III
The Stone Wall Turrets of Hadrian's Wall

P. R. Hill

IN the course of the last seventy years several attempts have been made to reconstruct the internal and external form of turrets. In particular, Mr. Parker Brewis in 1932[1] looked at turret 18a, Mr. Richard Bellhouse discussed both stone and turf wall turrets in 1969,[2] Miss Dorothy Charlesworth gave a general survey of the current state of the evidence in 1977,[3] Dr. Brian Dobson, in course of the 1985 Horsley lecture,[4] reviewed several alternatives for the external appearance, and in 1992 the present author, with Dr. Dobson,[5] looked at the doors, windows, roofs, and overall height as part of a general discussion on the design of the Wall. All these expositions have limitations in the scope of the evidence presented, and it is the intention here to make a more searching examination of the design of stone wall turrets from the viewpoints both of the builders and of the users.[6]

It may be felt that the several hypotheses discussed below go into unnecessary, not to say tedious, detail. But it is only by considering the minutiae that theories which are both practical and appropriate to the structural remains can be developed. This method also allows other students of the Wall the evidence on which more easily to confound the theories put forward and to develop improved ideas.

THE PHYSICAL EVIDENCE

Dimensions

The only certain information available is the more or less complete ground plans of about 18 turrets; this represents about one fifth of the presumed total of 98 turrets between Wallsend and the Irthing. Rather more fragmentary information is available on a further fourteen turrets. A convenient summary of measurements is given in table 1; Peel Gap and Pike Hill towers are included for comparison. They are all broadly similar, varying only in the width of their walls and the position of the doorway which was set at either the east or the west end of the south wall.[7] The majority of the side walls fall within the narrow range of 34–38" (860–965 mm[8]); in only five turrets are they as much as 48" (1220 mm) wide (including turret (hereafter t) 39b at 46"), generally considered to be the mark of a particular legion.[9] The only three turrets known in the block[10] t12a to milecastle 17 all have side walls of 48", but the other three are isolated examples in the block 27a to milecastle 43. Even if these examples are sufficient to define the work of one legion, and five out of ninety-eight is a small sample, the identity of the legion responsible is open to conjecture.[11] The majority of the north walls are between 47" and 52" thick, with a few important exceptions mentioned below.

The width of the north wall is by any standards an extravagance, and is a feature occurring in observation towers only on Hadrian's Wall where, uniquely, they have to bond with a running barrier. It may have been copied from the interval towers in forts where the towers are, as it were, applied to the back of the fort wall, usually 5' thick.[12] Perhaps standard plans showed that all walls facing a potential enemy should be this thickness. Neither reason is entirely convincing, especially as signal towers had thin north walls all round and not all turrets show this extravagance; turrets 48a and 48b are discussed below, page 42. Some thought must have gone into the design of the north walls, as the turrets are invariably

recessed into the curtain wall unlike the fort interval towers which are never recessed; this must have been an essential element of turret design as all three legions took care to incorporate it in their plans. It was however not so important that the builders of the later Peel Gap tower felt it essential to take down the existing curtain wall in order to form a recess.

Internally the north–south measurement is predominantly in the range 11'9"–12'6"; east–west the range is wider, the majority evenly spread between 11'5" and 13'9". The average external width, east–west, is about 18'6", and the external north–south measurement is typically about 19'.

The only significant variations from the above occur in three distinct groups: the pre-Wall t45a[13] and Pike Hill signal tower, in which all four walls are between 30" and 36" (760–915 mm) thick; narrow wall turret 44b which has a 6' (1220) thick north wall and is only 10' (3050 mm) north–south, and narrow wall t39a with a north wall of 33"; and t48a and t48b, which are unique in being broad wall turrets with north walls of only 32" (810 mm). These three groups will be discussed individually. There are other individual aberrations such as t40b with an E–W width of 19', and t41a which is only 10'7" N–S.

The typical turret, then, was about 12' by 13' square internally, about 19' square externally, with all walls except the north being about 3' thick. All these measurements relate only to the lower part of the turrets; the highest extant masonry today stands some 7' (2130 mm) high,[14] and the form of the turrets above this point enters the realms of conjecture—what Mr. Bellhouse rightly referred to as "a house of straw",[15] capable of being blown down by the smallest piece of new evidence.

Platforms

Twelve turrets have somewhat rough, stone-built, platforms of over 6' in length built against the south wall in the corner not occupied by the door; this total excludes the much smaller, raised and flagged areas found in several positions in a number of turrets. There may well have been more, but many of the excavations were early and thorough clearing of the interior may have destroyed them. Evidence varies from the very good, at t18a Wallhouses East[16] to the conjectural, at t35a Sewingshields Crag where the evidence relies on the absence of the rough cobbling which covers the rest of the floor.[17] The dimensions are remarkably uniform; seven of them are between 7'6" and 8' long and ten of them are about 3' (915 mm) wide. Two of them are just over 7' long, and three of them are between 6' and 6'7". A thirteenth platform, that in t33b Coesike, is only 4'6" long and may not belong to the rest of the series. The figures may be seen and compared in the table of dimensions (table 1, page 44). The original height of the platforms is unknown; the best estimate is that from t18a Wallhouses East, where the excavator believed that it was almost complete, with five steps each intended to have a rise of 7·5" (190 mm), a total of 37½" (950 mm). The four treads were each one foot (305 mm) wide. The other platforms were more or less ruinous or robbed, but the general uniformity of size and position suggests that they all served the same purpose and were presumably all stepped.[18] The purpose of these platforms is discussed below (page 36ff.).

The greatest uniformity occurs in the group t17a–t19b inclusive; they fall into a legionary group as defined by Hooley and Breeze.[19] It is this group which has been used in the following reconstruction.

CONSTRUCTIONAL DETAILS

General

All the turrets are built in the usual hammer-dressed squared rubble[20] typical of the curtain wall but perhaps a little shorter, usually running 12–15" (305–380 mm) into the wall, although at times only half that depth. Turret 45a has stones noticeably smaller on the face than those of the curtain wall which, especially in the light of the use of 50% whinstone in the surviving walls,[21] perhaps reflects a low-key operation in which it was not worth opening a better quarry for work on a single turret built

as part of the Wall programme but begun in advance of more general work.[22] This turret has a generally third-rate appearance, despite one or two stones on the west exterior face which are more carefully dressed than those in the average turret.

Peel Gap tower is an exception to the general appearance of turrets. The walls are built of rough boulders and slabs of whinstone, and the width of the walls varies noticeably. Falling midway between t39a and 39b, and butted-up to the Narrow Wall, it is clearly an addition to the series. Like t45a it does not seem to have been worthwhile to locate and transport more suitable building stone, and it has the appearance of having been built by a gang not well accustomed to the work. As an addition it may well have been the work of auxiliaries. It is a little below the average in internal size.

In almost every turret the quoins and reveals are hammer-dressed like the rest of the walling, brought to something like right angles but with no serious attempt to provide chiselled margins and a sharp line to the angle. This is not to say that the turrets were particularly poorly built, but rather that the appearance is workman-like rather than sophisticated. In this they are very different from the milecastle and fort gateways, where a degree of sophistication was at least pursued even if not always effectively overtaken.

Pike Hill tower draws attention to the usual lack of sophistication; it is both visibly and by measurement built with rather more care than the average run of turrets and the stones of the one surviving quoin are dressed with a blade to something like fair faces set at right angles. The higher quality is not surprising if this tower were built in advance of the rest of the wall, at a time when skilled men were at less of a premium. But even at Pike Hill the high standard was not always maintained. The walling at the rebate for the putative wooden door frame (see below, *Doors and windows*) seems to have been built up against the frame but with little effort to make a neat end to the courses; the rebate now varies from 5" wide at the bottom to 8" wide at the top of the surviving wall, the difference presumably originally made up in mortar or small stones which have now been lost.

There are two exceptions to the rough and ready quoins in standard turrets. Turret 34a, Grindon West, has quoins well above the average. This site is of particular interest as the ends of the wing walls have been carefully finished off with similar high-quality quoins, suggesting that here, uniquely, the legion completing work after dislocation made strenuous efforts to work to a high standard. The single quoin at t44b Mucklebank is also noticeably better than the average, but this turret, with its small size and very thick north wall, is already something of an anomaly.

It is not possible to make a realistic assessment of the foundations as so little information is available at most sites. It is certainly not possible to use the depth of foundations to judge the height to which turrets might have been built; if it could be established beyond peradventure that two given turrets were built by the same legionary gang and at the same time, then it might be possible to say that the one turret was designed to be higher than the other.

THE TURRETS RECONSTRUCTED (FIGS 1–4)

Wall thicknesses

The walls of the turret may be presumed to maintain their thickness up to the top of the curtain wall, although there is no evidence above the height of the surviving remains; it is not necessary for the same thickness to be maintained for the first and second floors. It has been shown that the north and south walls of the first and second floors of the milecastle towers could not have been more than about 18" (460 mm) thick, and that the east and west walls were probably the same.[23] There is no reason to suppose that the turrets were any different, and there is certainly no structural reason why the wide gauge found at ground level should have been used all the way up. Reducing the thickness of all four walls to 18"

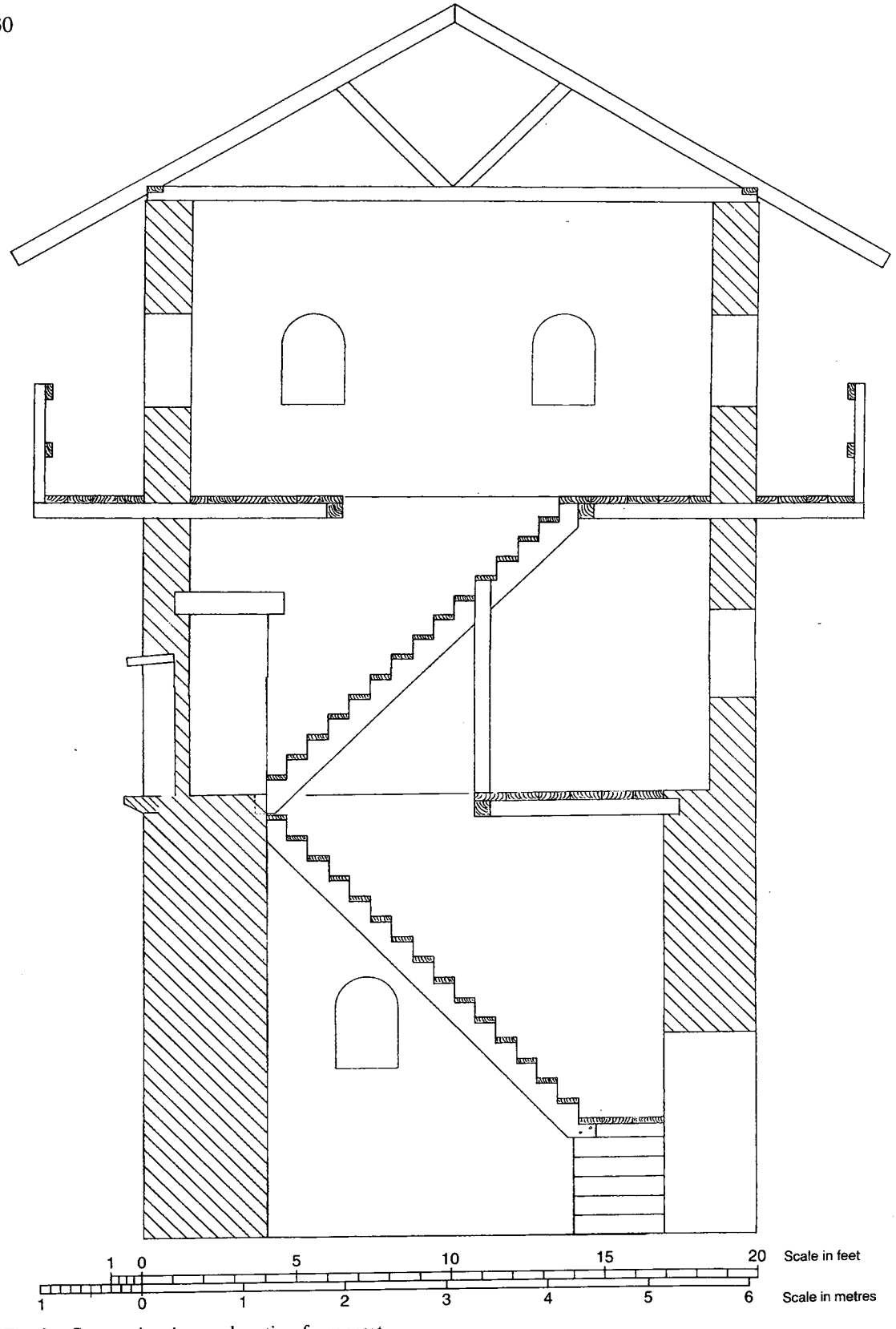

Fig. 1 Composite view and section from west.

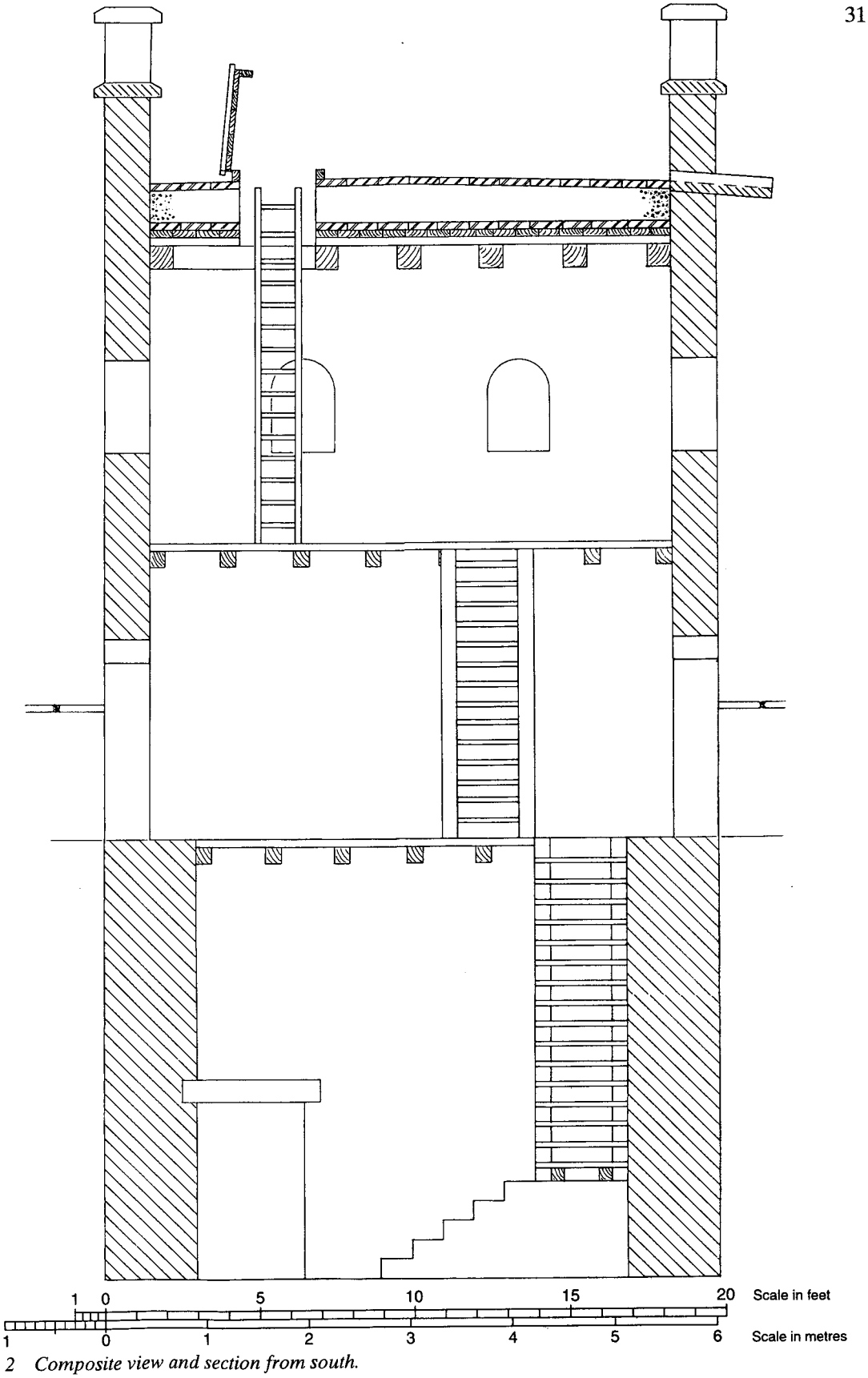

Fig. 2 Composite view and section from south.

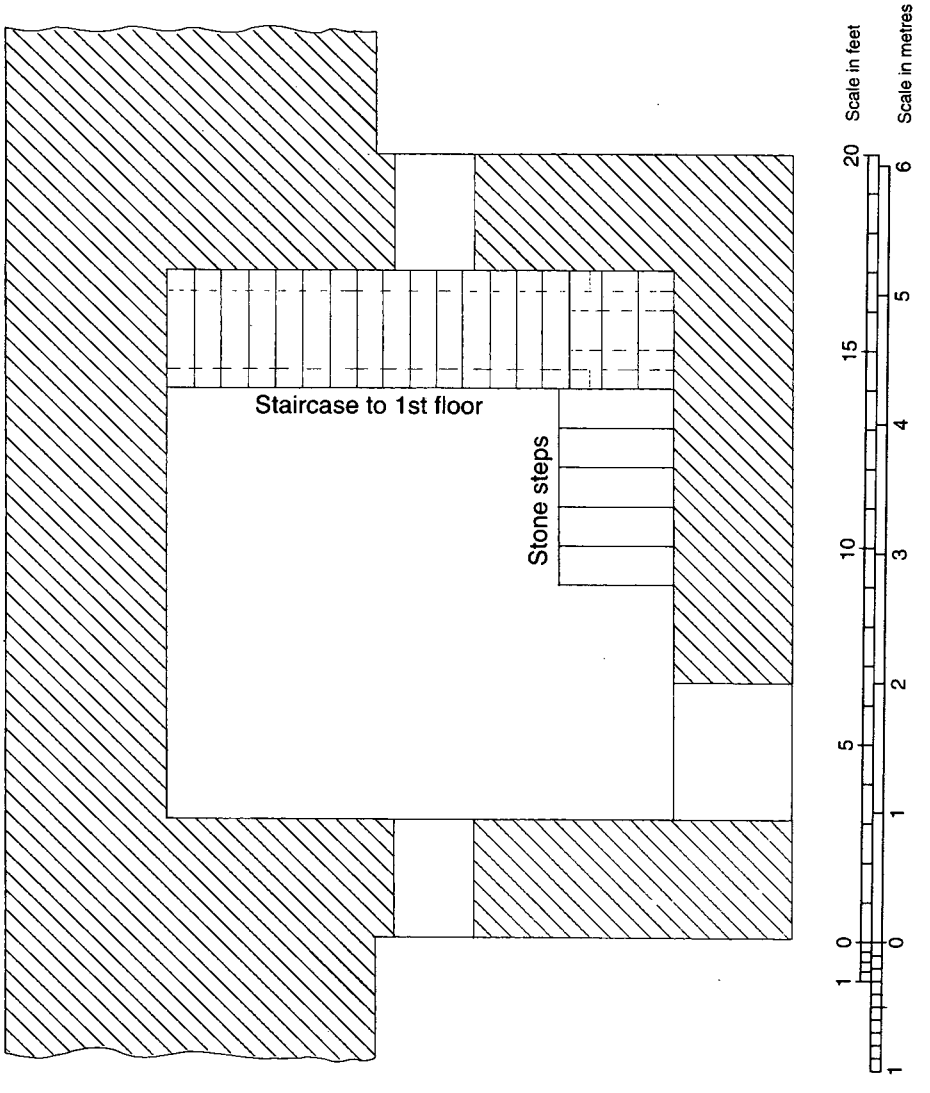

Fig. 3 Ground floor plan.

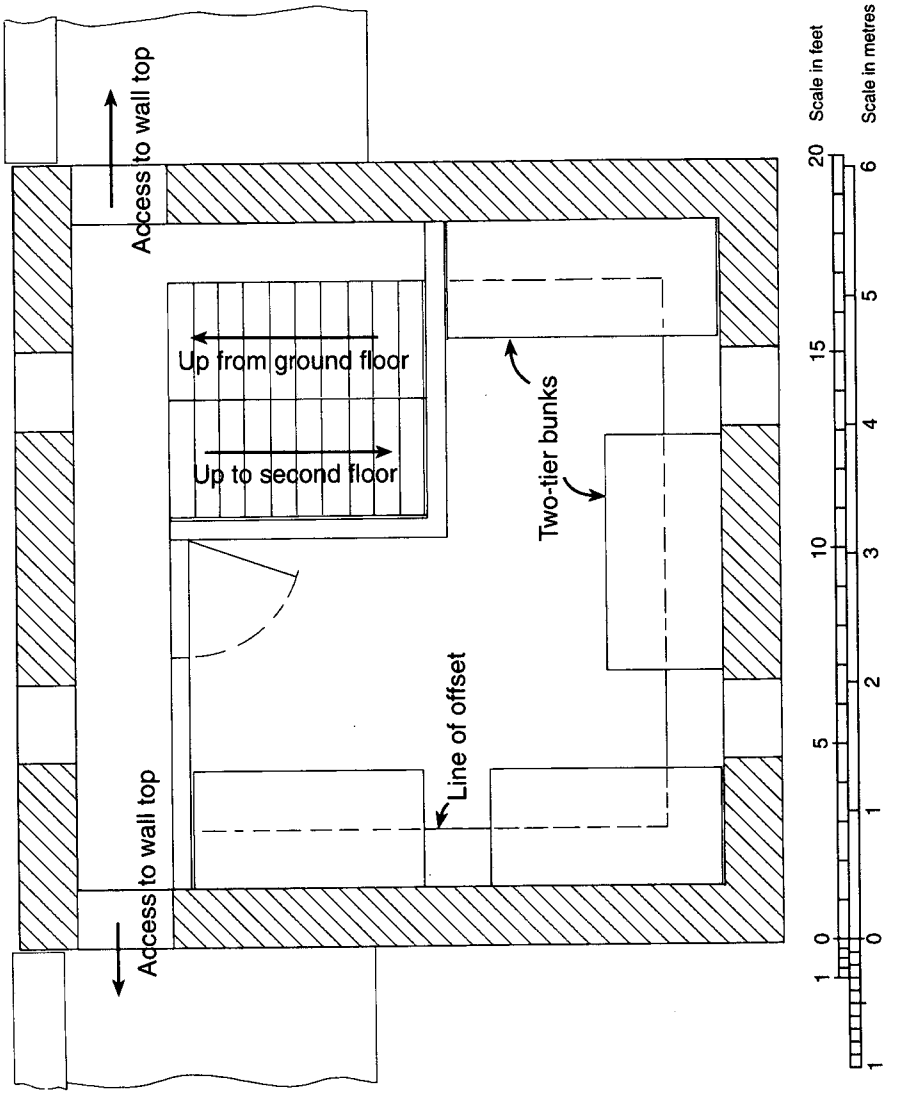

Fig. 4 First floor plan.

all round would save 50% on the volume of the core in the side walls, and about 65% on the north wall, as well as reducing the load on the foundations. It would have the added advantage of increasing the size of the first and second floors from about 12' by 13' to 15' by 16', and the area from 156 square feet on the ground floor to 240 square feet on each of the upper floors. It would also have a big advantage in relation to the access from ground to first floor—see below, *Staircases*.

The walling which has fallen in a piece from t52a neither proves nor disproves this hypothesis. It is 25" thick, only 4" less than the already very narrow west wall from which it came. There is no reason why it could not have come from the upper part of the ground floor.

When excavated, the east angle tower of the fortress wall at York had a single course of stone above the string course;[24] this represented the remains of the north (i.e. outer) wall of the tower rather than the parapet as stated by the excavator, and ought to have confirmed whether or not there was a reduction in width. Unfortunately, insufficient remained at the back of the wall to give the original width.

Doors and windows

It has been suggested that the external rebate in the opening at Pike Hill tower was to take a wooden door frame,[25] an unusual feature. The threshold, in two slabs, has no sign of a pivot hole, and it may be that the door was hinged on a wooden frame, and not pivoted as seems to have been the norm in turrets.[26] The absence of rebates for a timber frame at t45a may strengthen the suggestions that it is of Hadrianic rather than Trajanic date.

A number of turrets, seven in the present state of knowledge (see table 2), had monolithic[27] thresholds (as distinct from thresholds made up of a number of rough flags) and, to judge by the shallow slots cut at each side of the threshold, monolithic door jambs as well. The reason for the latter feature is obscure. They were not a substitute for wooden frames, on which a door would be hung or against which it would close; they are simply facings to the opening, within which the door was pivoted.

It is difficult to see what advantage was gained by this feature. Unless the slabs split along the beds to give a very clean, flat surface it would not have improved the draught-proofing of the door; from the present writer's observations the stone along the line of the wall is not of the necessary fissile nature. It is extremely laborious and calls for a good deal of skill to work a flat surface over an area of some 3' by 6' (915 × 1830 mm). If comfort was the intention, it would have much easier to apply a thick coat of render to the rough stone of the reveals.

At t34a Grindon West there is what appears to be the lower part of the stone jamb still in the western slot; it could be there as the result of the mediaeval occupation of the site, but some care has been taken to delineate the outer edges which would give a neat appearance to the frame, and this might suggest the Roman builders. The face on the reveal is so uneven, apparently natural, that a squared rubble reveal would have looked better and allowed the door to fit more tightly.

A further point in relation to slab jambs is that the upper end would have to be secured in position against the reveal. Slots cut into the soffit of the lintel would serve the purpose, but no such lintel has been found. Iron holdfasts driven into the joints of the reveals would serve equally well and make it unnecessary for the jambs to be in one piece.

The occurrence of slab jambs seems to be limited, on present evidence, to small groups of turrets, from t19a Clarewood East to t35a Sewingshields Crag inclusive, possibly t39a Peel Crag (see note 32), and t48a, Willowford East.[28] This may be due to the occurrence in these areas of quarries which readily yielded large thin slabs, or it may have been a signature of one or two legions. Slab jambs occur in turrets identified by Hooley and Breeze[29] as the work of the "square" legion and the "triangular" legion.

The arguments for door and window design have been rehearsed elsewhere[30] and will not be repeated here. In summary, the doorways must have been flat-headed where monolithic thresholds with pivots were provided, and the

windows were probably round-headed.

Examination on site at t44a, Mucklebank, shows that the two surviving pieces of an arcuate head have a radius of curvature of about 16·7" (425 mm), a span of 33½" (850 mm). The clear opening between the reveals (there is no sign of there ever having been slab jambs) is 34", strongly suggesting that the arch came from the doorway. This is one of the turrets with a threshold of small flags rather than a monolith and has no pivot hole, so here we may be, indeed ought to be, looking at a hinged door hung at the inner or outer angle of the reveal.

Door openings vary between 2'10" and 3'8"; doorways with slab jambs tend to be narrower than those without, but there is no clear distinction (see table 2). The height of the doors is a matter of judgment, and perhaps 6 Roman feet (hereafter Rf) (5'10"/1880 mm) is a reasonable guess. A reused monolithic jamb is recorded in the blocking of the recess at t19a Clarewood East;[31] this is given as "5 feet long", but with no comment as to whether it appeared broken or whole. A long thin slab, about 6'3" × 6", appears in the blocking wall of t39a Peel Crag,[32] and it is conceivable that this was a door jamb.

Excavations at 29a showed that the same threshold served for two successive floors,[33] and Parker Brewis[34] pointed out that the pivot tracks always lead from the outside, both factors indicating that the doors normally opened outwards.[35]

The single voussoir preserved in t44b is appropriate to an opening with a span of 24", and will therefore have come from a window. It measures 21" from front to back and, following the argument above, *Wall thicknesses*, is likely to have come from the ground floor. It is not deep enough to go right through the wall, but one would not expect that; the dressing of the stone would be easier if the arch were built in two faces with any intervening space filled by a rough vault of corework. One can speculate about the height of the windows; the height to the springing line will not have been less than the span, giving a minimum overall size of 2' wide by 3' high as shown in Figs 1 and 2—they may have been taller.

The number and position of the windows is unknown. Presumably there was at least one on each face of the second floor, and perhaps also on the first floor. Figures 1, 2, and 4 show two windows on each face of the second floor, and two in the south face and two in the north face of the first floor. Professor Birley, in his excavation of t7b Denton Hall[36] infers, from finding parts of the same pot both inside and outside, that there was an unglazed window on the east face of the turret; the part found inside was used in the make up of the period I floor, which suggests that the window was on the ground floor. It would certainly be desirable, as Miss Charlesworth suggests,[37] to have at least one shuttered but unglazed window to vent the smoke from the hearth, and the ground floor would be an appropriate place. A window on both east and west faces would be useful, to use according to the prevailing wind; Figs 1 and 3 show windows so placed.

Figure 1 also shows a balcony of the type depicted on Trajan's column; there is no evidence for or against their presence on the Wall, but if there were one, one of the windows on the second floor would be replaced by a door.

Floors and overall height

It has been argued elsewhere that the turrets had three floors:[38] the ground floor for access and cooking, the first floor for sleeping and general living accommodation, and the second floor for the lookout and signalling functions. The height to the first floor was probably the same as the curtain wall, that is, 15Rf (14'6¾"/4440 mm). The height of the first and second floors is largely a matter of choice; it seems reasonable to assume a module of 5Rf to match the design height and width of the broad wall. They may both have been 10Rf (9'8½"/2960 mm), or 15Rf and 10Rf respectively, giving an eaves height of between 35 and 40Rf (34'/10.36 m and 38'10"/11·8 m. In the illustrations (figs 1 and 2) a height of 10Rf has been chosen for both floors, the first floor measured from floorboard to floorboard, the

second floor from floorboards to the top of the ceiling beams.

The above figures assume a pitched roof rather than a flat one. If there were a flat roof, then the height to that level, including the thickness of the flat roof, would have been either 27Rf and 37Rf depending on whether the flat roof formed the ceiling to the first or second floors; these figures do not include the height of the parapet. Some aspects of the roof form are discussed below, *Roofs and access*.

In the reconstruction drawings the joists to first and second floors are shown as 6" (150 mm) square timbers set at 39–42" (990–1065 mm) centres, floored with 3" (75 mm) boarding, all based on no more than reasonable assumption as there is no evidence. The joists may well have been set closer, as ancient builders tended to over-timber their work, but joists of the suggested number and dimensions would perform their functions in an economical manner suited to the size of the overall building programme.

The ends of the joists at first floor level are shown built into the wall just below the offset so that the boarding finished level with the offset. Building-in is not particularly good practice, but to set them on top of the offset would have meant providing another 95 square feet (8·8 m^2) of boarding; it would have been easier to finish the offsets in stone to the level of the boarded floor. There was no alternative to building-in the joists at second floor level, at least in the absence of any evidence for corbels. It is conceivable that the "bevelled stones" found inside t48a Willowford East[39] were from a corbel table used to support the second floor, but this is conjectural. A possible alternative use for these stones is discussed below under *Roofs and access*, page 40.

PLATFORMS AND ACCESS

Ladders

In 1932 Parker Brewis looked at the possible design of t18a Wallhouses East,[40] with particular reference to the platform. He argued that it formed the base for a vertical ladder giving access to the first floor. The platform, he reasoned, was of a height which would enable a ladder to be drawn up into the upper room in order to give greater security. However, his argument is in part based on the first floor chamber being ten feet high, a hypothetical figure upon which no other arguments should be based. Convenience was also a factor; it is certainly easier to pull up his 11'6" (3500 mm) ladder than one of 14'8" (4470 mm), but the necessity for doing so must be questioned.

The entrance door could presumably be bolted on the inside,[41] which would give adequate protection against casual intruders. It has been persuasively argued[42] that the wall was not designed to be a fighting platform, where each structure would form a unit of defence against a besieging enemy and in which a removable ladder might be of importance.

Parker Brewis suggests a vertical ladder, up which the sentry climbed before pulling it up after him in order to use it to give access to his putative attic room; a grave disadvantage to other soldiers going about their legitimate business. The sentry squatting in his attic must be a matter of conjecture, but the angle of any ladder must be examined closely. Vertical ladders are not impossible to use, but they are most inconvenient, especially when carrying anything. It is possible to mount such a ladder with one or even both hands full, as the author has done in the course of his employment, but it is something to be avoided if possible. The sentry would presumably have in one hand either his spear, ready to cast at marauding *Brittunculi*, or his dinner which he had just cooked on the ground floor hearth, and perhaps his shield in the other hand. Quite apart from such disadvantages in use, a vertical ladder would not require a landing four foot long, or indeed any length at all. It cannot be argued that the platform would keep the foot of the ladder clear of the damp ground, as a vertical ladder must be fixed to or hung from the wall and need not rest on the ground at all.

It will be as well to look at the ease of handling this vertical ladder. Taking the minimum

safe sizes, the stiles (vertical pieces) might be of 2" × 3" timber, the rungs 1½" × 1½". Modern ladders have the rungs at about 10" centres, but a vertical ladder is easier to climb if they are a little closer, so that the knees, which have limited clearance on such a ladder, have to rise less; in this example 8" centres will be assumed, giving 17 rungs. An overall width of 16" is about the minimum for comfortable use. Such a ladder would weigh at least 52 lbs (23·6 kg) if made in softwood and perhaps 65 lbs (29·5 kg) in oak. The ladder would be fixed on hooks below the floor so that the trap door could be closed. The unfortunate soldier would have to bend double or kneel on the floor in order to grasp the top rung, several inches below his feet, and then stand erect while pulling the ladder up into the room. It must be allowed that it would be possible, but one would perhaps need the urgency of barbarians at the door to make it anything but a struggle.

Parker Brewis also suggests that, as the platforms were not bonded into the turret wall, they were installed as the result of a change from fixed vertical ladders to moveable ones as the Romans grew more timorous. Bellhouse[43] disposed of this argument in terms of the likely sequence of trades working on the turrets, and in fact it is rare in buildings of any period for minor items to be bonded-in unless structurally necessary—bonding is troublesome and it is easier to put them in later. If the platforms were genuinely secondary work, in the sense of alterations to functioning turrets,[44] it is more likely that they represent a change from inconvenient (but fixed) ladders to staircases.

It has been argued that the range of artifacts suggests that the turrets were more than mere sentry boxes,[45] and that they probably provided living accommodation for a permanent force of perhaps eight or twelve men.[46] In the light of this regular occupation it is likely that some more convenient form of access would be provided. A fixed ladder set at an angle would be easier to use, but a ladder, assuming it does not have to hauled up at night, does not require a stone platform of any size, let alone one 8' by 3'. However, the case for an angled ladder resting on the platform should be examined.

Such a ladder would ideally project about 3' into the first floor in order to give a grip when coming on to or leaving the ladder. This could be accommodated easily in the extra space left by the first-floor offset in the wall referred to above. The ladder would rest on the edge of the offset, and thus effectively rise only the required 11'6" from platform to first floor. Ladders are best and most safely used (and this must always have been the case) under the "one out and four up" rule of thumb, where for every four units of height the foot of the ladder should be one unit out from the foot of the wall, an angle of 76°. Following this rule, the ladder would have its foot almost 2'11" (890 mm) from the wall, allowing just over one foot for a landing. This sounds superficially attractive, but does not work in practice. After descending the ladder backwards, one would wish to turn round rather than try to make a backwards descent of the very shallow stone steps; a one foot landing is inconveniently small for this purpose, even when empty handed. A ladder of any description in conjunction with a platform simply will not do. A staircase is the obvious reason for the provision of the platforms.

The design of a staircase

The maximum vertical height of step, the "rise", which is convenient in use is partly a matter of agility, but anything over 9" (230 mm) becomes something of an obstacle course, and rather less is to be preferred. The "going", that is the vertical distance from the edge of one tread to the edge of the next, is related to the size of the foot, but 7½" (190 mm) is about the minimum that can be traversed in reasonable safety when descending forwards. Using these two figures gives a maximum angle for a staircase of a fraction over 50°. This, however, is neither particularly safe nor comfortable in use.

Bellhouse comments that open tread stairs "are still comfortable to use at an angle of 60 or 65° ....", but this is not strictly true. They

are convenient to ascend but, as with a step ladder, the descent has to be made backwards. Forty five degrees is about the maximum angle that can be used freely, and even then some care is necessary. For permanent accommodation, forwards ascent and descent are to be preferred, and this must be the reason for a platform, which allows the staircase to make a quarter-turn; the turn increases the length of the staircase for a given height, and this decreases the angle of the stair.

It may be argued that the turn could have been formed in timber, but this would have been less practical. Not only does the platform keep the timber stair from contact with the damp floor, but it is much easier to use stone for this purpose than timber. No joints are needed, less timber has to be laboriously sawn, and fewer nails are required. As Bellhouse rightly points out, "... a handy-man among the carpenters [could have] built the landings from waste stone on the site...."[47] It is much easier to work with rough stone than to cut down and split and saw trees, and calls for less skill. It could be argued that the entire staircase could have been built in stone, but this would have become a serious constructional job. Not only would more skill be required than for building a low platform, but the volume of stone would rise from 56 cubic feet to 430 cubic feet (1·6 to 12·2 cubic metres).

The ground floor of t18a is 12'9" from north to south, and probably about 14'7" high. For a man carrying anything from a bucket to a shield, a space of 2'6"–3' would be required between the foot of the stair and the south wall; this limits the horizontal run of the staircase to 9'9". From floor level, this allows fifteen treads of just over the minimum going of $7\frac{1}{2}$" (190 mm); the risers, of which there would be 16, would be an awkward 10·9" (277 mm) high, giving an angle of 55° which as noted above is too steep. A staircase rising from a platform 3'2" (965 mm) high, as at t18a, can be built with 15 treads of $7\frac{1}{2}$" going and 16 risers of just over $8\frac{1}{2}$" (215 mm), at an angle of 48°. The latter is practicable but, without stretching the evidence too far, it is possible to reduce the angle.

The landing on the platform in t18a measures 4' long by 3' (1220 × 915 mm) wide. The staircase, which would have risen at right angles to the axis of the platform, is likely to have been no more than 3' wide, to match the width of the stone steps, and thus the long axis of the landing would have been 1' wider than necessary.

The upper surface of the platform in t18a has no signs of the foot of the staircase having been built in to it. But if the junction of staircase and landing is considered, this would have been most easily made by laying two short timbers across the landing, with the ends bearing against the south wall, and spiking the feet of the strings to these. (Strings are the sloping timbers which carry the treads.) This would hold the foot of the staircase firmly and, with the cross-timbers boarded over, would give an extra step while leaving the upper stone step with a tread of 12" (305 mm) to match the lower ones. If cross-timbers and boards totalled $7\frac{1}{2}$" in height, to match the stone steps, the height of the main staircase would be reduced from 11'5" to 10'10" (3480 to 3300 mm). If, in addition, the main stair overlapped 3" onto the quarter landing, an acceptable reduction, this would allow 15 treads with a going of 8" (203 mm) and 16 risers of a fraction over 8" (206 mm), to give an angle of just about 45°. This is still steep by modern standards but slightly easier to descend than the staircase in the present author's house which has a rise and going of $7\frac{1}{2}$"; it is safe when used with the exercise of a little care but gives rise to the occasional disaster.

This reconstruction places the upper end of the stair abutting the north wall of the ground floor chamber at first floor level. At first sight this leaves no room to step off the stair. But if, as suggested above, the north wall reduces at this point to 18" (460 mm), there would be a landing of 2'6"–3' (760–915 mm) depending on the ground floor width of the north wall; the upper figure is comfortable, the lower just sufficient, for leaving and entering the stair. The same advantage would not be gained if the stair abutted 3' side walls, as the reduction in thickness gives an offset of only 18", which is

not wide enough for a landing. This must be the reason why the platforms seem always to have been against the south wall, allowing the stairhead to be on the wider north wall.[48]

The figures given for the minimum width of the upper landing apply only to the turrets (about 12 so far identified) with north walls of 4' or more. Only t33b (43"), the narrow wall turret 39a (33"), the signal tower t45a (32"), and turrets 48a and 48b (both 32") fall below this figure. These turrets, and t41a Caw Gap and t44b Mucklebank with N–S width of under 11', must have had different access arrangements.

Turrets below 12'9" but above 11'9" N–S could have had a staircase of the type suggested above, but only by reducing the width of the lower landing to 2', as occurs in t19a and t25b (the latter is only 11'4" N–S); this would be cramped but would serve. Many readers must have had experience of attic stairs, with winders, where the width is no more than 2'. Considerations of safety and comfort today are very different from earlier times, and staircases less commodious and comfortable in use than those presented in this reconstruction could certainly have been fitted into turrets smaller than the average.

The above does not prove the existence of staircases in turrets; it merely shows that they were possible. Platforms with steps suggest a means of ascent, and the present author is entirely unconvinced that they were designed to be used in conjunction with ladders. Platforms have no relevance to ladder access if the notion of the vertical, removable ladder can be abandoned.

It must be remembered that the discussion relates only to broad wall turrets, built as designed (if, in fact, any were); if the narrow wall were a little lower, for which there is no evidence, the provision of a staircase would have been even easier.

There is just one potential problem with a staircase. This concerns the position of hearths, which in some turrets (for example t7b,[49] t18a,[50] and Peel Gap tower[51]) are placed against the platform directly beneath the proposed staircase. This need not be an insuperable problem, as other apparently inexplicable locations for fires have been found. Turrets 10a[52] and 18b[53] had substantial hearths built directly on their thresholds during the period that the turrets were in commission. It is difficult to see how this would have been practicable, both for using the entrance and closing the door, yet they are there. A hearth against a platform would have been at least 3'2" from the strings and 4'4" from the treads. A certain amount of care would have been needed, but the substantial timbers of the stringers would not be all that easy to set on fire. Stone slabs, spiked to the underside of the stairs, would have provided a good insurance, although evidence is wholly lacking.

Another point is that a fire against the platform might not set light to a vertical ladder, but it would certainly make life difficult, not to say unnerving, for those ascending or descending. A fire should not be anywhere near a means of access, but that is where they appear to be.

Access to the wall walk and upper floors

The width of the stone upper landing would allow the doorway from a parapet walk to open on to the stone wall rather than on to a timber floor.[54] There is no structural necessity for this to be an essential feature of the design; an obvious, if unappealing, reason might be the absence of a first floor with the stone landing giving access to, and footing for, the next flight. If that were the case, it is not easy to see how the accommodation might have been arranged, given that the turrets were occupied on a permanent basis, unless the look-outs shared their second floor position with the sleeping quarters.

The first floor stair is shown in Figs 1 and 2 springing from the landing on the north wall; the strings are built-in to the wall. Fifteen risers of $7\frac{3}{4}$" (197 mm) fit the assumed storey height of 9'$8\frac{1}{2}$" (2960 mm) and fourteen treads with a going of 8" have been used to give a reasonably comfortable staircase at an angle of 44°. In practice, as access to the second floor may only be required when going on or off

duty, a ladder might well have been thought sufficient.

A flat roof is shown in Fig. 2 for readers who prefer that form. The thickness of the flat roof, based firmly on Vitruvius,[55] adds another 2' (610 mm) to the suggested height, plus say 1½" (38 mm) to allow for a slight camber, a total of 10'10" (3300 mm); seventeen risers of just under 7¾" and sixteen treads of 8" going will serve and reach the flat roof about 3'4" (1015 mm) from the parapet. The angle is 44°.

For the construction of all the staircases, strings cut from 6" × 11" timber are suggested, with treads of 2" boarding. No riser boards would be needed.

Roofs and access

Figure 1 shows a section through a pyramidal roof, with a pitch of 30° which would be suitable for covering with tiles or stone slates. There is some evidence for stone slates, but no serious fragments of tile have been discovered. This evidence, and the evidence for and against the utility of flat roofs, have been discussed at length,[56] and need not be repeated here. Only one point may be added.

It has been suggested[57] that there may have been a roof of very low pitch with a parapet walk around the edge, the bevelled stones found at t48a[58] being used to carry the inner edge of the walk. This has good mediaeval parallels, but it would take more than a single such corbel to increase the width of the narrow walls sufficiently to give space for the eaves of the roof, the walk, and a parapet. The presumed merlon capping found at t51a[59] suggests, from the size of the bevel, a parapet wall thickness of 15" This leaves no room for the roof to terminate on the wall head with space for even a gutter, unless either the walls were carried up at 3' thickness or the top of the wall was corbelled out by a minimum of 18", and preferably more, if there were to be room for a sentry to walk round in safety.

A possible alternative use for such stones is suggested above, under *Floors*. Access to such a roof walk would require a penthouse of the form discussed at the end of this section.

The reconstructed pitched roof is shown built up of 5" square timber, with laths to take the slates. No ceiling is shown; there may or may not have been one.

The flat roof is made up according to Vitruvius,[60] with two layers of 3" boarding, a layer of 3" tiles, 12" of concrete, and a covering of 3" flat tile or brick laid to a fall. It is shown supported on 9" square timbers at 33" (840 mm) centres. Water from the roof is shown as being discharged by a stone channel, of which two fragments (of unknown origin) are to be found in the field wall adjacent to the site of t33a; another example of such a water spout is to be seen outside the east gate of Housesteads fort.

One question which remains to be discussed is the matter of access to a flat roof. Figure 2 shows it approached by a staircase, but how was the hole through the roof covered? The traditional answer is a trapdoor.

Reverting for the moment to a ladder, the ideal angle of 76° has been discussed. For access to a flat roof the ladder would be fixed with its upper end close to the surface of the roof, so as to make the first rung reasonably easy to find when descending; about one foot down is the most that can be allowed. The top rung will be close, say 3", to the framing of the hole, but one can manage. A man wearing a helmet is likely to need at least 6' (1830 mm) headroom as he ascends, and he will hit the ceiling or the trimmer framing the hole when his centre line is about 18" (460 mm) from the top rung of the ladder, measured horizontally. (A trimmer is the short joist supporting the end of a joist which has been cut short, as for an opening thorough the floor.) To give some clearance for his back at least another 6" is required, to which must be added the distance of the first rung from the edge of the trap; a length of no less than 2'6" will serve. Carrying a spear, and perhaps a shield, no less than 2' width is necessary; more would be easier to negotiate and a trap of 2'6" square may be regarded as the absolute minimum requirement.

Around the hole, an upstand of say 3" (76 mm) is needed to prevent rain blowing in

around the edges, with a similar downstand on the trap to complete the seal. The trap itself might be made of two layers of 2" boards at right angles, and if well caulked and covered with well-greased leather should keep out all but the severest weather. Such a trap will weigh at least 125 lbs (57 kg), not easy to push up from below, even if well-hinged and provided with a chain stay to prevent it falling backwards, but it would be a practical proposition.

As has been suggested as a possibility for access to the second floor, a ladder might have been thought sufficient to reach the look-out point on a flat roof. However, staircase access should be considered if only because it raises an interesting point in relation to the evidence for roof forms.

Using a 44° staircase, the sentry would meet the trimmer at a minimum of 75" from the head of the stair, and because of the greater width of treads as compared to rungs, the opening would have to be about 7' long. Even if the width of the stair were kept down to 2'6", a trapdoor made as described above (but with extra framing to keep it rigid) would weigh at least 336 lbs (153 kg). This is clearly not practical. The alternative is a penthouse over the stair, perhaps following the same angle, and closed by a door.

Such a penthouse could have boarded sides and would be roofed with stone slates or tiles. This would solve the problem of finds of slates at some turrets and merlons at others, although traces of the heavy concrete flat roofs have yet to be discovered.

It must be said that the idea of a penthouse does not find favour with the present writer both on architectural grounds and because of his innate agnosticism towards flat roofs in the absence of any evidence for them. The preferred option is still a pitched roof, probably pyramidal.

ACCOMMODATION

Omitting the area of the platform, the ground floor of the average turret offered some 132 square feet (12·26 m^2) for cooking and food preparation. The space available on the first floor is less easy to calculate. Parker Brewis[61] put forward the idea of a partition across the turret to separate the wall walk from the accommodation. This seems quite likely, but it is also possible that the access to the second floor was also screened off, so that those on duty were less likely to disturb sleepers at night. On the other hand, any patrols were likely to go outwards from the turret rather than pass through it, reducing the possible disturbance; in any case, military duties are carried on during the night to an amazing extent, and soldiers become accustomed to sleeping through events which do not involve them.[62] If the staircase to the second floor has its foot on the north wall, as shown in Figs 1, 2, and 4, it can be approached directly from both the lower stair and the wall walk. Not only would this separate duty and non-duty personnel, should this be desirable, but it would have the added advantage of keeping smoke from the hearth out of the living accommodation. Unglazed windows to the north, as Parker Brewis suggests, and the doors to the wall walk, would help to disperse the smoke before it choked the look-out on the second floor. The partition shown in Fig. 4 provides comfortable, indeed spacious, accommodation with room for four sets of two tier bunks,[63] ample for twelve[64] men working four hours on and eight off, sharing bed spaces.

The area of the first floor accommodation thus described and illustrated in Fig. 4 is about 180 square feet (16·7 m^2); adding to this the ground floor area calculated above gives a total of 312 square feet (29 m^2) which may be compared with about 275 square feet (25·5 m^2) of one *contubernium* in the Hadrianic barracks at Housesteads.[65] The barrack accommodation per man works out at 34 square feet (3·12 m^2) and in the turrets at 39 square feet (3·6 m^2) if manned by eight men, and 26 square feet (2·4 m^2) if manned by twelve men. As the area of the turret is the net amount available and that of the barrack the gross internal amount, it is clear that the scale of accommodation in the turrets was not dissimilar to that provided

in the forts, even if they were manned by twelve men rather than eight; if manned by eight men, the scale was generous.

NON-STANDARD TURRETS AND TOWERS

Turrets 48a Willowford East, and 48b Willowford West

Marking them out from all other known broad wall turrets, these two turrets alone have a north wall only 32" (810 mm) thick, to match their side walls.[66] This is so distinctive that it is worth seeking the reason.

The simple, "non-conspiracy", solution is that it was a mistake, but this of itself might be instructive. Gangs of legionaries, to say nothing of their centurions, would hardly build two turrets to the same incorrect design if they had already built several others to the standard design. Perhaps these turrets were the first that the legion had built; they are built like signal towers with wing walls, which is how they might have appeared to the legionaries who were unused to watch towers in a running barrier. Turret 48a is irregular and far from square which may indicate inexperience, although an inexperienced gang might appear at any time owing to the inevitable changes in personnel over a long building programme.

The division of labour into legionary blocks seems reasonably secure, at least away from the crags. It is believed that the legion which built t48a and t48b also built the stretch from t17a to milecastle 22,[67] and the latter structures appear quite normal. The legion is also thought to have built the bridge over the Irthing.[68]

This is not the place to discuss labour allocation on the wall, but the legion will presumably have been split between the eastern and western blocks. Even if only half the legion were engaged at any one time on the building programme, at least two and a half cohorts would be working on each block. The western block would very likely begin with building the bridge, but this would hardly absorb two and a half cohorts, or around 1400 men; some would be put to work on the wall structures. Turrets 48a and 48b would then be the first turrets built by this gang, and mistakes could occur. Meanwhile in the east, the rest of the legion was busy on that block and either made no mistake or made their mistakes still further east where remains are scanty or non-existent.

Another very distinct possibility is that work began simultaneously at the east and west ends of the stone wall, and that these turrets and the first two or three of those now lost under Newcastle were the first to be built anywhere on the wall, after which the design was changed. In the absence of evidence for the turrets in the east this cannot be confirmed, but there is no doubt that work began in the west, even if the curtain wall was built later, well before work in the east was completed.[69]

The reason for a possible change of design is not immediately obvious. It has been shown that the broad north wall would have been useful in conjunction with a staircase in that it provided a broad landing, but this could have been made up in timber without the exercise of more skill than was needed for constructing the floors. On the other hand t48a and t48b were between 12' and 12'6" north–south, and there would have been no room for a broad landing in timber without building a dog-leg stair (in which the flight turns at 180°) or a second quarter-landing. But the provision of staircases is an argument not a fact, and so must be used carefully least the argument for a change in design becomes circular.

The reason for the design of these two turrets remains obscure to the present writer. The basic problem to be resolved is the intention behind the broad north wall in almost every other turret.

Pike Hill and t45a Walltown Crags East

The pre-Wall,[70] but nearly contemporary, Pike Hill and t45a towers were of similar internal dimensions to the standard wall turrets; they vary only in that t45a has a thin north wall (the width at Pike Hill is unknown) and that they are not bonded into the curtain wall. The provision of ground floor doorways, unlike Mains Rigg and Robin Hood's Butt, suggests that

they were designed as part of a running barrier. J. G. Crow[71] points out that t45a fits into the regular spacing of turrets and milecastles. The implication of this is that it was very firmly part of the overall scheme. As with t48a and t48b, t45a may have been a very early turret, in this case built even before wing walls were added to the design. Building did not begin at each end and roll onwards towards the middle; gangs were at work simultaneously on many parts of the Wall.

These turrets were presumably also furnished with staircases for the reasons outlined above, but in the absence of platforms, of which no trace has been found, and of broad north walls, these must have been of a different form. Built in advance of the Wall, they may have been furnished with all-timber stairs with two flights to each storey but using the full length of two adjacent walls.

Turret 44b, Mucklebank

This is one of the few turrets built with the narrow wall and no broad foundation (t39a is another) and the only one which is now visible. It is anomalous in almost every way, something encouraged by its unusual situation lying as it does in a right angle of the curtain wall.

It is little over 10′ square internally, although the plateau on which it stands gives ample room for a larger size, the north wall is 75″ thick, and it is recessed into the curtain by only 12″ into the wall on the north side, and by 14" on the west side. It is the shallow recess which gives the unique width to the north wall; perhaps the recess was kept very small so as to allow the north wall, which appears to stand on level ground, to give a buttressing effect to the wall coming down the hill to the east. If that were the case one wonders why any recess at all was provided, especially considering the extra work involved. The recess on the west side is even more strange; it called for extra work to build the 14" return, and the need for any recess at all is not clear. Perhaps, in the case of the north wall, the builders regarded it as essential that turrets be recessed into the curtain, and as the outer face of the west wall continues the line of the curtain a recess had to be provided there also. This would be typical "building by the book" which is not unknown on the Wall. The inner face of the curtain is a continuation of the line of the west jamb, the offset of the doorway from the west wall thus giving no advantage of extra clearance when entering the turret.

As noted above (page 35) the door head was almost certainly arched which means that the door must have turned on the inner or the outer edge of the reveal. As there is no monolithic threshold or pivot hole, it is probable that the door was hinged, which would make it much easier than with a pivot to have it turning virtually flush with the inner or outer wall face.

No trace of a platform was found, and the small size of the turret led the excavator to conclude that there was no room for "any internal means of communication larger than a ladder".[72] The narrow wall may have been lower than the broad wall (there is no evidence either way), making it possible to squash in a usable staircase, steep though it might have been, but the consequent reduction in the already small floor area available would have been very inconvenient.

An unspecified number of "... heavy slabs ... from three to four inches in thickness and about twenty four inches square ..." were found in the upper levels of the excavation.[73] It was suggested that they might have come from an upper floor or from a continuation of the path along the wall, over or through the turret. They could also have been used on a flat roof, although it is difficult to see how such a roof could have been made watertight without a good deal of concrete, which was not discovered.

This turret is so unlike any other that no parallels can be drawn from it.

Milecastle towers

Milecastle towers fall into a different category. They were very unlikely to have been used for accommodation, for which the barrack was provided, and they are very small by comparison with turrets: internally, types I and II were 11′ × 6′ and type III 11′ × 8′.[74] A dog-leg

staircase could have been fitted to each floor. The six foot internal depth of the towers on type I and II is just sufficient to take a dog-leg; type III would have had ample room. However, as access to the upper floors would have been used only by the sentry on his spell of duty a ladder would have been more acceptable.

SUMMARY

The foregoing pages demonstrate clearly that the use of ladders would have been highly impractical and that they played no part in the design of the platforms. It has been shown that platforms seem to have been built with staircases in mind, and that the provision of stair-

Table 1 Turret walls, internal size, and platforms

No	Internal N–S	E–W	Depth of recess	Side walls (average)	North wall	Platform L × W × H
7b[76]	12'9"	13'6"	60"	34"	47"	7'6" × 3'8" × 1'7"
10a[77]	13'6"	13'9"		36"	51"?	6'7"*
12a[78]				48"		
12b[79]				48"		7'3"* × 3'0"* × ?
13a[80]				48"		6'3"* × 2'10" × ?
17a[81]				34"		8'3"* × 3'0"* × ?
17b[82]				34"*		8'0"* × 3'0"* × ?
18a[83]	12'9"*	14'0"*		36"*		8'0" × 2'11" × 3'1"
18b[84]		15'2"		38"		
19a[85]	12'2"*	14'*	57"*	35"	51"*	8'0"* × 2'3"* × ?
19b[86]	12'3"*	12'9"*	54"*	32"*	51"*	8'0"* × 3'0"* × ?
25b[87]	11'4"	13'7"	54"	36"	63"	7'6" × 2'2" × ?
26a[88]	12'6"	11'10"				
26b[89]	11'3"	12'7"	57"	35"	51"	
27a[90]		11'		54"		
29a[91]	12'1"	11'5"	52"	43"	61"	
29b[92]	12'3"	12'8"	60"	34"		7'1" × 3'8"/2' × ?
33b[93]	13'0"	13'4"	72"	35"	43"	4'6" × 2'11" × 12"
34a	12'0"	12'9"	58"	36"	48"	
35a[94]	11'2"	13'1"	63"	36"	47"	? × ?3'[95] × ?
36a[96]				36"		
39a[97]	13'	13'8"	49"	33"	33"[98]	
39b[99]	11'9"*	11'7"	26"	46"*	50"	
40a[100]				39"		
40b[101]		19'		48"		
41a	10'7"	11'9"	49"	(47")[102]	57"	
44b[103]	10'2"	10'1"	12"	40"	75"	
45a[104]	12'3"	13'2"	-	33"	32"	
45b[105]	11'10"	13'0"	30"	38"	54"	
48a	12'5"	13'9"	77"	32"	32"[106]	6' × 2'6" × ?
48b[107]	12'	13'9"	77"	32"	32"	
Pike Hill[108]				35"		
Peel Gap[109]	11'6"	12'4"	–	38"	83"[110]	5'7" × 3'3" × ?[111]

cases would not render the turret inconvenient for use as accommodation. The picture presented of turret 18a and similar turrets, with comfortable stairs and carefully screened and draught- and smoke-free sleeping quarters, is perhaps a little idealized, not to say Ideal Home, but armies have ever been renowned for making themselves as comfortable as possible. This is normally due to the soldiers themselves adapting the uncomfortable surroundings in which they have been set down, and so any uniformity of interior features must be surprising rather than expected.

More work is needed on the reason for the thick north walls of almost all turrets, and the care with which they are all recessed, even if

Table 2 The doorways

No	Width	Original Threshold	Pivot	Jambs	E/W
7b[112]	3'6"	small flags	yes	sq. rubble	east
10a[113]	3'6"	none	none	?[114]	east
12a[115]	3'6"*	"not monolithic"	?	"not slabs"	east
12b[116]	3'6"*	"not monolithic"	?	"not slabs"	east
13a[117]	3'6"*	"not monolithic"	?	"not slabs"	east
17a[118]	?	?	?	?	west
17b[119]	?	?	?	?	west
18a[120]	3'6"*	?	?	?	west
18b[121]	2'10"	?	none	?	west
19a[122]	?	?	?	?slab	west
19b[123]	3'0"*	?	?	?	west
25b[124]	3'6"*	?	?	?slab[125]	east
26a[126]	?	?	?	?	east
26b[127]	2'11"	monolithic	yes	slab	east
27a	?	?	?	?	?
29a	3'0"	monolithic	yes	slab	east
29b[127]	3'6"	monolithic	yes	slab	east[128]
33b[129]	3'8"	?	?	?	east
34a	3'0"	monolithic	yes	slab	east
35a	3'3"	monolithic	yes	slab	east
36a[130]	?	?	?	?	east
39a[131]	3'5"	?	?	??slab[132]	east
39b[133]	?	?	yes	?	east
40a[134]	?	?	?	?	?
40b[135]	?	?	?	?	east
41a	3'4"	?	?	?	east
44b	2'10"	small flags	none	sq. rubble	west
45a	3'6"	small flags	none	?	east
45b[136]	?	?	?	?	?
48a	2'9"	monolithic	yes	slab	west
48b	?	?	?	?	?
Pike Hill[137]	2'9"	monolithic[138]	none	wood?	east
Peel Gap	3'2"	small flags	not visible	not slabs	east

Note: where slots for stone jambs exist, the width of the doorway is taken between the inner edges of the slots. In other cases the width is between the squared rubble reveals.

only a little, into the curtain wall. Despite all the foregoing discussion, the reasons for the provision of both these elements remains a matter of speculation.

Further work is needed on identifying building elements which might give clear information on the thickness of the turret walls above Wall-top height; in the present state of knowledge the best that can be done is to draw parallels with the milecastle towers.

As part of the research for this paper every extant turret was measured afresh, revealing that not one but two broad wall turrets have thin north walls (t48a as well as t48b). The significance of this feature is at present obscure, but it may well be that other excavated turrets, now reburied, are also anomalous. These two turrets may have been built right at the beginning of the project, as may t45a.

The older published plans tend to be stylized and to omit important information. The very least that is urgently needed is a full and accurate plan of every visible structure, with tables of agreed dimensions; without these, serious study of the Wall is severely hampered. Elevation drawings can be useful, but plans are vital.

TABLES OF DIMENSIONS

All extant turrets have been measured by the present author and an average between these figures and those given in excavation reports has been used in compiling this table. Where significant discrepancies exist, they are noted alongside the references. An asterisk * shows that the dimension has been scaled from the published drawing. References are given only where the report yields dimensions; where no reference is given the figures are all taken from the author's survey. Where, in partial excavations, the excavator has given estimated dimensions they have not been used in these tables. All dimensions have been taken above any offsets, unless otherwise indicated.

As a general point, discrepancies of an inch or two either way are not significant; the imprecision inherent in building, consolidating, and measuring roughly squared rubble means that measurements can never be better than approximate.

Only those turrets which are either visible or for which reliable information is available have been included in these tables. The same turrets are listed in both tables, even where little or no information is available for one or other table.

The horizontal lines show the division into legionary lengths as put forward by Hooley and Breeze.[75] Peel Gap tower, as a later addition, has been put with Pike Hill tower at the end of the tables so as not to confuse legionary patterns.

NOTES

[1] Parker Brewis, "Conjectural Construction of Turret No. 18a on Hadrian's Wall" *AA*^{4}, ix (1932) 198–204 and plate xxiv.

[2] R. L. Bellhouse "Roman Sites on the Cumberland Coast, 1966–1967" *CW*^{2} lxix (1969) 54–101. This is one of the very few discussions which goes into possible constructional details in any depth.

[3] Dorothy Charlesworth, "The Turrets on Hadrian's Wall" in M. R. Apted, R. Gilyard-Beer, and A. D. Saunders, *Ancient Monuments and their Interpretation*, 13–26, (Phillimore 1977).

[4] B. Dobson, "The Function of Hadrian's Wall" AA^5, xiv (1986) 1–30.

[5] P. R. Hill and B. Dobson, "The Design of Hadrian's Wall and its Implications" *AA*^{5}, xx (1992) 27–52.

[6] Mrs. J. Watkinson assisted with the on-site measurement, sought out references, and checked the proofs, Dr. Brian Dobson, as so often, made invaluable comments on a draft of the paper and encouraged clarity, and Dr. Brenda Heywood discussed the evidence from the east angle tower at York. The author is grateful for their help and remains responsible for all surviving errors and omissions.

[7] "North" is throughout taken to mean the side facing to the outer or enemy side of the Wall, and the other cardinal points take their position from this theoretical aspect.

[8] All conversions are approximate. The use of Imperial measure has been deliberately chosen as almost every excavation report is in that system; using the Metric system, every reference to those reports by the reader would call for re-conversion. Metric equiv-

alents are given except where they seem to be superfluous or would lead to unnecessary repetition.

[9] C. E. Stevens, *The Building of Hadrian's Wall* CW Extra Series Vol. XX, 1966, 11.

[10] As defined by Joyce Hooley and David Breeze, "The Building of Hadrian's Wall: a Reconsideration" *AA*^{4}, xlvi (1968) 97–114.

[11] Following the argument put forward in P. R. Hill, "Hadrian's Wall: Some Aspects of its Execution" *AA*^{5}, xix (1991) 33–39, in which a measure of doubt was cast on the allocation of structures to named legions.

[12] For example, the towers to the east and west of the south gate at Chesters fort have outer walls of 60" and 65" respectively, while the side walls are between 30" and 32".

[13] But see below, note 22, and page 42.

[14] This includes those parts which have, or may have, been rebuilt; e.g. Clayton rebuilt t26b Brunton "... to about the height of five feet ..." (*AA*^{2}, xxiv (1903) 13. The north and east walls of this turret are now 7'8" high, the west wall 6'10", and the south wall 3'4" high; it is not clear what may have been rebuilt by Clayton.

[15] op. cit., 79.

[16] Parker Brewis, loc. cit.

[17] Charmian Woodfield, "Six Turrets on Hadrian's Wall" *AA*^{4}, xliii (1965) 152.

[18] Such platforms have an exact parallel on the German frontier. In the Bavarian section, tower 15/15 has a platform with five steps in the rear corner not occupied by the doorway (Günter Ulbert, Thomas Fischer, *Der Limes in Bayern* Stuttgart (1983), 100 and Fig. 74).

[19] Hooley and Breeze, op. cit.

[20] P. R. Hill, "Stonework and the Archaeologist" *AA*^{5}, ix (1981) 3, where a paragraph was omitted in error by the present writer, and the description of "squared rubble" appeared under the heading of "coursed rubble". See also P. R. Hill and J. C. E. David, *Practical Stone Masonry* (Donhead Publishing 1995) 33.

[21] Woodfield, op. cit. 164.

[22] ibid. 166–7, where it is argued that the turret is Hadrianic and part of the first phase of Wall building. See also page 42, below.

[23] Hill and Dobson, op. cit., 33.

[24] S. N. Miller, "Roman York: Excavations of 1925" *Journal of Roman Studies* xv (1925) 176–94, plates XXVI and XXXI.

[25] F. G Simpson and James McIntyre, "Pike Hill" *CW*^{2} xxxiii (1933) 271.

[26] The threshold runs well under both jambs (*CW*^{2} xxxiii (1933), Fig. 24), and should therefore be original.

[27] "Monolithic" is taken here to include those thresholds made up of two squared and well fitted slabs, as well as those consisting of single slabs.

[28] The phenomenon also appears in, for example, Chesters bath house, the strong room of the west compound at Corbridge, and the north doorway of the post-Hadrianic *principia* at Housesteads.

[29] op. cit. Fig. 2. The use of "square" and "triangular", derived from the use of the symbols in their figure, obviates the need to refer to legions by number, which seems unwise in the present state of knowledge.

[30] Hill and Dobson, op. cit. 39.

[31] *AA*^{4}, x (1933), 98.

[32] F. G. Simpson, *Watermills and Military Works on Hadrian's Wall* (ed. Grace Simpson 1976), Fig. 20. The dimensions were obtained by scaling from the photograph.

[33] *AA*^{3}, ix (1913), 58.

[34] op. cit., 198.

[35] But at t25b it has been suggested (*AA*^{4}, xliii (1965) 111) that clearance of part of the floor was to allow the door to open more easily; at t7b the threshold was raised by 24" to a new floor level (*AA*^{4}, vii (1930), 148); at t33b (*AA*^{4}, I (1972) 149), the threshold was raised by two courses to accommodate a rise in floor level. Some turrets may have had inward opening doors. It may or may not be significant that at none of these three turrets is there clear evidence for a monolithic threshold.

[36] E. B. Birley, "Excavations on Hadrian's Wall West of Newcastle upon Tyne in 1929" *AA*^{4}, vii (1930), 150.

[37] op. cit., 16. The same article also points out that there is no evidence that Roman glazed windows could be opened.

[38] Hill and Dobson, op. cit., 37, 38.

[39] *CW*^{2} xxvi (1926), 442.

[40] op. cit. (note 1).

[41] As at t44b, where bolt sockets were noted by the excavator, *AA*^{2}, xxiv (1903), 17.

[42] Dobson, op. cit., 6–7.

[43] op. cit., 84.

[44] This may be the case at, for example, t25b, where the platform replaced a "working area", *AA*^{4}, xliii (1965) 111, and at t48a where the platform over-lies the third floor surface, *CW*^{2} xxvi (1926), 441.

[45] Lindsay Allason-Jones, "Small finds from turrets on Hadrian's Wall" in J. C. Coulston (ed.) *Military Equipment and the Identity of Roman Soldiers* (BAR International Series 394, Oxford 1988) 197–233.

[46] Hill and Dobson, op. cit., 39.

[47] op. cit., 84.

[48] The width of the north wall in 18a is not known, as the north face of the wall was not available to the excavator. In the reconstruction drawings it is shown as 4'6" (1370 mm), giving a 3' landing.

[49] *AA*[4], vii (1930), 147 and plate XXXVII.

[50] *AA*[4], ix (1932) plate xxiv. No precise location is shown.

[51] J. G. Crow, *Britannia* xix (1988) 436. The very short original length of the platform (see table 1) makes the use of a staircase less likely in this tower, if the Narrow Wall was the same height as that postulated for the Broad Wall.

[52] *AA*[5], xi (1983), 34.

[53] *AA*[4], xliii (1965), 90.

[54] The existence of this wall top within the turret might argue that there was no need to build up the recesses in dismantled turrets in order to maintain any patrol walk on the wall, and that the building up was for some other, perhaps structural reason. But the sudden set-off of the line of the south face of the wall would be dangerous for a patrol operating in the dark, and the need to maintain the width of the wall top, rather than just a passage of varying width, perhaps adds weight to the existence of at least occasional patrols.

[55] *The Ten Books on Architecture*, Book 7, Chapter 1.

[56] Hill and Dobson, op. cit., 40–3.

[57] E.g. Charlesworth, op. cit. (note 3), 14.

[58] *CW*[2] xxvi (1926), 442.

[59] Woodfield, op. cit., 182.

[60] loc. cit. (note 55).

[61] op. cit. 199.

[62] The present author, having led a sheltered, non-military, life, is indebted to Dr. Dobson for both these observations.

[63] There is no archaeological evidence for bunks, which are suggested here as a convenient means of allowing as much free floor space as possible.

[64] Hill and Dobson, op. cit., 38–39.

[65] *AA*[4], xxxix (1961) 282.

[66] See note 106.

[67] Hooley and Breeze, op. cit. (note 10).

[68] ibid. 106.

[69] For example, the western turrets were begun with wing walls, so must have been started before the decision to narrow the wall. But t48b must have been started later than t48a, as the latter shows wing walls on both sides whereas the curtain wall on the west side of the former joins in a smooth taper, widening from 7'7" to 9'8" over a distance of 39' (*CW*[2] xxvi (1926), 433). Building the lower part of a turret was a very quick business, and the difference was probably no more than a few days. See Hill, op. cit. (note 11). A detailed discussion of the programme and time scale for building the wall is in preparation.

[70] In the sense that they seem to have been built in advance of the main building programme (see note 22).

[71] *Britannia* xxii (1991), 62.

[72] *AA*[2], xxiv (1903), 17.

[73] ibid., 14.

[74] Hill and Dobson, op. cit., 33.

[75] op. cit. (note 10).

[76] *AA*[4], vii (1930), 146. The figures given in the table are as measured on site; the report shows the internal size as 13' N–S by 14' E–W.

[77] *AA*[5], xi (1983), 34. *Scaled from Fig. 12, p. 39.

[78] *AA*[4], viii (1931), 322–324.

[79] *AA*[4], viii (1931), 322–324. *Scaled from Fig. 9.

[80] *AA*[4], viii (1931), 322–324. *Scaled from Fig. 9.

[81] *AA*[4], ix (1932), 257. *Scaled from plate xlv.

[82] *AA*[4], ix (1932), 257. *Scaled from plate xlv.

[83] *AA*[4], ix (1932), 198ff, and 258. *Scaled from plate xlvii.

[84] *AA*[4], ix (1932) 258; *AA*[4], xliii (1965), 88.

[85] *AA*[4], x (1933), 98, and plate vi. *Scaled from plate vi.

[86] *AA*[4], x (1933), 99 and plate vi. *Scaled from plate vi.

[87] *AA*[4], xliii (1965), 108, 111.

[88] *AA*[4], xliii (1965), 128.

[89] *AA*[3], ix (1913), 70.

[90] *AA*[5], x (1982), 200.

[91] *AA*[2], vii (1876), 258, *AA*[3], ix (1913), 70.

[92] *AA*[3], ix (1913), 60–61, 70.

[93] *AA*[4], l (1972), 145f.

[94] *AA*[4], xliii (1965), 151–2.

[95] This relies on the absence of cobbling on the floor surface.

[96] *JRS* xxxvii (1947), 168.

[97] F. G. Simpson, *Watermills and Military Works on Hadrian's Wall* (ed. Grace Simpson 1976), 99 and plate v.

[98] Only narrow wall at this turret, with no broad foundation.

[99] F. G. Simpson, op. cit. (note 94) 110–11, and plate v. *Scaled from plate v; the N–S dimension given in the text is to the blocking wall.

[100] *JRS* xxxvii (1947), 168.

[101] *JRS* xxxvii (1947), 168.

[102] This appears to be below the offset.

[103] *AA*[2], xxiv (1903), 13–18 (in which J. P. Gibson gives the internal dimensions as "about 11' square"), and *AA*[3], ix (1913), 70 (in which the dimensions are very close to those obtained by the present author).

[104] *AA*[3], ix (1913), 70, *AA*[4], xliii (1965), 162.
[105] *AA*[2], x (1885), 57, and *AA*[3], ix (1913), 70.
[106] *CW*[2] xxvi (1926) 438–9, where the north wall is given incorrectly as 3'2", and the side walls as 2'11"; the latter appear to have been measured below the offset. The internal figures are averages, as the building is not square.
[107] *CW*[2] xxvi (1926), 431.
[108] *CW*[2] xxxiii (1933), 271.
[109] J. G. Crow, *Britannia* xix (1988), 434–6 and Fig. 12. The walls of this turret are so unevenly built that the width of the side walls is very much of an average.
[110] Built against narrow wall with no recess. The north–south measurement is taken to the face of the first narrow wall.
[111] Later extended to 6'10" long, J. G. Crow, op. cit., note 109.
[112] *AA*[4], vii (1930), 146, where the width is given as 3'8".
[113] *AA*[5], xi (1983), 34.
[114] ibid. where the excavator suggests that recesses in the rubble jambs might have held "battens" (*recte* plugs) to hold a timber frame.
[115] *AA*[4], viii (1931), 322–4. *Scaled from Fig. 9.
[116] *AA*[4], viii (1931), 322–4. *Scaled from Fig. 9.
[117] *AA*[4], viii (1931), 322–4. *Scaled from Fig. 9.
[118] *AA*[4], ix (1932), 257 and plate xlv.
[119] *AA*[4], ix (1932), 257 and plate xlv.
[120] *AA*[4], ix (1932), 258 and plate xlvii. *Scaled from plate xlvii.
[121] *AA*[4], xliii (1965), 88–9.
[122] *AA*[4], x (1933), 98 and plate vi.
[123] *AA*[4], x (1933), 99 and plate vi. *Scaled from plate vi.
[124] *AA*[4], xliii (1965), 108f. *Scaled from drawing p. 122.
[125] A gap at the east side of the secondary threshold may indicate a missing jamb slab (ibid. 111).
[126] *AA*[4], xliii (1965), 128f. *Scaled from drawing, p. 122.
[127] *AA*[3], ix (1913), 56ff and plate ii.
[128] There is a short return from the east wall, setting the doorway 9" from the south east internal angle (ibid. 58).
[129] *AA*[5], l (1972), 145ff.
[130] *JRS* xxxvii (1947), 168.
[131] F. G. Simpson, op. cit., 98f and plate v.
[132] ibid., Fig. 20, where a slab used in the blocking wall *may* be a door jamb. *Scaling from the photograph gives dimensions of 6'3" × 6–7".
[133] F. G. Simpson, op. cit., 110f and plate v.
[134] *JRS* xxxvii (1947) 168.
[135] *JRS* xxxvii (1947) 168.
[136] *AA*[3], x (1895), 57, *AA*[3], ix (1913), 70.
[137] *CW*[2] xxxiii (1933), 271.
[138] Made up of two squared flags.