from either end, as at Pen Llystyn, whereas at Caerhun (FIG. 12) this spot coincides with the east side of the courtyard.

The barracks and other buildings of the *praetentura* and *retentura* are equally susceptible to analysis in 12 *p.M.* measurements, but certainty is naturally harder to achieve here and the reader is referred to Appendix, Table D for details. In the *retentura* Buildings II and III, the former not a barrack, were probably set out over a length of 159 *p.M.*/47.09 m, Building X over 156 *p.M.*/46.20 m rather than 159 *p.M.*, but the similarity to the Pen Llystyn barracks is clear. The 42.74 m measured width of the north *retentura* up to the eastern *via sagularis* leaves little doubt that 144 *p.M.*/42.65 m was the planned total here. In the south *praetentura* the 46.25 m length of Building XV is near-decisive for 156 *p.M.* The precise width (east–west) of this half of the *praetentura* cannot be determined, but closely matches the 39.32 m/132.76 *p.M.* overall length of Granary XVI. That 132 *p.M.*/39.09 m was the intended figure at this point is strongly supported by the 38.81 m/131 *p.M.* measured width of the north *praetentura*, not to mention the 39.09 m/132 *p.M.* measured frontage along the *via quintana* north of the *principia*. Finally, it is interesting to note that the probable planned length of Granary VIII north of the *via praetoria*, 108 *p.M.*, implies a combined total of 240 *p.M.* or two *actus* for Strageath's granaries, equalling that of Pen Llystyn's two 120 *p.M.* long buildings.

Fendoch has fascinating insights to offer into the development of fort planning in the later first century A.D., but there is no disguising the serious problems posed by the patchy excavation of the internal buildings despite claims of 'complete examination'![38] The central range was investigated fairly fully, but barracks were little more than sampled by 'trial-trenches' and *Praetentura* 1 and *Retentura* 5 alone provide enough information for judgement of planned length.[39]

Despite these difficulties, some striking aspects of the Fendoch layout are immediately apparent (FIG. 10). The external dimensions of the fort, 598 ft long by 320 ft wide, are the equivalent of 616 by 330 *p.M.*, though it is noticeable that the north-west rampart deviates from

36 Hyginus, *de munitionibus castrorum* 4: '120 feet are assigned to the hospital'.
37 And, indeed, 38.33 m seems to be an underestimation by *c.* 0.60 m/2 *p.M.*: see Appendix, Table D.
38 Richmond and McIntyre 1939, 152.
39 Richmond and McIntyre 1939, 134–5 and fig. 2, facing p. 114.

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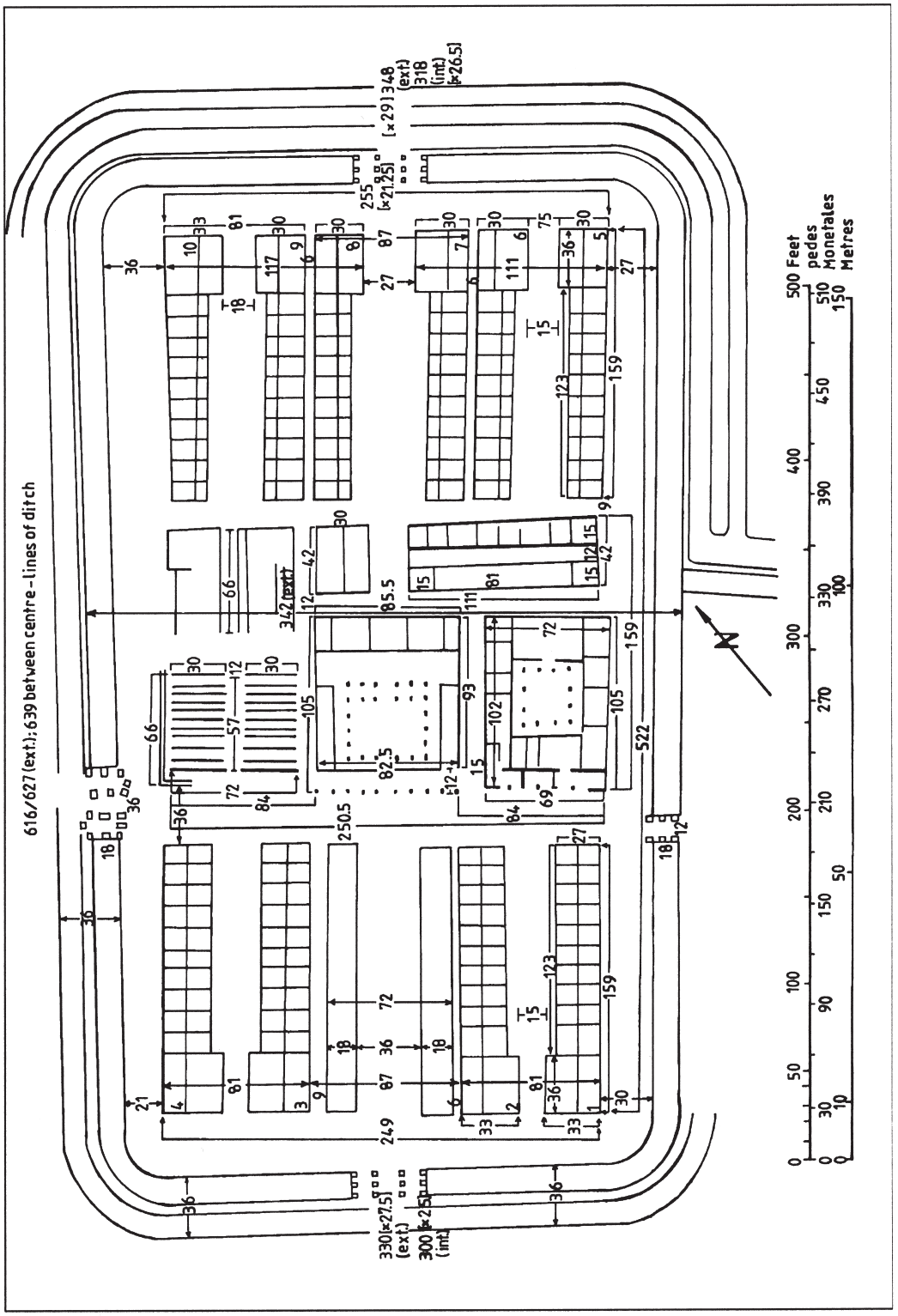


FIG. 10. Fendoch fort plan after Richmond and McIntyre 1939, fig. 2, facing p. 114. Dimensions in *pedes Monetales*; multiples of 12 *p.M.*

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a straight line by 18 ft to the north-west, resulting in a north-east rampart 338 ft/348 *p.M.* long. Between the inner lips of the defensive ditch, given a berm 'about 5 ft wide', the external length rises to *c.* 608 ft/627 *p.M.* The significance of these figures comes into full focus when related to the dimensions of the *principia*, 100 ft long by 80 ft wide, in other words a sixth of the fort's external length and a quarter of its width respectively.

Such neatly-rounded measurements are not, of course, to be taken too seriously, as comparison with the detailed plan of the *principia* shows (FIG. 1), and actually manage to conceal the sophistication of the design. The external width of the building on the *via principalis* frontage may be interpreted as 82½ *p.M.* (i.e. 330 *p.M.* ÷ 4) and the depth as 93 *p.M.* (mirroring Pen Llystyn), behind a portico 12 *p.M.* wide, the resulting total of 105 *p.M.* fractionally exceeding a sixth of the fort's 627 *p.M.* length within the ditches. But the most interesting aspect of the *principia* is the 85½ *p.M.* external length of the rear wall, since it represents a carefully calculated response to the overall configuration of the fort, as we shall see.

The precise setting-out of the buildings flanking the *principia* is harder to determine, but 12 *p.M.* measurements do seem to have been employed here too. Thus the *praetorium* presents a frontage 69 *p.M.* long to the *via principalis*, as does Gellygaer's (FIG. 11), its 72 *p.M.* long rear wall matched by the 70 ft/72 *p.M.* combined width of the two north-western granaries; their 56 ft/57 *p.M.* length is increased to 66 *p.M.* by the eaves-drip gully at the south-west end. What is clear is the division of the *via principalis* frontage into three almost equal parts, allowing the following scheme to be proposed:

Granaries	Street	*Principia*	Street	*Praetorium*	
72	12	82½	15	69	= 250½ *p.M.*

From which it may be seen, of course, that the built-up width of the central range was designed to occupy three quarters of the fort's external width (in excess of 330 *p.M.*).[40]

The planned length of Fendoch's barracks must remain in doubt for reasons already stated, but the 154 ft length of *Praetentura* 1 is obviously close to Pen Llystyn's 155 ft, and Davison's 47.24 m external dimension for all four *praetentura* blocks is the precise equivalent of 159½ *p.M.*[41] On the other hand, Davison's estimate of 48.01 m for the length of the six *retentura* barracks is not supported by the general plan, and it should be noted that Richmond ascribes a length 'exactly matching Barrack 1' to *Retentura* 5. What does seem to emerge is a *prima facie* case for supposing that the surveyors projected a length of around 159 *p.M.* for both *praetentura* and *retentura*, and this is supported by the recognition that the depth (south-west–north-east) of the central range was designed to match this, comprising 105 *p.M.* (*principia*[42] including front portico) + 12 *p.M.* (*c.* 3.55 m width of street to rear) + 42 *p.M.* (42 ft/12.80 m width of 'hospital'[43]) = 159 *p.M.* It may be possible to go one stage further and to argue from the fairly even subdivision of the central range on the *via principalis* frontage and the widths of barrack-pairings in both *praetentura* and *retentura* (FIG. 10 and Appendix, Table E) that the built-up area of Fendoch is based on a blueprint prescribing nine blocks 159 *p.M.* long by 81 *p.M.* wide,[44] but the plan of the fort has further subtleties to reveal which will be discussed later.

[40] Although more accurate figures cannot be produced from the information available, it is clear that the fort's external width on the line of the *via principalis* was slightly greater than 330 *p.M.*

[41] Davison 1989, iii, 738.

[42] Matched by the '100 ft' length of the *praetorium*, the south-east wall of which may be seen from the detailed plan (Richmond and McIntyre 1939, 128, fig. 8) to have been set out as 105 *p.M.*

[43] The published width is 40 ft, but the plan (Richmond and McIntyre 1939, 133, fig. 11) clearly shows that *c.* 42 ft is a more realistic figure.

[44] The width of barrack-pairings 1-2, 3-4, and 9-10; the width of the *via praetoria*, flanking 'sheds' and street to the north-west amounts to 81 *p.M.*; and Barracks 5-6 plus alley to north-west measure 81 *p.M.* wide.

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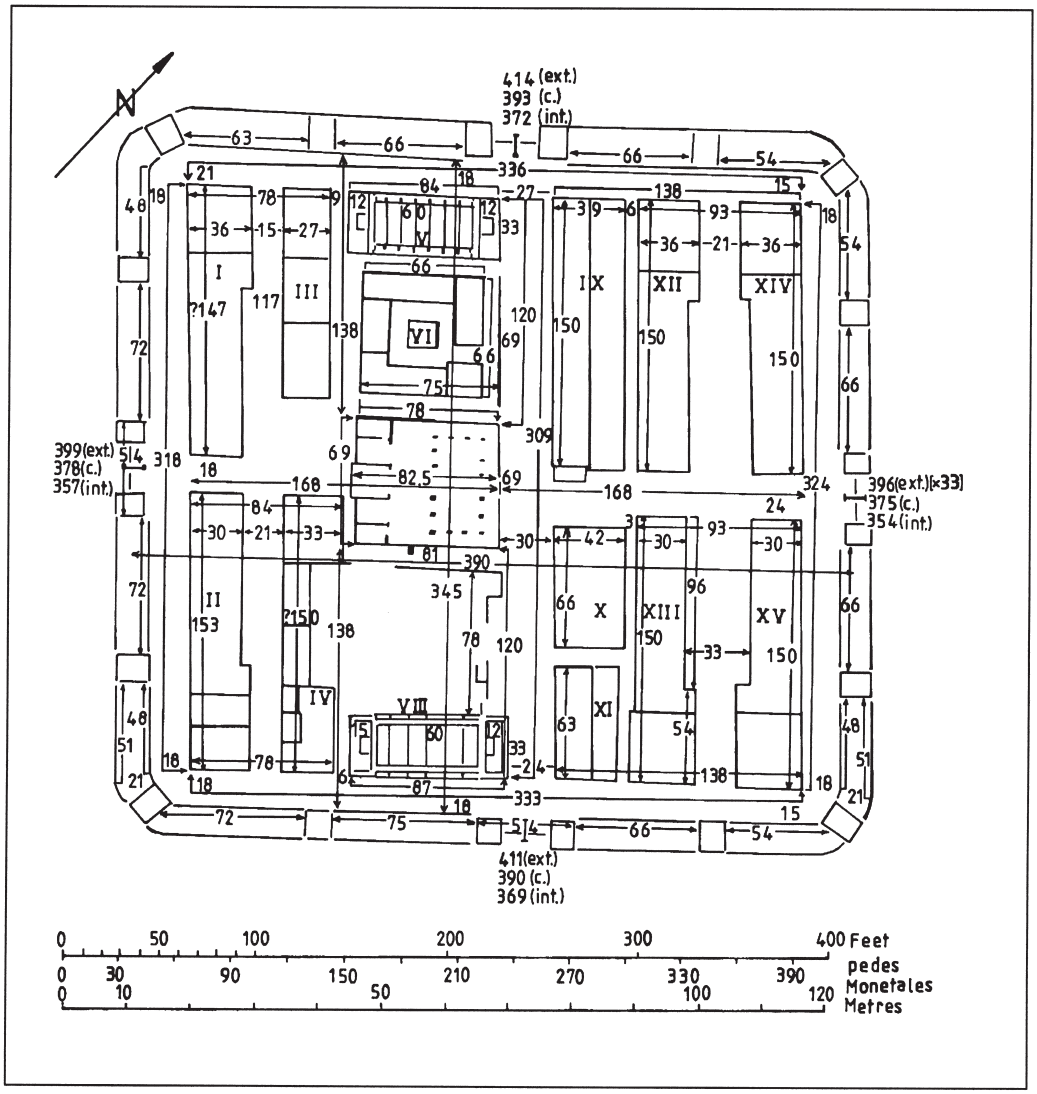


FIG. 11. Gellygaer fort plan after Ward 1903, opp. p. 104. Dimensions in *pedes Monetales*; multiples of 12 *p.M.*

Regarded as a classic demonstration of Roman fort planning since Ward's pioneering study of 1903, Trajanic Gellygaer is, if anything, even more fraught with difficulties than Fendoch. The main problem is the unreliability and inconsistency of the general plan of the excavations (FIG. 11) drawn at a scale which is said to be 30 ft to the inch, but which in fact fluctuates from 1 : 365 to 367/8, in other words is inaccurate by up to 2¼ per cent. The detailed plans of the *principia* and granaries appear to be more accurate.[45] Interpretations offered here are based on

45 Ward 1903, pls VI and VII.

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the published measurements which frequently conflict with the general plan. Close examination of individual buildings at once casts doubt on Ward's belief that all were set out in multiples of 5 and 10 Roman feet.[46]

A key role in the planning of the fort is played by the *principia*, the dimensions of which can fortunately be analysed in detail (FIG. 14). The maximum length of the building, including the rearward projection of the *aedes*, is 80 ft/82½ *p.M.*, the external length of the north-west wall 77½ ft and that of the south-east wall 79 ft. The last two measurements should be interpreted with caution, but probably indicate planned lengths of 78 and 81 *p.M.* respectively, i.e. multiples of 12 *p.M.*, as is the probable 69 *p.M.* planned width of the building (although the 69½ ft long rear wall falls just inches short of 72 *p.M.*). Despite the uncertainties, the closeness to The Lunt *principia*'s 72 by 81 *p.M.* and Strageath's 72 by 78 *p.M.* remains strikingly clear.

Equally remarkable is the relationship between these dimensions and those of other buildings or groups of buildings throughout the fort. Thus the external length of the *principia*'s north-west wall is mirrored by the 77 ft 3 in combined width of Buildings I and III in the north-western *retentura* and the street separating them, and the maximum length of the *principia* by the 80 ft joint width (measured between centre-lines of walls) of Buildings II and IV in the south-eastern *retentura*. On the larger scale, the 314 ft 1 in measured width of the fort's built-up area on the north-eastern frontage is 4½ times the maximum width of the *principia*, the 384/386 ft external width of the fort 5½ times the same. The published measurements for the external length of the fort (north-east–south-west) range from 400 to 404 ft, but were in any case clearly designed to be 5 times the maximum length of the *principia*. That bald statement does scant justice to the extraordinary detail in which these relationships were worked out, since it may also be seen (FIG. 11) that the 82½ *p.M.* maximum length of the *principia* falls just short of a quarter of the 333/336 *p.M.* built-up length of the fort (north-east–south-west), whilst the 78 *p.M.* planned length of the north-west wall occupies exactly a fifth of the 390 *p.M.* length of the fort measured between the centre-lines of the north-east and south-west ramparts. Something of the meticulously co-ordinated precision which Roman fort planning was capable of achieving by the early second century A.D. begins to come into sharper focus.

All the relationships outlined above can be reliably documented, but by no means exhaust the striking features which Gellygaer's design suggests, but which are harder to substantiate for reasons already given. The internal width of the fort (north-west–south-east) between the inner faces of the rampart's revetment walls is clearly 5 times the 69 *p.M.* planned width of the *principia*, in other words 345 *p.M.*, implying a 138 + 69 + 138 *p.M.* distribution. The mid-point of the fort lies 168 *p.M.* from the limits of the built-up area on the north-east–south-west axis and 162 *p.M.* from the same on the north-west–south-east axis, coinciding with the centre of the entrance to the *principia* and so indicating the likely station for the *groma*, as Ward notes.[47]

The remaining buildings in the central range seem equally responsive to the *principia*'s 12 *p.M.* module. Thus the *praetorium* was set out as an approximate square 66 *p.M.* wide by 69 *p.M.* long, to judge from the 64 ft 6 in and 67 ft 6 in lengths of the north-east and south-east walls respectively, though the depth of the house was increased to 75 *p.M.* by the width of the fronting portico, which flanked the *via principalis* over a distance of *c.* 67 ft/69 *p.M.* The two granaries comprise a central section 60 *p.M.* long by 33 *p.M.* wide, as the detailed plans will confirm;[48] their slight difference in overall length is explained by the varying widths of the loading bays. Those adjoining the north-west granary (Building V) were 12 *p.M.* wide, producing an overall length of 84 *p.M.*, whereas the south-west bay of the south-east granary (Building VIII) was 3

46 Ward 1903, 22–4.
47 Ward 1903, 24.
48 Ward 1903, pl. VII.

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p.M. wider, for a total of 87 *p.M.* The central section of the latter granary is especially interesting in that, as originally planned, it incorporated end-walls 3 *p.M.* thick and nine compartments measuring 6 *p.M.* wide to the mid-points of the cross-walls, later replaced by six compartments 9 *p.M.* wide. At a distance of 36 *p.M.* from the south-west end Cross-walls 6 and 4 from the two phases may be seen to coincide.

The dimensions of the fort's barracks, ?stables, and storage buildings may give some support to Ward's belief that multiples of 5 and 10 Roman feet were in operation, but close examination reveals a more complex picture. With an average length of 145 ft 6 in, the barracks were almost certainly set out over 150 *p.M.*, and the 146 ft external lengths of Buildings XV and IX in the *praetentura* leave little doubt of this. But 150 *p.M.* is, of course, a multiple of 12 *p.M.*, as are the probable 30 and 36 *p.M.* widths of *contubernia* ranges and officers' quarters respectively. In Building XIII the *contubernia* were planned with a length of 96 *p.M.* and the officer's quarters with one of 54 *p.M.* The pairings of Barracks XII and XIV, XIII and XV in the *praetentura* measure 90 ft 3 in and 91 ft wide overall respectively, strongly suggesting a planned 93 *p.M.* As reference to the details in Appendix, Table F will show, ancillary Buildings III, X, and XI were very probably set out with lengths of 117, 66, and 63 *p.M.* respectively. Taken as a whole the figures are hard to reconcile with multiples of 5 and 10 *p.M.* and make better sense in relation to a 12 *p.M.* module.

Three quarters of the fort at Caerhun was excavated between 1926 and 1929,[49] and although the detailed history of the broadly Flavian-Antonine military occupation remains to be clarified, the plan[50] reveals highly significant metrological information (FIG. 12 and Appendix, Table G). The most striking feature, as at Gellygaer, is the relevance of the *principia*[51] to the overall design of the fort. The Flavian timber *principia* may be seen to have been set out as a square of 84½ ft/25.75 m, clearly 87 *p.M.*, which also happens to be the length of the Hod Hill *principia* (FIG. 3), the original plan calling for a rear range 21 *p.M.* wide and a forecourt 66 *p.M.* long in both buildings. At Caerhun the 87 *p.M.* square of the first *principia* represents exactly a fifth of the internal length and breadth of the fort measured between the inner faces of the gate towers on both major axes, thus 435 *p.M.*/128.83 m. But 87 *p.M.* was clearly also influential in the setting out of the fort's barracks, as may be inferred from the 174 *p.M.* overall lengths of Barracks VI and XIX in *praetentura* and *retentura* respectively. With lengths ranging from 168 *p.M.* (Barrack I) to 171 *p.M.* (Barrack IV, matched by *retentura* Buildings XVI and XVIII), to 177 *p.M.* (Barrack XVII), the remaining barracks and storage buildings diverge only slightly, and it is noticeable, finally, that the planned width (east–west) of the south *praetentura*, including the width of the *via principalis*, was also 174 *p.M.*, suggesting, perhaps, that the south-east quarter of the fort was set out as its square.

The Caerhun barracks are equally striking for the consistent 120 *p.M.* length of the *contubernia* ranges (the 126 *p.M.* of Barrack VI being the only exception), the slightly varying lengths of the officers' quarters naturally creating the differences in overall lengths. This seems very reminiscent of Hyginus' prescription for the length of tent-lines per century in marching-camps and provides some support for Alan Richardson's belief in the use of the *actus* in permanent forts as well as temporary camps.[52] 120 *p.M.* measurements are certainly conspicuous elsewhere at Caerhun, e.g. in the *actus* square on which the *praetorium* was set out, including the 3 ft interval separating it from Building XVI, and the *c.* 115 ft 6 in combined width of Granaries XIII and XIV and the street flanking the northern side of the *principia*. Barracks I, IV, and VI in the

[49] Baillie Reynolds 1926, 283–323; 1927, 292–332; 1929, 61–99.
[50] Baillie Reynolds 1929, fig. 20.
[51] Baillie Reynolds 1929, 74, fig. 11.
[52] Hyginus, *de munitionibus castrorum* 1; Richardson 2000, 425, 434.

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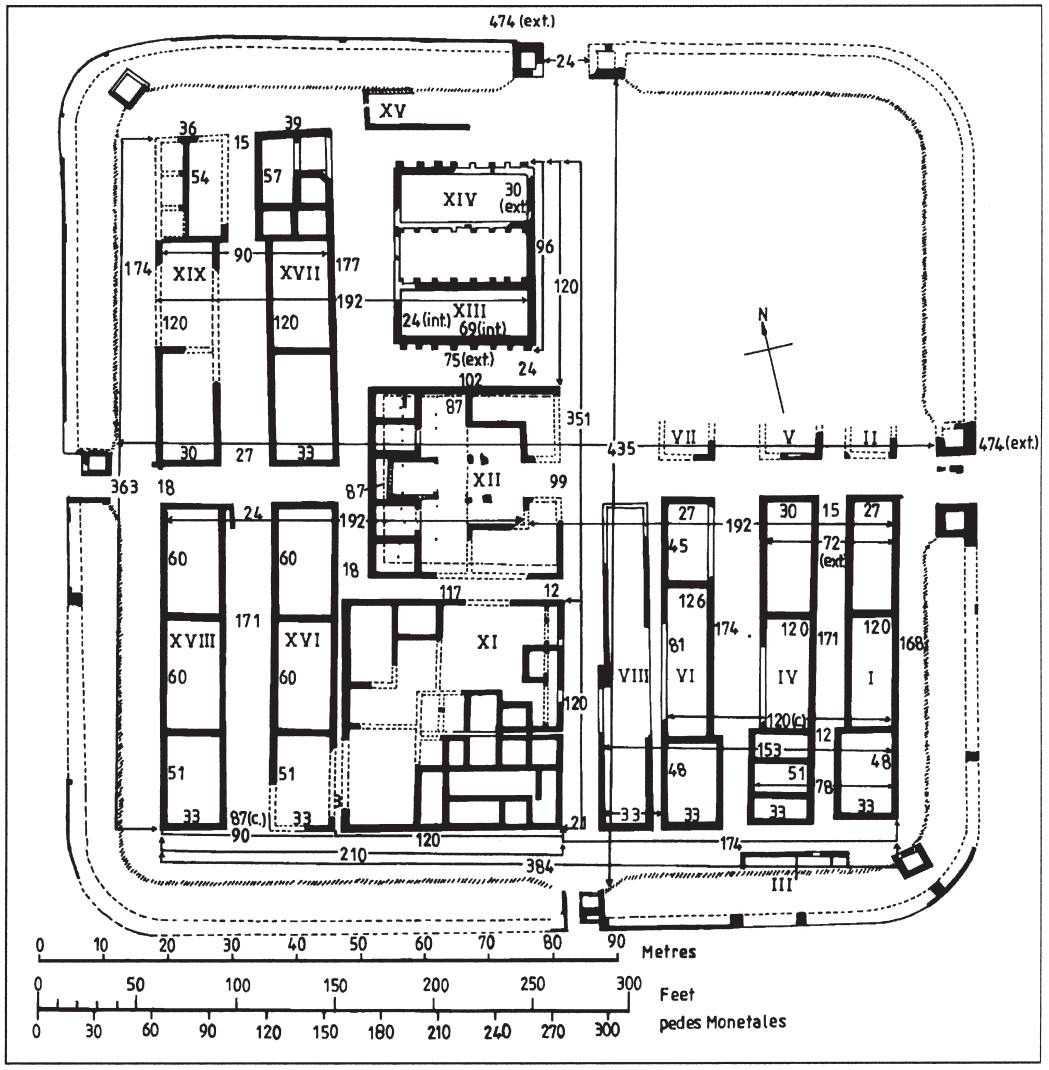


FIG. 12. Caerhun fort plan after Baillie Reynolds 1929, fig. 20. Dimensions in *pedes Monetales*.

praetentura jointly occupy a space 35.50 m/119.86 *p.M.* wide (east–west),[53] and it should not be overlooked that the 363 *p.M.* measured width (north–south) of the *retentura* at its western edge exceeds 3 *actus* by just 3 *p.M.*

The general plan of Caerhun (FIG. 12) allows a fairly accurate estimate of the fort's built-up length (east–west): *retentura* 90 *p.M.* wide; central range 120 *p.M.* wide; *praetentura* (including *via principalis*) 174 *p.M.* wide, amounting to 384 *p.M.* and reproducing the built-up lengths of

53 Davison 1989, iii, 853.

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Pen Llystyn and Strageath (FIGS 8–9). At Caerhun the mid-point falls, no doubt significantly, at the inner face of the east range of the stone-built *principia* and at the inner faces of the east walls of Granaries XIII and XIV and the yard(?) separating them.

CONCLUSIONS

This paper has taken a close look at the planning of a small number of auxiliary forts and forts with mixed garrisons over a period extending from the mid-first to the early second century A.D. What has emerged in the preceding pages, it is hoped, is a wealth of evidence for a much higher level of precision and co-ordination in the process than has normally been associated with such installations. That much is clear; what is less clear and more controversial is the exact means by which such impressive results were achieved. While the writer believes that the use of a 12 *p.M.* module had a significant part to play, it is not claimed that its application was universal. The sample of sites is too small to support such a claim, much of the evidence remains difficult to interpret for reasons already given, and the lack of sufficiently detailed information is a persistent obstacle. It may be easy enough to detect 12 *p.M.* measurements in the larger buildings of the central range (including granaries); it is much harder in barracks, stables, and storage buildings, especially where these have been less thoroughly investigated. In the present imperfect state of knowledge it would be unwise to rule out the possibility that buildings of different types and origins were set out on the basis of different modules. Evidently, no one system or solution can be assumed to take precedence over any other.

The single most striking conclusion to have emerged from the earlier part of this paper concerns the pivotal role of the *principia* in the overall design of the fort and while this is brought into sharper focus by the assumption of an underlying 12 *p.M.* module, it is not dependent upon it. Thus as early as Hod Hill both the planned length (north–south) and internal width of the fort can be seen to represent precise multiples of the width and length of the headquarters building respectively, while Baginton, despite the apparent eccentricities of the overall layout, reveals a relationship between the dimensions of the *principia* and the fort's internal width and built-up length (a quarter and a fifth respectively) which is entirely typical of later auxiliary forts.[54] The most telling example is perhaps Caerhun, where the 87 *p.M.* square layout of the Flavian wooden *principia* seems to have exercised a decisive influence upon both the internal dimensions of the fort as a whole and the setting-out of barracks and other buildings not in the central range. The proportional link between *principia* width and fort width in particular (both internal and external) seems so carefully calculated in many instances that it is difficult not to suspect a connection with the procedure followed in temporary camps at least as early as the second century B.C., whereby 'they first measure out the area of the *praetorium* (for which read *principia* in the Imperial context), next they draw the straight line along which the tents of the tribunes are set up … all the distances are regulated and familiar'.[55]

At Strageath, as at Baginton, we have seen that the planned length of the *principia* occupies a fifth of the fort's built-up long axis (east–west), but there is a good deal more to the relationship than that. The shape of the building (FIG. 13) mirrors that of the fort, as Frere and Wilkes note,[56] and the published dimensions themselves reinforce the close connection between the two. The external width of the fort is 5¾ times, the width within the *via sagularis* 4¾ times, the width

[54] And finds a precursor at Claudian Oberstimm in Raetia, where the *principia*, *c.* 23.4 m square, occupies a quarter and a fifth respectively of the fort's *c.* 98 m wide by 115.5 m long built-up area: Schönberger 1978, 96.

[55] Polybius, *Histories* 6.41.

[56] Frere and Wilkes 1989, 33, 125.

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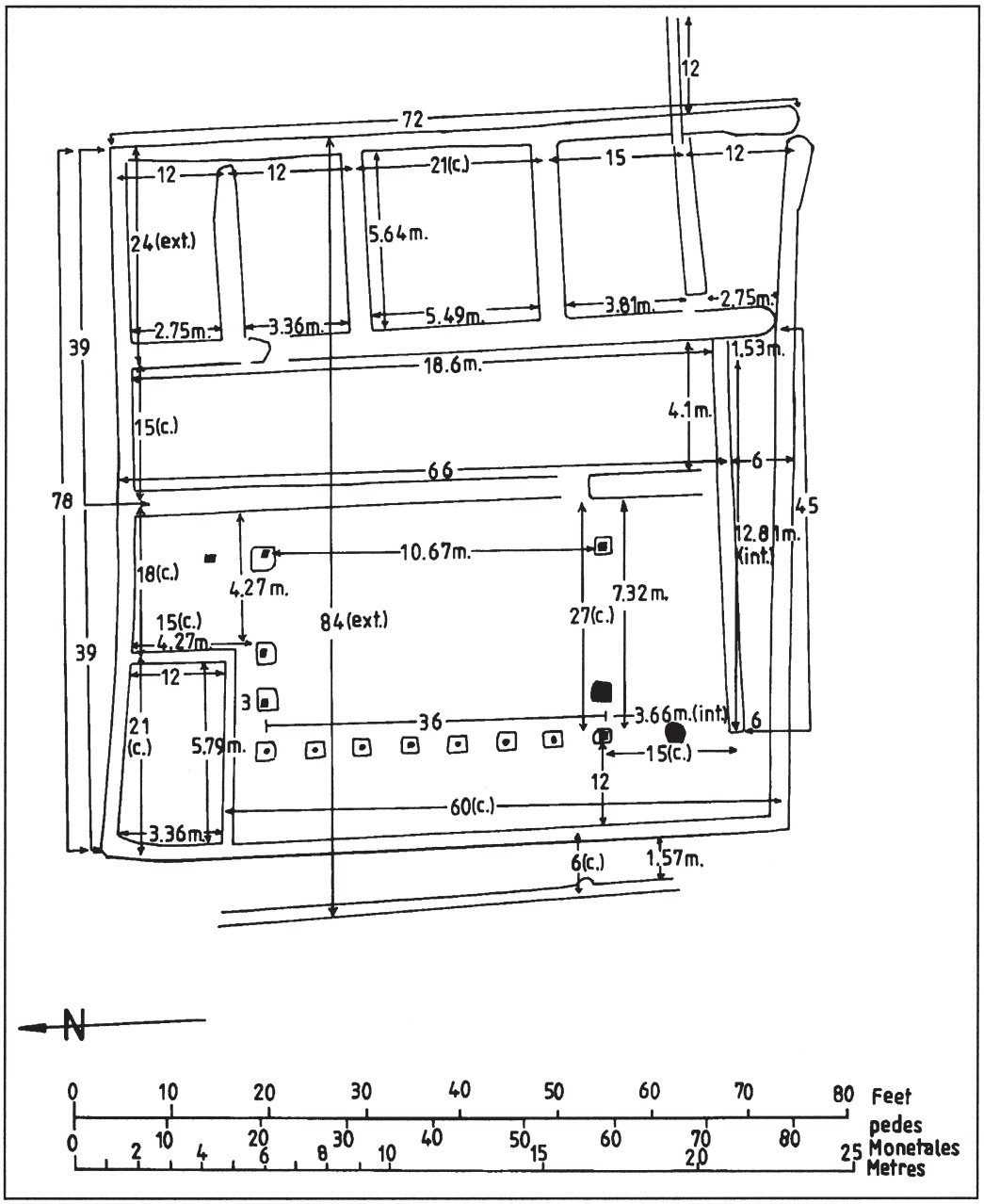


FIG. 13. Strageath Flavian *principia* after Frere and Wilkes 1989, 34, fig. 17. Dimensions in metres and *pedes Monetales*.

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of the headquarters building, but calculation will yield other significant multiples. Measured between the mid-points of north and south ramparts the width of the fort proves to be 117.47 m, readily translated into 396 *p.M.*, 33 times 12 *p.M.*, and exactly 5½ times the 72 *p.M.* planned width of the *principia*. Measured over the north and south *via sagularis* the internal width amounts to 107.86 m/364.18 *p.M.*, barely exceeding 5 times the width of the headquarters building. It is tempting to associate this figure with the 363 *p.M.* planned width of the Caerhun *retentura* and, as there, to suspect a close connection with the 3 *actus*/360 *p.M.* which would, of course, be precisely 5 times 72 *p.M.* As for the fort's long axis, the overall length measured between the centre-lines of east and west ramparts emerges as 138.57 m, fractionally more than 6 times the 22.9 m length of the *principia*; if the figures are interpreted as 468 *p.M.* (39 times 12 *p.M.*) and 78 *p.M.* respectively, the ratio becomes exact.

Tedious though this catalogue may seem, it does serve to highlight the extraordinarily intimate relationship between the size and proportions of the *principia* and those of the the fort at large. Again, it is hard not to see a link with the planning of temporary camps here,[57] as notoriously illustrated by the criteria which led to the identification of the site of Varus' first camp following the German disaster of A.D. 9: 'prima Vari castra lato ambitu et dimensis principiis trium legionum manus ostentabant'.[58] Although in a marching-camp of this date the term *principia* probably denotes (as it had under the Republic) the area at the centre of the *via principalis* in front of the *praetorium*, rather than the separate building it became by the end of the Julio-Claudian period,[59] it is significant that the measurements with which it was set out evidently varied in relation to the overall size of the camp and its garrison.

One clear implication of the preceding discussion is that apparent eccentricities in the planning of military buildings should not be dismissed too readily as the result of careless setting-out or construction. Of course, mistakes were frequently made (and corrected, as in the Hod Hill *principia*, though here it is more accurate to speak of a controlled change of plan[60]), but before such a conclusion is reached the relationships between buildings and their place within the overall context of the fort must be examined very closely. At Gellygaer, as at Strageath, none of the *principia*'s outer walls is set out at right-angles to another (FIG. 14), but each runs parallel to the corresponding side of the fort, and it is noticeable that the 69 and 69½ ft lengths of the north-east and south-west walls observe the same 1 : 5.5 ratio with the 384 and 386 ft external lengths of the fort's north-east and south-west sides respectively. The most telling example is provided by Fendoch, where we have already seen that the width of the *principia* occupies a quarter of the fort's external width (330 *p.M.*) at the south-west end. The care and precision with which the building was set out may be seen (FIGS 1 and 10) from the right angle at the northern, and near-right angle at the western corner,[61] and yet the rear (north-east) wall measures *c.* 85½ *p.M.* long in contrast to the front wall's 82½ *p.M.* The explanation surely lies in the desire to maintain a consistent 1 : 4 ratio, in this case with the 342 *p.M.* external width of the fort on the line of the *principia*'s rear wall. With the same objective in mind, the *praetorium* was set out with right angles at the north and south corners, but was increased in width by 3 *p.M.* from the south-west to the north-east end of the building.

The north-eastward expansion in the fort's external width also accounts for the deviating

57 The observation is not new, but was made several times by A. Schulten in his analysis of Roman siege camps of the second century B.C. in Spain (Schulten 1927, 128–31; 195).

58 Tacitus, *Annals* 1.61.

59 Fellmann 1958, 82–4; Tacitus, *Histories* 3.13; Josephus, *Bellum Iudaicum* 3.5.82–3 (who comments on the resemblance of the headquarters in a marching camp to a shrine). Note, however, that I.A. Richmond in Wellesley 1972, 221–2 takes *Annals* 1.61 to refer to 'one large building'.

60 Walthew 2002, 187–8.

61 Richmond and McIntyre 1939, pl. LV, 2.

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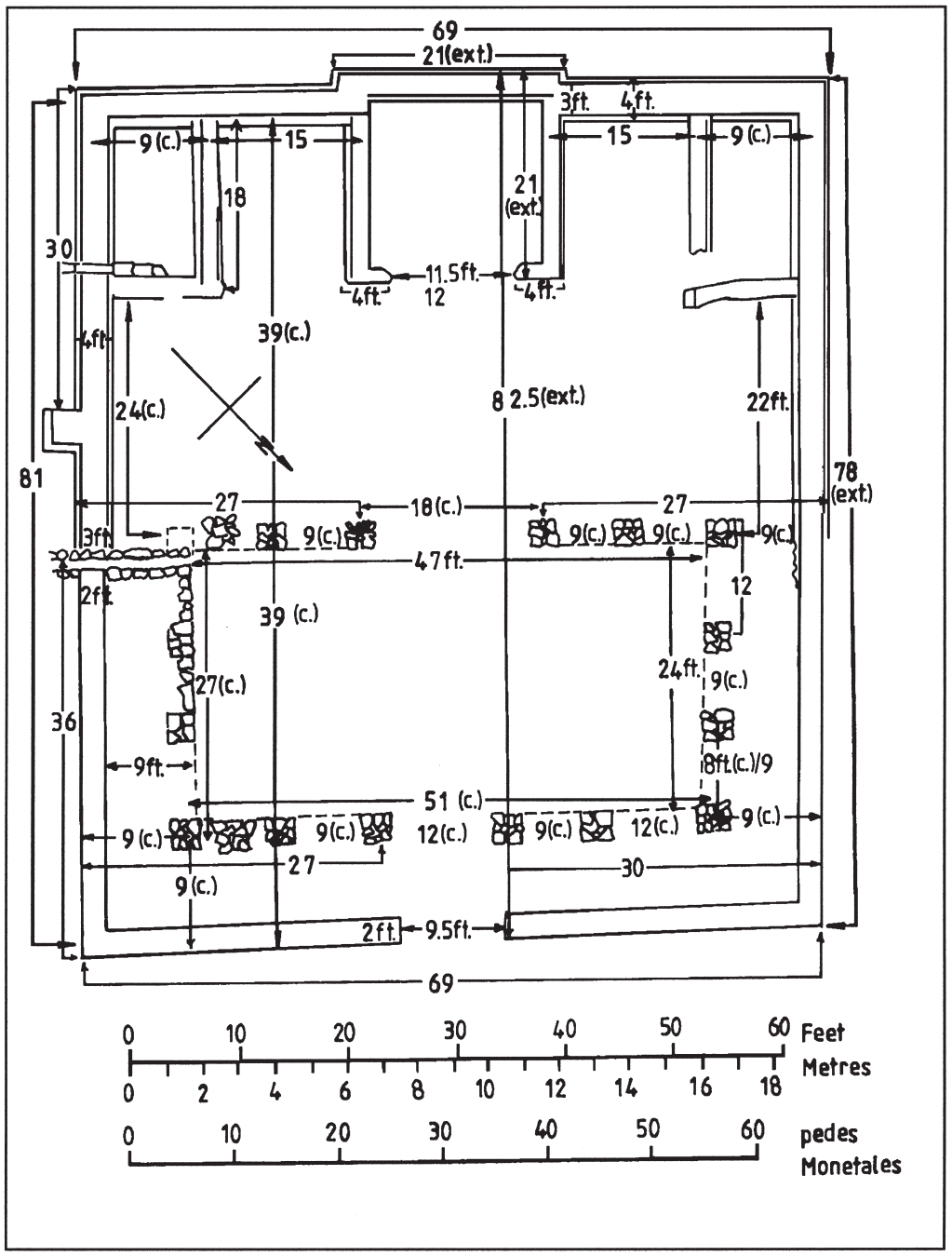


FIG. 14. Gellygaer *principia* after Ward 1903, pl. VI. Dimensions in Imperial feet and *pedes* Monetales.

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alignment of the north-west wall of Barrack 10, as Richmond recognised, though he chose to characterise this as an error in setting-out.[62] It should be noted, however, that the result of the process is a gradual increase in width of the internal built-up area from 249 *p.M.* at the south-west (*praetentura*) end, to 250½ *p.M.* on the line of the *via principalis*, to 255 *p.M.* at the north-east (*retentura*) end (FIG. 10). The reason for the expansion presumably lies in the local topography, reflecting the slightly diverging line of the north-west edge of the plateau on which the fort stands,[63] but what should be emphasised is the surveyors' controlled and measured response to it. The modified shape of Barrack 10 still leaves it as part of a pair (with Barrack 9) which occupies 81 *p.M.* in overall width, matching the widths of the pairings in the other three corners of the fort (in the case of Barracks 5 and 6 the 81 *p.M.* includes the width of the alley to the north-west). Each of these pairings flanks a central section 87 *p.M.* wide, the only difference between the south-west and north-east ends of the fort being the 6 *p.M.* wide alleyway unobtrusively separating Barracks 8 and 9. Rather than the outcome of error, this represents an admirably adroit solution to the problem posed by the topography.

Does the demonstrable concern to maintain a consistent ratio between the dimensions of the *principia* and those of the fort allow a specific rule or principle to be detected? As far as the long axis of the latter is concerned, the answer seems to be a qualified yes, as the following table will show :

	Planned length of *principia*	Planned length of fort (*p.M.*)
Strageath	78	390
Gellygaer	78	390
The Lunt	81	405
Caerhun	87	435
Pen Llystyn	93	465
Fendoch	105	522

It will, of course, be objected that slightly varying criteria for assessing fort length have been employed here, built-up lengths at Strageath, The Lunt, and Fendoch, intramural length at Caerhun, and overall lengths to the centre-lines of ramparts at Gellygaer and Pen Llystyn, and that the figures for Fendoch do not provide an exact fit. Nevertheless, the consistency with which the 1 : 5 ratio is applied seems significant (allowing for the small sample of forts included), and may be documented on later military sites, for example on Hadrian's Wall, where it is precisely replicated at Carrawburgh (Hadrianic) and South Shields (mid-Antonine), and nearly so at Great Chesters (Hadrianic).[64]

Might we expect to find similarly consistent ratios in operation between other buildings and overall fort dimensions? As far as barracks are concerned, there seem grounds for cautious optimism on this score. Taking first those forts where the barracks are aligned *per strigas*, the 165 *p.M.* length of Barracks 4 and 5 in the *retentura* at Baginton occupies two fifths of the fort's built-up long axis, a measured 121.84 m/411.38 *p.M.*, as we have seen (FIG. 7), while at Fendoch the 621 ft overall length of the fort measured between the centre-lines of the defensive ditch is just over four times the 154 ft recorded length of the *praetentura* and *retentura* barracks. If the latter is correctly interpreted as 159 *p.M.*, as argued earlier, then the fort plan may be seen (FIG. 10) to have comprised four blocks of this length, three of which were assigned to the interior. Turning to barracks aligned *per scamna*, the 155 ft long blocks at Pen Llystyn take up two fifths of the fort's 388 ft measured internal width, while at Strageath the *retentura* barracks were

62 Richmond and McIntyre 1939, 136 and fig. 2, facing p. 114.
63 Richmond and McIntyre 1939, 112, fig. 1.
64 As clearly demonstrated by the dimensions set out in Taylor 2000, 140, appendix 3, tables 1–2.

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probably set out over a length of 159 *p.M.*/47.10 m, as already noted, this representing two fifths of the 117.47 m width of the fort measured between the mid-points of the north and south ramparts. Finally, the same ratio (precisely!) may be detected between the 146 ft external length of Barrack XV in the *praetentura* at Gellygaer and the 365 ft distance separating the centre-lines of the north-west and south-east ramparts and is almost as closely reproduced by the relationship between the 169.6 ft/174.69 *p.M.* average length of the five barracks at Caerhun and the 435 ft width of the fort assessed on the same basis.[65]

The sample may be small, but the occurrence of the 2 : 5 ratio on five out of six sites is clearly impressive and echoes Davison's conclusion that the lengths of *per scamna* barracks of late first- to early second-century A.D. date do not generally exceed 38 per cent of the overall width of the fort.[66] The evidence from Baginton suggests that the same ratio might also be sought in barracks aligned *per strigas*, though a great deal more careful analysis will be required to substantiate this notion. On the face of it, there appears to be no obvious link between the ratio and the type or size of the military units garrisoning the forts in question.[67] Thus we are left with a picture of military design at this period in which sets of recurring ratios may be detected between barrack lengths and *principia* dimensions on the one hand and the overall sizes of forts on the other. Admittedly, the latter have been assessed somewhat loosely during this exercise, but the presence of barracks of comparable lengths and *principia* of closely similar dimensions on a small number of sites would seem to imply that a set of norms, desirable targets perhaps, for the overall sizes of forts was also beginning to emerge, as suggested earlier in this paper. Naturally, not all the factors involved in this process, which is to be seen not as the imposition of standardisation,[68] but as a gradual and limited movement towards uniformity in military planning, can be distinguished in the present state of knowledge, but one of them may have been the adoption of a 12 *p.M.* module for which there is a growing body of archaeological evidence and some ancient support in the *de munitionibus castrorum*.

11 St.Luke's Crescent, Milltown, Dublin 14

65 Baillie Reynolds 1926, 314; 1927, 292–4; 1929, 90 and fig. 20.

66 Davison 1989, i, 104–5.

67 On which see Davison 1989, iii, 643–53, table XIII.

68 For example, the overall dimensions of the Strageath *principia* (FIG. 13) may be effectively reproduced by Gellygaer (FIG. 14), and the mid-point on the long axis of both buildings falls at the front of the cross-hall, but the 24 *p.M.* depth of the rear range at Strageath becomes the width of Gellygaer's cross-hall. The *aedes* in both is 21 *p.M.* wide, but the subdivision of the flanking rooms differs markedly, and, although the main dimensions of the forecourt area are common to both (51 *p.M.* long by 27 *p.M.* wide), the planning of the enclosing spaces is handled quite differently. The picture is clearly one of detailed diversity within broad overall uniformity.

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APPENDIX: TABLES OF PUBLISHED DIMENSIONS[69]

TABLE A: HOD HILL

(A) Overall dimensions of fort

External (axial) 753 ft N–S by 587 ft E–W = 775.62 by 604.63 *p.M.*, suggesting perhaps 780 by 600/606 *p.M.*, 65 by 50/50½ × 12 *p.M.*
Internal (axial) 587 ft N–S by 508 ft E–W = 523.26 *p.M.*, perhaps 522 *p.M.*, 43½ × 12 *p.M.* and 6 × 87 *p.M.* length of *principia.*
E Gate[70] 38½ ft wide by 19 ft deep overall; towers 10 ft wide by 19 ft deep (ext.), separated by portal 18½–19 ft wide by 10 ft deep; carriageways 9 ft wide. Planned dimensions between post-centres: 39 by 18 *p.M.* overall; towers 9 *p.M.* wide by 18 *p.M.* deep; portal 21 *p.M.* wide by 9 *p.M.* deep; carriageways 9 *p.M.* wide.
S Gate[71] 14 ft wide by 11¼ ft deep.
NW Gate[72] 10 ft wide by 13 ft deep, possibly 12 *p.M.* deep by 9 *p.M.* wide at inner end, 12 *p.M.* wide at outer end.

(B) Internal buildings

(i) *Principia*: see FIGS 2 and 3 for published measurements and interpretation: 'its own axis set about 13 ft south of the true axial position (of the fort)'.

(ii) *Praetorium* II
Located 20 ft (?21 *p.M.*) behind (W of) *principia*; set out as a square of 70 ft/72 *p.M.*;[73] foundation-trenches 'presumed to have been in general the same as those of the *principia*' i.e. *c.*16 in wide.
(a) Courtyard 26 by 19 ft (between post-centres?), with (b) portico 6/7 ft wide; (c) S 'hall' 15 by 6 ft; (d) 'office' 36 by 11 ft; (e) 'dining-room' (very improbable!) 40 by 9 ft; (f) 'kitchen' 32 by 11 ft 3 in; (g) W room (much more plausible *triclinium*?) 51 by 22 ft.
Interpretation
(a) 27 *p.M.* (E); 24 *p.M.* (W); 18 *p.M.* (N); 21 *p.M.* (S), all between post-centres (post-holes 'not less than 2 feet in diameter').
(b) varies from 6 to 9 *p.M.* wide between post-centres and centre-lines of walls; courtyard (including portico) 42 by 36 *p.M.* (centre-lines).
(c) 15 by 9 *p.M.*
(d) 39 by 15 *p.M.*
(e) 42 by 9 *p.M.* (N), 12 *p.M.* (S).
(f) 33 by 15 *p.M.*
(g) 54 by 24 *p.M.* (between centre-lines of foundation-trenches: 51 ft + 1 ft 4 in = 53.90 *p.M.*; 22 ft + 1 ft 4 in = 24.03 *p.M.*)

(iii) *Praetorium* I
Overall 119 by 56 ft; NE 're-entrant' 11 by 9 ft.
Courtyard 41 by 27 ft (including portico).
Triclinium 27 by 22 ft; post-holes 2 ft in diameter, set 10 ft apart.
N aisle 7 ft wide.

69 For reasons of space not all the detailed measurements of individual barracks and stables published by Davison can be included: see Davison 1989, iii, 738–801, tables XVII–XIX; 847–72, tables XXIII–XXIV.
70 Richmond 1968, fig. 41A.
71 Richmond 1968, fig. 41B.
72 Richmond 1968, fig. 42A.
73 Note 70 + 20 + 84½ ft (length of *principia*) = 174½ ft/179.74 (?180) *p.M.*, as a useful guide to the planned length (east–west) and width of the north and south *praetentura* (FIG. 4).

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(iv) Legionary barracks (I–VI)
All 118 ft long by 20–25 ft wide (ext.); officers' quarters 37–40 ft long by 19½–25 ft wide; *contubernia* 12 by 10 and 10 by 8 ft (int.).
Barrack I centurion's quarters: front passage 36 by 6 ft; E room 12 ft 4 in by 11 ft 3 in; W room 9 ft 4 in by 11 ft 3 in; next room to W 10 ft wide by 9 ft deep.
Widths of barrack pairings:[74] I–II, III–IV 21.50 m/72.59 *p.M.*

(v) Cavalry barracks (VII–XIII)
Contubernia room sizes 11 ft wide by 13 ft deep (average); 17 ft deep (Barrack XI), possibly 12, 15, 18 *p.M.*
Davison:[75] Barrack VII length 37.19 m (ext.)/37.70 m (c.)(?); width 6.71 m (ext.)/6.31 m (c.); officer's quarters length 12.50 m (ext.)/12.10 m (c.) by 6.71 m wide (ext.)/6.31 m (c.); *contubernia* length 24.69 m (ext.); width 4.88 m (ext.)/4.48 m (c.).
Richmond's plan[76] clearly suggests overall length 126 *p.M.*/37.32 m by 21 *p.M.*/6.22 m wide (officer's quarters), 15 *p.M.*/4.44 m (*contubernia*); officer's quarters 42 *p.M.*/12.44 m long; *contubernia* range 84 *p.M.*/24.88 m long, containing 7 *contubernia* 12 *p.M.*/3.55 m wide.
Barrack VIII length 38.10 m (ext.)/37.70 m (c.); width 9.45 m (ext.)/9.05 m (c.); officer's quarters length 16.25 m (ext.)/15.85 m (c.) by 4.57 m wide (ext.)/4.17 m (c.); *contubernia* 21.85 m long (ext.) by same width.
Suggested interpretation: lengths 126; 54; 72 *p.M.*; widths 30; 15 *p.M.*
Barrack IX length 34.14 m (ext.)/33.74 m (c.); width 9.00 m (ext.)/8.60 m (c.); officer's quarters length 11.58 m (ext.)/11.18 m (c.) by 8.23 m wide (ext.)/7.83 m (c.); *contubernia* length 21.95 m (ext.)/21.55 m (c.); width 5.49 m (ext.)/5.09 m (c.); interval between *contubernia* and officer's quarters 0.61 m wide (ext.)/1.01 m (c.).
Suggested interpretation: lengths 114; 39; 72; 3 *p.M.* (interval); widths 27 *p.M.* (officer's quarters); 18 *p.M.* (*contubernia*).
Barrack X length 33.83 m (ext.)/33.43 m (c.); width 8.23 m (ext.)/7.83 m (c.); officer's quarters length 8.23 m (ext.)/7.83 m (c.); width 8.23 m (ext.)/7.83 m (c.); *contubernia* length 22.10 m (ext.)/21.70 m (c.); width 5.49 m (ext.)/5.09 m (c.); interval between officer's quarters and *contubernia* 3.50 m (ext.)/3.90 m (c.).
Suggested interpretation: overall length 114 *p.M.*/33.76 m by 27 *p.M.*/8.00 m wide; officer's quarters 27 *p.M.* square; *contubernia* 75 *p.M.*/22.21 m long by 18 *p.M.*/5.33 m wide; interval 12 *p.M.*/3.55 m.
Barrack XI length 32.91 m (ext.)/32.51 m (c.); width 10.50 m (ext.)/10.10 m (c.); officer's quarters length 6.50 m (ext.)/6.10 m (c.); width 9.50 m (ext.)/9.10 m (c.); *contubernia* length 23.41 m (ext.)/23.01 m (c.); width 6.00 m (ext.)/5.60 m (c.); interval between officer's quarters and *contubernia* 3.00 m (ext.)/3.40 m (c.).
Suggested interpretation: overall length 111 *p.M.*/32.87 m; *contubernia* 78 *p.M.*/23.10 m long (but module remains hard to identify).
Barrack XII/XIII length 44.20 m (ext.)/43.80 m (c.); width 11.58 m (ext.)/11.18 m (c.); officer's quarters length 18.00 m (ext.)/17.60 m (c.); width 11.58 m (ext.)/11.18 m (c.); *contubernia* length 26.20 m (ext.); width 5.18 m (ext.)/4.78 m (c.).
Suggested interpretation: overall length 147 *p.M.*/43.54 m by 39 *p.M.*/11.55 m wide; officer's quarters 60 *p.M.*/17.77 m long by 39 *p.M.* wide; *contubernia* 87 *p.M.*/25.77 m long by 16½ *p.M.*/4.89 m wide (module possibly 12 *p.M.*, but remains doubtful).
Widths of barrack pairings/groupings: VII–VIII 25.00 m/84.41 *p.M.*; IX–XI 33.50 m/113.11 *p.M.*

(vi) Granary 55 ft long by 21 ft 3 in wide (ext.); posts 9–10 in square.
Suggested interpretation: 55 *p.M.* long by 21 *p.M.* wide between post-centres.[77]

(vii) ?*Valetudinarium* (W of Barrack VII) 80 ft long by 60 ft wide (ext.); courtyard 48 by 28 ft; hall 60 by 25 ft; rooms around courtyard 15 ft deep.

74 Davison 1989, iii, 854.
75 Davison 1989, iii, 748–9, 771.
76 Richmond 1968, fig. 45B.
77 Richmond 1968, fig. 46A.

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Suggested interpretation: 81 by 60; 51 by 30; 60 by 27; 15 *p.M.*; total length of frontage on *via principalis* 108 *p.M.* (all these suggestions very tentative).

(viii) Stables 187–195 ft long (192.62–200.86 *p.M.*) by 12 to 17 ft wide (12 to 18 *p.M.* perhaps).
Stable 2: five central rooms 18 ft long by 11 ft deep; two sets of three end-rooms 12–13 ft long.
On Davison's figures[78] Stables 1–4 appear to centre around 198 *p.M.*/58.64 m long; 5 perhaps 195 *p.M.*/57.75 m; and 6 192 *p.M.*/56.86 m.
Possible widths:[79] Stable 1 27 *p.M.*; Stable 2 15 *p.M.*; Stable 3 30 *p.M.*; Stable 4 15 *p.M.*(?); Stable 5 15 *p.M.*; Stable 6 24 *p.M.*

(ix) Latrine:[80] 34 ft long; E room 17 ft N–S by 11 ft E–W (int.); two S rooms said to be 22 ft long by 10 ft wide (int.), but the more southerly clearly narrower than this.
Suggested interpretation (supported by plan): 36 *p.M.* long by 21 *p.M.* wide; E room 18 by 12 *p.M.* (int.); S rooms 24 *p.M.* long by 12 and 9 *p.M.* wide.

TABLE B: THE LUNT, BAGINTON (PERIODS 1 AND 2)

(A) Overall dimensions of fort

91.44 m wide by 167.64 m long (121.84 m less northern granaries).
= 308¾ by 566 (411.38) *p.M.*
East Gate/*Porta Principalis Sinistra*,[81] 6.07 m wide by 3.04 m deep, clearly 22 *p.M.* wide, comprising two 11 *p.M.* wide portals (measured between post-centres), but apparently 10 *p.M.* deep.

(B) Internal buildings

(i) *Principia*[82] *c.* 21.28 m/71.85 *p.M.* wide by 24 m/81 *p.M.* long (ext.), rather than 21.28 m square; located *c.* 30.48 m/102.91 *p.M.* W of E Gate, though general plan suggests *c.* 31.92 m/107.77 *p.M.* to centre of NW post of gate; wall-trenches *c.* 0.45 m wide.
Published measurements: courtyard 15.24 m square, flanked by E and W ranges 3.04 m wide; S entrance 3.04 m wide; three central rooms in N range *c.* 4.55 m square, flanked by outer rooms 4.55 by 3.04 m.
Published plans indicate: courtyard *c.* 16 m long by 13.2 m wide (int.); S entrance not 'centrally placed'; *aedes c.* 6.4 m wide by 5.8 m deep (ext.); *aedes* and two flanking rooms ('planned as one unit'[83]) *c.* 14 m long by 5.8 m wide; that unit part of central rectangle of building *c.* 14 m wide by 24 m long.

(ii) *Gyrus c.* 32.77 m/110.63 *p.M.* in diameter; circumference 102.96 m/348 *p.M.* (29 × 12 *p.M.*); entrance *c.* 3.04 m wide.

(iii) Granaries at N end of fort
NE granary 21.33 m/72 *p.M.* long by 9.14 m/30.86 *p.M.* wide.
Central granary (Period 1) 21.28 m/71.85 *p.M.* long by 9.12 m/30.79 *p.M.* wide, replaced in Period 2 by building 25.84 m/87.25 *p.M.* long by 6.07 m/20.49 *p.M.* wide.
W granary (3.04 m N of Barracks 4–6) 22.80 m/76.98 *p.M.* long by 9.12 m/30.79 *p.M.* wide.

(iv) Granary 10 ft/3.04 m W of *principia*; 16.75 m/56.55 *p.M.* long by 9.14 m/30.86 *p.M.* wide,[84] replaced by ?*praetorium* 18.28 m square, W half comprising five rooms *c.* 7.62 m long by 3 m wide (int.); 18.28 minus 7.62 m = 10.66 m/36 *p.M.* width of E half, divided into two equal areas 36 by 30 *p.M.*

78 Davison 1989, iii, 749.
79 Davison 1989, iii, 771.
80 Richmond 1968, fig. 46B.
81 Hobley 1973, 19 and fig. 6.
82 Dimensions taken from plans in preference to those recorded by the excavator (Hobley 1973, 23–5), which seem highly inaccurate.
83 Hobley 1973, 23.
84 Hobley 1975, 9, fig. 2 suggests a length of 16 m/54 *p.M.*

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Width of ?*praetorium* 18.28 m + street 3.04 m wide to E = 21.32 m/71.98 *p.M.*, i.e. matching width of *principia* and producing *via principalis* frontage 144 *p.M.* long to SE corner of latter.
Building E of *principia* 18.66/22.21 m long by 10.66 m wide = 63/75 by 36 *p.M.*

(v) *Retentura* barracks, Period 1: Barracks 1 and 2 (3.04 m apart): 45.72 m long by 6.07 m wide (ext.); *contubernia c.* 4.25 by 3.64 m; verandahs *c.* 1.36 m wide; wall-trenches *c.* 0.30 m wide.
Davison:[85] Barracks 1 and 2 45.32 m/153 *p.M.* long (centre-lines); Barrack 1 officer's quarters 9.90 m long (ext.)/9.50 m (c.); *contubernia* range 35.82 m long (ext.)/35.52 m (c.), suggesting 33 + 120 *p.M.*; Barrack 2 officer's quarters 11.50 m long (ext.)/11.10 m (c.); *contubernia* range 34.33 m long (ext.)/34.03 m (c.), probably 39 + 114 *p.M.*
Combined width of Barracks 1 and 2 15.18 m/51.25 *p.M.*; 153 : 51 *p.M.* = 3 : 1.
Barracks 4 (2.42 m W of 3) and 5 48.76 m long by 6.07 m wide (ext.); officers' quarters 8 m long; *contubernia* ranges 40.8 m long (in preference to Davison's 39.05 m for 4, 37.72 m for 5), suggesting 27 + 138 = 165 *p.M.*
Period 2 Barrack 1 27.80 m long (ext.)/27.40 m (c.); officer's quarters 9.90 m long (ext.)/9.50 m (c.); *contubernia* range 17.90 m long, suggesting 93 (33 + 60) *p.M.*
Period 2 Barrack 2 30.85 m long (ext.)/30.45 m (c.); officer's quarters 11.50 m long (ext.)/11.10 m (c.); *contubernia* range 19.35 m long, suggesting 102 (39 + 63) *p.M.*, though general plan favours 105 (39 + 66) *p.M.*[86]

(vi) Built-up long axis of fort (N–S) based on published measurements:

W granary	9.12 m wide	
street to Barrack 5	*c.* 3.04 m wide	
Barrack 5	48.76 m long	
via quintana	*c.* 2.28 m wide	
principia	24.00 m long	
via principalis	5.00 m wide	
R *praetentura* barrack (Period 1)	41.80 m long	(Period 2 *c.* 30.48 m long)
Total	134.00 m/452.44 *p.M.*	
Less width of W granary and street	121.84 m/411.38 *p.M.*	

(vii) Period 2 ?*praetorium* (SE *praetentura*): 33.52 m long (N–S) by 30.48 m wide (general plan rather suggests *c.* 41.04 by 29.28 m).

TABLE C: PEN LLYSTYN

(A) Overall dimensions of fort

External length over ramparts *c.* 463 ft/141.12 m/477(?480) *p.M.* NE–SW (cf. Caerhun 460 ft/474 *p.M.* square externally).
External width over ramparts *c.* 419 ft/127.71 m/431.21(?432) *p.M.* NW–SE.
Within ramparts 433 ft/132 m/445½ *p.M.* long NE–SW by 388 ft/118.26 m/399.66 *p.M.* NW–SE; rampart 15 ft/4.57 m wide; berm 15 ft wide; inner ditch 12 ft wide (also outer berm).
Built-up area *c.* 373 by 332 ft = probably 384 by 342 *p.M.* or 32 by 28½ × 12 *p.M.*
NW and SE gates set out with centre-points *c.* 33 ft from building line, NE gate *c.* 31 ft from same.

(B) Internal buildings

Wall-trenches generally 1–1½ ft wide, up to 2 ft in *praetorium.*

[85] Davison 1989, iii, 746.
[86] Hobley 1975, fig. 1.

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(i) *Principia* 75 ft wide by 92 ft long; courtyard 53 ft long by 36 ft wide, flanked by colonnade 10 ft wide; cross-hall 73 ft long by 12 ft wide; *aedes* 16 ft wide by 17 ft long.
Note ?ritual deposit on central axis of *principia* 'almost exactly 1 ft south of the true mid-point of the 320 by 360 "foot" (i.e. Hogg's local "foot" of 1.034 modern feet) parallelogram' = the *c.* 332 by 373 ft built-up area.

(ii) *Praetorium* 119 ft long by 91 ft wide overall; courtyard 43 ft wide by 49 ft long; entrance passage 8 ft wide by 20 ft long; portico 5 ft wide; posts centred at 5 ft intervals; NW and NE ranges: rooms 13 ft long by 10 ft wide; 25 ft wide 'space' NW of NW range, comprising SE 'passage' 8 ft wide, NE room 40 ft long by 16 ft wide, and SW room 16 ft long by 7 ft wide.

(iii) Granaries
Long axes 32 ft/33 *p.M.* apart; length 99 ft/101.97 *p.M.*; width 24 ft/24.72 *p.M.*; loading-bays 8–9 ft deep.

(iv) 'Hospital' 120 ft long by 25 ft wide; ten rooms 9/10 ft wide by 14 ft long; at NW end a room 8 ft square, entered from ante-chamber 8 by 13 ft; verandah 5 ft wide and partial screen-wall 7 ft from SW side.

(v) Barracks: 155 ft long by just under 30 ft wide = 159(1 + 39 + 1 + 117 + 1) by 30 *p.M.*; *contubernia* ranges 115 ft long; centurion's quarters 40 ft long; *contubernia* comprise two rooms *c.* 13 ft deep where verandah is lacking.
Barrack P5: centurion's quarters 46 ft long; Building P3: 155 ft long by 23 ft wide; Building P6: 28 ft wide.

TABLE D: STRAGEATH (FLAVIAN)

(A) Overall dimensions of fort

Over the ramparts 472 ft/143.90 m long E–W by 403 ft/122.80 m wide N–S; within *via sagularis* 385 ft/117 m long by 330 ft/100.6 m wide. Rampart 17–17½ ft/5.18–5.33 m wide (base); N *via sagularis* N of central range 5.33 m wide.

(B) Planned internal dimensions of fort (within *via sagularis*)

(i) N–S along *viae principalis-quintana*
Measured total along *via quintana* N of *principia* (Building B + E–W street) 39.09 m/131.985 *p.M.*; measured total of buildings S of *principia* 38.33 m/129.42 *p.M.*, but see C(iv) below. Overall measured total N–S within *via sagularis* 98.72 m/333.32 *p.M.* cf. Davison's figures,[87] which yield a built-up width N–S for the *praetentura* of 42.50 + 9.00 + 48.00 m = 99.50 m/335.95 *p.M.* Measured width of *retentura* 47.85 m (length of Building II) + 4.88 m (width of *via decumana*) + 46.79 m (length of Building X) = 99.52 m/336.02 *p.M.*
N rampart to central range 7.16 m/24 *p.M.*; to *principia* 46.25 m/156.16 *p.M.*
Suggested distribution on this alignment 156 + 72(width of *principia*) + 156 = 384 *p.M.*, i.e. matching built-up E–W axis.

(ii) W–E south of *viae praetoria-decumana*
Built-up width of S *praetentura* to front of *principia* 153 *p.M.*/45.31 m + 78 *p.M.*/ 22.9 m (length of *principia*) + 153 *p.M.* (rear of *principia* to E *via sagularis*) = 384 *p.M.*/113.53 m. This suggested distribution conforms closely to the general plan,[88] which also shows the front wall of the cross-hall falling at the precise mid-point W–E, 192 *p.M.* from either end. All but 6 *p.M.* of the 153 *p.M.* wide S *retentura* may be documented: rear of *principia* to E wall of Building XII 11.58 m/39.10 *p.M.*; verandah W of Building XI to E *via sagularis* 32.01 m/108.08 *p.M.*; only lacking is the distance from E wall of XII to verandah W of XI.

87 Davison 1989, iii, 847 and 860.
88 Frere and Wilkes 1989, fig. 66.

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N of the *viae praetoria-decumana* the measured length of the built-up area totals 114.96 m/388.15 *p.M.*, suggesting a planned 390 *p.M.*

(C) Internal buildings

(i) *Principia* 21.3 m wide N–S by 22.9 m long E–W = 72 by ?78 *p.M.*; wall-trenches 0.305–0.61 m wide, posts 0.152 by 0.204 m, spaced at *c.* 0.61 m intervals.

(ii) Building A (?*praetorium*) *c.* 33.22 m long N–S by 17.07 m wide E–W (estimated).

(iii) Building B (?hospital) 35.13 m long + S portico(?) 0.91 m wide = 36.04 m/121.69 *p.M.* long N–S, located 3.05 m N of *principia.*

(iv) Buildings C and D and intervening space S of *principia* are given a measured total N–S of 38.33 m/129.42 *p.M.*, clearly an underestimation, since the E–W street flanking *principia* is *c.* 3.34 m wide at E end adjoining *via quintana*, rather than the 2.74 m stated. C + space + D measures 35.59 m/120.17 *p.M.* overall. C's 13.72 m ext. width is compatible with 13.36 m/45.11 *p.M.* between centre-lines of wall-trenches 0.36 m wide and on same principle the 10.36 m wide space becomes 10.72 m/36.19 *p.M.* Given wall-trenches 0.36–0.46 m wide, the 4.04–4.11 m int. widths of the three E–W ranges constituting C suggest a planned 15 *p.M.*/4.44 m and the 11.51 m/38.86 *p.M.* ext. width of D clearly hints at 39 *p.M.*

(v) Granary VIII 32.61 m/110.10 *p.M.* long ext., 32.23 m/108.82 *p.M.* between centre-lines of foundation-trenches *c.* 0.38 m wide.

(vi) Granary XVI 39.32 m/132.76 *p.M.* long.

(vii) Barracks
(A) N *retentura*
Buildings II and III alone have measured ext. length. Building II (not a barrack) 47.85 m/161.56 *p.M.* long, but Frere and Wilkes' plan[89] suggests 47.1 m/159 *p.M.* long: N block + interval 11.7 m/39½ *p.M.* long; S block 35.5 m/119.86 *p.M.* long between centre-lines. Likely interpretation 39 + 120 *p.M.*
Building III 47.40 m/160 *p.M.* long; officer's quarters 10.7 m/36 *p.M.* long; interval to *contubernia* 0.91 m/3 *p.M.* between centre-lines; *contubernia* range 35.97 m long (ext.), 35.59 m between centre-lines of wall-trenches 0.38 m wide, suggesting a planned 120 *p.M.*
Measured width of N *retentura* up to E *via sagularis* 42.74 m/144.31 *p.M.* Within that total note 21.34 m/72 *p.M.* joint width of Buildings I and II and 19.52 m/66 *p.M.* joint width of Buildings III and IV.
(B) S *retentura*
Building X alone of known (though not agreed!) ext. length 46.94 or 46.79 m/158.49 or 157.98 *p.M.*,[90] the latter corroborated by the plan;[91] officer's quarters 12.80 m and *contubernia* 33.98 m long; given wall-trenches 0.26–30 m wide, the figures suggest 42 *p.M.*/12.44 m and 114 *p.M.*/33.76 m long between centre-lines respectively and a planned total of 156 *p.M.*/46.20 m (?int.), but in view of the uncertainty an ext. length of 159 *p.M.*/47.09 m cannot be completely excluded. The 0.42 m distance from the S end of the block to the edge of the *via sagularis* creates a space 47.21 m/159.40 *p.M.* long overall.
Building IX overall length of *contubernia* variously given as 27.74/27.58 m, the latter suggesting 93 *p.M.*/27.54 m.
Building XI overall length of *contubernia* 32.31 m = 32.01 m/108.08 *p.M.* between centre-lines of wall-trenches 0.30 m wide.
Dimensions relevant to the planned width E–W of S *retentura* (see B(ii) above):
(a) E rampart to Building IX 9.74 m/32.89(?33) *p.M.*
(b) Building IX 7 m/24 *p.M.* wide (*contubernia*), 8.85 m/30 *p.M.* wide (officer's quarters).
(c) Interval between IX and X, including wall-trench 0.30 m wide, 5.34 m/18.03 *p.M.*

89 Frere and Wilkes 1989, fig. 33.
90 cf. Frere and Wilkes 1989, 89 with table III, p. 136.
91 Frere and Wilkes 1989, fig. 51.

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(d) Building X 7.32 m/24.71 *p.M.* wide, probably 24 *p.M.* to centre-lines of wall-trenches 0.26–0.30 m wide.
(e) Combined width of IX and X 19.81 m = 19.55 m/66 *p.M.* between centre-lines of wall-trenches.
(f) Interval between X and XI 1.53 m = 1.79 m/6 *p.M.* between centre-lines of wall-trenches.
(g) Building XI 8.54 m wide (ext.) probably = 27 *p.M.*/8 m given unusually wide wall-trenches 0.30–0.61 m.
(h) Building XII 7.92 m wide at N end and 9.37 m at S (ext.), possibly 27 and 30 *p.M.* respectively (the latter 8.85 m/29.88 *p.M.* (int.) between wall-trenches 0.26 m wide).
Insufficient information to calculate planned width E–W of S *retentura* but note:
(i) E rampart to Building IX 9.74 m/32.89 = 33 *p.M.*?
(ii) Width of *retentura* from E *via sagularis* to W (veranda) side of Building XI 32.31 m/109.09 *p.M.*, ?110 *p.M.* cf. 32.31 m long *contubernia* of Building XI.
(iii) Joint width of Buildings IX and X 19.81 m, less wall-trench 0.26 m wide (i.e. between centre-lines) = 19.55 m/66 *p.M.*
(C) N *praetentura*
Measured width E–W 38.81 m/131(?132) *p.M.*; distance to W rampart 8.5 m.
Total to W rampart 47.31 m/159.74(?159) *p.M.*
Within that total note:
Building V 7.30 m wide (ext.), probably 24 *p.M.*/7.10 m between centre-lines, given wall-trenches *c.* 0.30 m wide.
Interval between V and VI 0.46 m.
Building VI 8.20 m wide (ext.), probably 27 *p.M.*/8.00 m between centre-lines.
Interval between VI and VII 1.20 m.
Building VII 10.67 m/36 *p.M.* wide.
Interval between VII and VIII 1.22 m.
Building VIII 8.84 m/29.85 *p.M.* wide.
Width of VIII + distance to W *via sagularis* 9.76 m/32.95 *p.M.*
(D) S *praetentura*
Measured width E–W:
Building XIII 8.23 m wide (ext.), probably 27 *p.M.*/8.00 m between centre-lines; *contubernia* range 34.44 m/116.29 *p.M.* long.
Interval between XIII and XIV 0.30 m.
Building XIV 6.93 m wide (combined 7.23 m = 24.41 *p.M.*).
Combined width XIII and XIV 15.46 m/52.20 *p.M.*, but 15.16 m/51.19 *p.M.* between centre-lines of wall-trenches 0.30 m/1 *p.M.* wide.
Interval between XIV and XV 1.52 m.
Building XV 8.23 m wide (*contubernia*); 10.97 m (ext.) at N end, suggesting 27 *p.M.*/8.00 m and 36 *p.M.*/10.66 m between centre-lines respectively.
Combined width of interval and XV 9.75 m/32.92 *p.M.*
Total measured width of XIII to XV (*contubernia*) 25.21 m/85.12 *p.M.* (ext.), 24.91 m/84.11 *p.M.* between centre-lines; also 27.95 m/94.37 *p.M.* (ext.) to N end of XV, 27.65 m/93.36 *p.M.* between centre-lines. Cf. Davison:[92] 27.60 m/93.19 *p.M.*
Building XV *contubernia* 33.07 m/111.66 *p.M.* long (ext.).
Interval to officer's quarters 0.84 m.
Officer's quarters 12.34 m/41.66 (?42) *p.M.* long.
Overall external length 46.25 m/156.16 *p.M.*[93]
Combined width E–W of Buildings XIII to XVI matches the length of XVI itself, 39.32 m/132.76(?132) *p.M.* cf. 39.09 m. to N of *principia* on *via quintana.*

92 Davison 1989, iii, 847.
93 Frere and Wilkes 1989, 136, table III 46.33 m.

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TABLE E: FENDOCH

(A) Overall dimensions of fort

External dimensions 598 ft long by 320 ft wide.
Width of rampart *c.* 17 ft; *intervallum* space *c.* 26–28 ft wide.
NW rampart deviates from straight line by 18 ft to NW, resulting in NE rampart 338 ft long.
External length of fort between inner lips of ditch (berm 'about 5 ft wide') is *c.* 608 ft/627 *p.M.*, just short of 6 times the 105 *p.M.* length of *principia* (including front portico). External length of fort to centre-line of inner ditch (13 ft wide) is *c.* 621 ft, just over 4 times the 154 ft length of the *praetentura* and *retentura* barracks. Cf. the 610 ft overall length of Housesteads fort.

(B) Internal buildings

Foundation-trenches in central range 'not less than 2 ft wide', barracks 1 ft wide.

(i) *Principia*[94]
Note good state of preservation of foundation-trenches, e.g. at N, W corners, with impressively vertical sides and precisely set-out right-angles; overall width 80 ft, quarter of ext. width of fort; overall length 100 ft, a sixth of ext. length of fort.
Close examination of plan (FIG. 1) indicates frontage set out over 82½ *p.M.* and rear wall over 85½ *p.M.* (ext.), both multiples of 12 *p.M.*
Planned length of building 93 *p.M.*, as at Pen Llystyn, behind front portico 12 *p.M.* deep, 105 *p.M.* total effectively a fifth of 522 *p.M.* built-up length of fort (FIG. 10).

(ii) *Praetorium*[95]
68 ft wide on *via principalis* frontage by 100 ft long. Internal courtyard 24 ft wide by 29 ft long.
Probable interpretation: frontage 69 *p.M.* wide; rear 72 *p.M.* wide between centre-lines (proportions of front to rear 1 : 1.04, matching *principia*); length 105 *p.M.* SE wall, 102 *p.M.* NW wall.
Note 342 *p.M.* ext. width of fort on alignment of rear walls of *principia* and *praetorium* is 4¾ times the length of the latter.

(iii) Granaries[96]
56 ft long by 30 ft wide (57.68 by 30.90 *p.M.*), sited 10 ft apart.
Probable interpretation: length 57 *p.M.*; width 30 *p.M.*; alley 12 *p.M.* wide; joint width 70 ft/72 *p.M.*, as *praetorium* rear wall. Length increased to 66 *p.M.* by eaves-drip gully on *via principalis* frontage.

(iv) 'Hospital'[97]
106 ft long by 40 ft wide = 109.18 by 41.20 *p.M.*; NE and SW ranges 15 ft wide; central corridor 10 ft wide.
Plan suggests 111 by 42 *p.M.*; central corridor 12 *p.M.* wide, flanked by ranges 15 *p.M.* wide.

(v) Two open-ended buildings NE of granaries 64 ft/65.92(?66) *p.M.* long; building behind *principia* 40 ft long by 30 ft wide (41.20 by 30.90 *p.M.*).

(vi) Barracks
Praetentura Barrack 1 154 ft long by 32 ft wide; centurion's quarters 34 ft long; *contubernia* 120 ft long by 26 ft wide; verandah 6 ft wide, figures suggesting 159 *p.M.* (cf. Davison[98] 47.24 m/159.50 *p.M.*) by 33 *p.M.*

94 Richmond and McIntyre 1939, 123, fig. 6 and pl. LV, 2.
95 Richmond and McIntyre 1939, 128, fig. 8.
96 Richmond and McIntyre 1939, 130, fig. 9.
97 Richmond and McIntyre 1939, 133, fig. 11.
98 Davison 1989, iii, 738.

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(Davison[99] 9.91 m/33.46 *p.M.*); 36 (Davison 10.67 m/36.03 *p.M.*) + 123 *p.M.* (Davison 36.57 m/123.48 *p.M.*) by 27 *p.M.*/8.00 m.
159 *p.M.* probable planned length of *praetentura.*
Barrack 2 located 12 ft NW of Barrack 1.
Retentura Barrack 5 154 ft long ('exactly matching Barrack 1') by 28 ft wide; centurion's quarters 35 ft long; cf. Davison[100] width 8.84 m/29.85 *p.M.* (ext.); length of centurion' s quarters 10.67 m./36.03 *p.M.* (ext.).
The evidence thus suggests 159 *p.M.* long by 30 *p.M.*/8.88 m wide; centurion's quarters 36 *p.M.*/10.66 m long; *contubernia* 123 *p.M.* long by ?21 *p.M.*/6.22 m wide.
159 *p.M.* probable planned length of *retentura.*
Measurements relevant to spacing of *retentura* barracks:
Street separating Barracks 5 and 6 14 ft wide.
Alleys separating Barracks 6 and 7, 8 and 9 4 ft wide.
Via decumana 28 ft wide.
Street separating Barracks 9 and 10 16 ft wide.
Intervallum NW of Barrack 10 34 ft wide.
Barrack 10 note '12-foot spacing of the *contubernia*'.
Theoretical distribution of barrack pairings
Slight variations in the widths of barrack pairings are visible on the general plan[101] for which the following figures may be suggested:
Pr. Barracks 1 and 2, 3 and 4 33 + 15 + 33 = 81 *p.M.*/23.99 m (Davison[102] 24.08 m/81.30 *p.M.*).
Distance separating Barracks 2 and 3 87 *p.M.*/25.77 m; 'sheds' 18 ft/5.49 m wide flanking *via praetoria* 10.15 m wide = 21.13 m/71.34(?72) *p.M.*
Total width of *praetentura* 249 *p.M.*/73.75 m.
R. Barracks 5 and 6 30 + 15 + 30 *p.M.* = 75 *p.M.*/22.21 m.
Barracks 7 and 8 30 + 27 + 30 *p.M.* = 87 *p.M.*/25.77 m.
Joint width of Barracks 9 and 10 30 + 18 + 33 = 81 *p.M.*/23.99 m, matching *Pr.* 1 and 2, 3 and 4.
Total width of *retentura* 255 *p.M.*/75.52 m, approximately half 522 *p.M.* built-up length of fort.
The general plan shows that the combined width of Barracks 5 to 7 matches the length of the 'hospital', i.e. 111 *p.M.* cf. Davison 32.92 m/111.15 *p.M.*

TABLE F: GELLYGAER (TRAJANIC)

(A) Overall dimensions of fort

Over ramparts 404 ft long by 385 ft wide = 416 by 396 *p.M.*
SE side 400 ft long, NW 402 ft, SW 386 ft, NE 384 ft.
Rampart 19 ft 4 in to 20 ft 2 in wide; ditch (*c.* 19 ft) plus berm (*c.* 5 ft) *c.* 24 ft wide.

(B) Internal buildings

(i) *Principia* (Building VII)
Maximum length 80 ft; NW wall 77½ ft long (ext.), SE wall 79 ft; external width 69½ ft (SW wall), 69 ft (NE wall); outer walls 3 ft thick (cross-hall, rear range), 2 ft thick (courtyard).
None of the external walls is set out at right angles to another, the NW lying at 89 degrees and the SE at 91 degrees to the rear wall, and the front (NE) wall lying at 88 and 92 degrees to the SE and NW walls respectively. All four, however, run parallel to the corresponding sides of the fort.

99 Davison 1989, iii, 758.
100 Davison 1989, iii, 738, 758.
101 Richmond and McIntyre 1939, fig. 2.
102 Davison 1989, iii, 847.

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(ii) *Praetorium* (Building VI)
External lengths of outer walls 64 ft 6 in (NE), 66 ft (NW), 64 ft 10 in (SW), 67 ft 6 in (SE); foundations 2 ft wide; NE portico foundation *c.* 67 ft long.

(iii) Granaries (Buildings V and VIII)
Overall length *c.* 83 ft; middle section 59 ft long by 34 ft wide; footings of side-walls *c.* 6 ft wide, of end-walls 4 ft+; buttresses 2 ft long and wide; walls of loading bays 'a trifle under 3 ft in width', enclosing platforms *c.* 9½ ft wide by 6 to 7 ft deep.
General plan adds for Building V: 81 ft 6 in long (NW side), 82 ft 5 in (SE side) by 34 ft 3 in wide; internal cross-walls 1½ ft thick.

(iv) Barracks (measurements are those recorded on general plan unless indicated otherwise). Average dimensions 145 ft 6 in long by 36 ft wide (officers' quarters), 30 ft (*contubernia*); wall-foundations 2 ft wide.

(a) *Retentura*
Building I 144 ft 8 in long;
officer's quarters 35 ft 6 in wide;
distance from Building III 15 ft.

Building II 148 ft 6 in long;
contubernia 30 ft wide;
distance from Building IV 19 ft.

(b) *Praetentura*
Building XII 146 ft 6 in long;
officer's quarters 35 ft 9 in wide;
distance from Building XIV 19 ft.

Building XIII 145 ft 3 in long;
contubernia 92 ft 3 in long by 29 ft 6 in wide;
officer's quarters 53 ft long;
distance from Building XV 32 ft 4 in.

Building XIV 145 ft 4 in long;
officer's quarters 35 ft 6 in wide.

Building XV 146 ft long;
contubernia 29 ft 2 in wide; verandah *c.* 6 ft wide;
posts *c.* 10 ft apart set in holes *c.* 18 in in diameter

(v) Other buildings (wall-foundations 2 ft wide)
(a) *Retentura*
Building III 113 ft 6 in long by 26 ft 9 in wide.
Building IV 148 ft long (though Ward[103] 149 ft) by 33 ft wide.
(b) *Praetentura*
Building IX 146 ft long by 40 ft wide (ext.), located 'nearly 5 ft' from Building XII;[104] the general plan, however, records a length of 142 ft 9 in (int.) and widths of 17 ft and 16 ft 8 in (int.) for the two sections into which the building is divided longitudinally, implying that the external length and width have been rounded down and up respectively.
Building X 66 ft long by 40 ft 9 in wide.
Building XI 61 ft 4 in long (ext.).
Measured depth NE–SW of left *praetentura* 135 ft 3 in/139.31 *p.M.*, alternatively 134 ft 11 in/138.97 *p.M.*
Measured depth NE–SW of left *retentura* 77 ft 3 in/79.57 *p.M.*
Measured depth NE–SW of right *retentura* 82 ft/84.46 *p.M.* (ext.), 80 ft/82.40 *p.M.* (between centre-lines of wall-foundations).

TABLE G: CAERHUN (FLAVIAN–ANTONINE)

(A) Overall dimensions of fort

Over ramparts 460 ft square; within ramparts 410 ft square.
Defensive wall 8 ft wide at base on W side and at SE angle; 6 ft wide at base on S side; rampart 24 ft wide (S side).

[103] Ward 1903, 68.
[104] Ward 1903, 69.

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N gate (masonry) W tower 10 ft long by 8½ ft wide (int.); E tower 10 ft long by 9 ft wide (int.); portal 23½ ft wide.
E gate S tower (timber) 19 ft long by 9 ft wide; portal (stone gateway) 24 ft wide.
SE angle tower NW and SE sides 15 ft 6 in long (ext.); NE and SW sides 13 ft 5 in long (ext.); int. measurements 9 ft 8 in E–W by 8 ft 3 in N–S; set back 8 ft 6 in from defensive wall.
W gate (masonry) N tower 10 ft long by 8 ft wide (int.), set back 8 ft from front of defensive wall.

(B) Internal buildings

(i) *Principia* (Building XII)[105]
Timber phase *c.* 84½ ft square; rear range 20.2 ft wide; forecourt 64.3 ft wide.
Masonry phase 98 ft wide N–S by 100 ft long E–W; outer walls 2 ft 9 in thick (2 ft 11½ in including ext. offset).
E side of cross-hall bounded by walls projecting from outer walls, 17 ft long to N and 25 ft long to S, which return eastwards for 30 ft, forming N and S sides of courtyard flanked by E–W colonnades 10 ft wide (int.).

(ii) *Praetorium* (Building XI)[106]
Located *c.* 3 ft E of Building XVI at N end, 4 ft 6 in at S end.
Masonry phase 118 ft N–S by 112 ft E–W; outer wall foundations 2 ft 10 in to 3 ft 8 in thick.

(iii) Granaries (Buildings XIII and XIV).
Located *c.* 22 ft N of *principia*; 74 ft 6 in long by 29 ft 6 in wide (ext.); walls 3 ft 6 in thick; int. dimensions 67 ft 6 in by 22 ft 6 in; buttresses 2 ft 6 in square, spaced 7 ft 6 in apart (average).

(iv) Masonry barrack dimensions.
Outer walls 2 ft 10 in to 3 ft thick; cross-walls 2 ft 6 in thick (average).
(a) *Praetentura*
Building I (*c.* 17 ft from E rampart); 165 ft long (ext.); officer's quarters 46 ft long by 33 ft wide; *contubernia* range 119 ft long by 28 ft wide.
Building IV (14 ft 6 in W of I); 170 ft long (ext.); officer's quarters 51 ft long by 33 ft wide; *contubernia* range 119 ft long by 29 ft wide.
Building VI (foundations 3 ft wide; walls 2 ft 8 in wide); 171 ft long (ext.); officer's quarters 48 ft long by 32 ft 3 in wide; *contubernia* range 123 ft long by *c.* 27 ft 6 in wide; ?verandah 4 ft 10 in wide; note cross-wall 76 ft N of officer's quarters.
Via praetoria 19 ft wide N of Buildings I and IV.
(b) *Retentura*
Building XVII 172 ft long (ext.); officer's quarters 57 ft long by 39 ft 6 in wide; *contubernia* range 115 ft long by 34 ft wide.
Building XIX 170 ft long (ext.); officer's quarters 55 ft long by 37 ft wide; *contubernia* range 115 ft long by 31 ft 6 in wide.

(v) Other buildings
Retentura
Buildings XVI and XVIII 168 ft long by 32 ft 6 in wide (ext.); each divided into three rooms, N and central 56 ft long, S 46 ft long; at NE corner of XVIII a porch 12 ft 6 in long by 8 ft wide (ext.).

[105] Baillie Reynolds 1929, 74, fig. 11.
[106] Baillie Reynolds 1927, 300, fig. 5.

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