Society of Antiquaries of Scotland

Anatomy of an Iron Age Roundhouse

The Cnip Wheelhouse Excavations, Lewis

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Chapter 5

Anatomy of a wheelhouse

5.1 THE NATURE OF THE EVIDENCE

The excavated structural elements of Wheelhouses 1 and 2 have been described in Chapter 2. From the partial dismantling of Wheelhouse 2, and the recording of the surviving superstructure of Wheelhouse 1, it is possible to reconstruct in large measure, how these structures were built, at least to the top of the stone corbelled roofs which covered each peripheral bay. The further evidence of building debris left within the unfinished Wheelhouse 2 provides insights into the organization of the building process. Evidence from each of these sources is combined here to provide an interpretation of how these wheelhouses were built. Following a discussion of the building process as reconstructed on the basis of Cnip, the applicability of this model to other wheelhouses in the Western Isles and elsewhere, will be considered.

5.2 RECONSTRUCTION DRAWINGS

The following discussion of the construction sequence is accompanied by a series of four reconstruction drawings, drawn by Alan Braby in discussion with the author, which show a series of broadly sequential stages in the construction of a wheelhouse. The drawings were funded by Comhairle nan Eilean for an exhibition in Lewis in 1995 and, inevitably, some changes in interpretation have been made since then. The broad principles of construction are, however, unchanged.

Although the evidence for construction has been drawn from both Wheelhouses 1 and 2, the reconstruction drawings show only one wheelhouse (Wheelhouse 1) under construction. This is simply a device to add clarity to the drawings, which should be regarded as essentially diagrammatic, and an aid to discussion, rather than an attempt to recreate any actual scene from the construction work at Cnip. Each drawing also combines a series of activities which would probably in reality have been sequential. The text should make clear, where known, the order in which these various activities were carried out.

A scale model of the wheelhouse constructed by Peter MacDonald, supported the structural viability of the reconstruction, although building up from the excavated floor plan produced a structure rather less symmetrical than that shown in the reconstruction drawings (MacDonald pers comm).

5.3 HOW TO BUILD A WHEELHOUSE?

5.3.1 STAGE 1 (ILL 5.1A)

1. The first stage in the process of construction, once the site had been selected, was presumably the gathering or quarrying of stones for the walls and other materials, such as timber for the roof. Stone must have been stacked ready for use at a convenient distance from the site. In the case of Cnip, there is no indication as to whether this material was newly gathered, or derived from an earlier settlement in the vicinity. Although there were querns present within various walls on the site, none were unambiguously primary to the original construction. Either way, the collection and transport of this material would have been a labour-intensive exercise, although not one requiring particular skill. The provision of elongated slabs for lintels (of which there were many in the finished building) may have required considerable ranging in search of suitable materials.

In recent centuries sleds pulled by the hardy local breed of small pony have been employed in Lewis to shift the large stones required for construction purposes (see, for example, plate 18 in MacDiarmid 1939), and similar methods may have been available during the Iron Age.

2. Once the building materials were in place, the process of construction would have begun with the excavation of a large circular pit to take the main body of the wheelhouse, and a linear trench to form the basis of the entrance passage. At Cnip, the site selected seems to have been a consolidated sand dune some distance back from the coast. The pit was positioned in such a way that the trench for the entrance passage cut through the north-west facing slope of the dune to enable the passage to exit at ground level. The pit was dug to a maximum depth of at least 1.5m. The

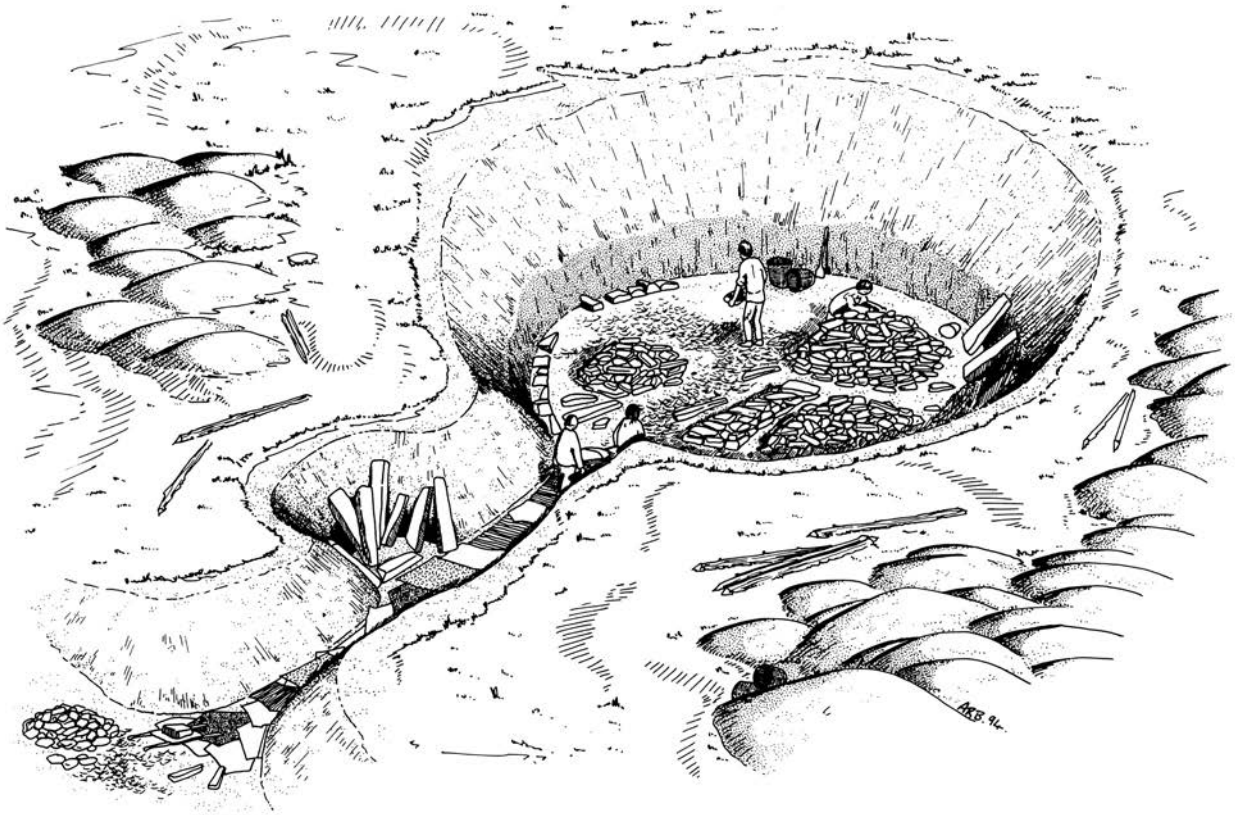

ILLUSTRATION 5.1(a)
Wheelhouse construction: Drawing One.

removal of sand would have been labour-intensive, but relatively straightforward, using simple spades of bone or metal, and baskets to remove the waste.

There are two ways in which this preparatory work could have been carried out. Version 1 (Ill 5.1a) is shown in the accompanying drawing. This shows the pit and trench being dug initially as 'rough-outs', since vertical sides of sand would have been prone to collapse. The straightening of the sand edges to take the dry-stone wall of the wheelhouse and its entrance passage would, according to this version of events, probably have come at a secondary stage.

Version 2 would have involved the excavation of sand and the construction of the lower wall being carried out together in a series of stages. Short lengths of pit or trench would have been dug and immediately lined with dry-stone walling to the top of the vertical sand face, before moving on to the next length. This seems to have been the technique employed for the rather later structures at Bostadh, on nearby Great Bernera (Tim Neighbour pers comm), and there is no obvious reason why it could not have been done at Cnip. Thus, for example, the entrance passage may have been built first by progressively cutting a series of short lengths of trench in towards the body of the dune, lining each length with stone, before proceeding to the next. The main pit for the wheelhouse could then have been dug out in similar piecemeal fashion, removing the sand along the already stone-lined entrance passage. This would have been considerably easier than working from above, as in Version 1, which would probably have created difficulties in the removal of spoil.

This alternative technique might explain the occasional near-straight joins running vertically down the dry-stone walls of various structures on the site, which do not appear to represent re-builds or multi-phase construction. It would also explain the peculiar features of the small cell in the entrance passage to Wheelhouse 2 which contained a well-built, low doorway with a weight-relieving void above. This seemed to have been built with the intention of giving

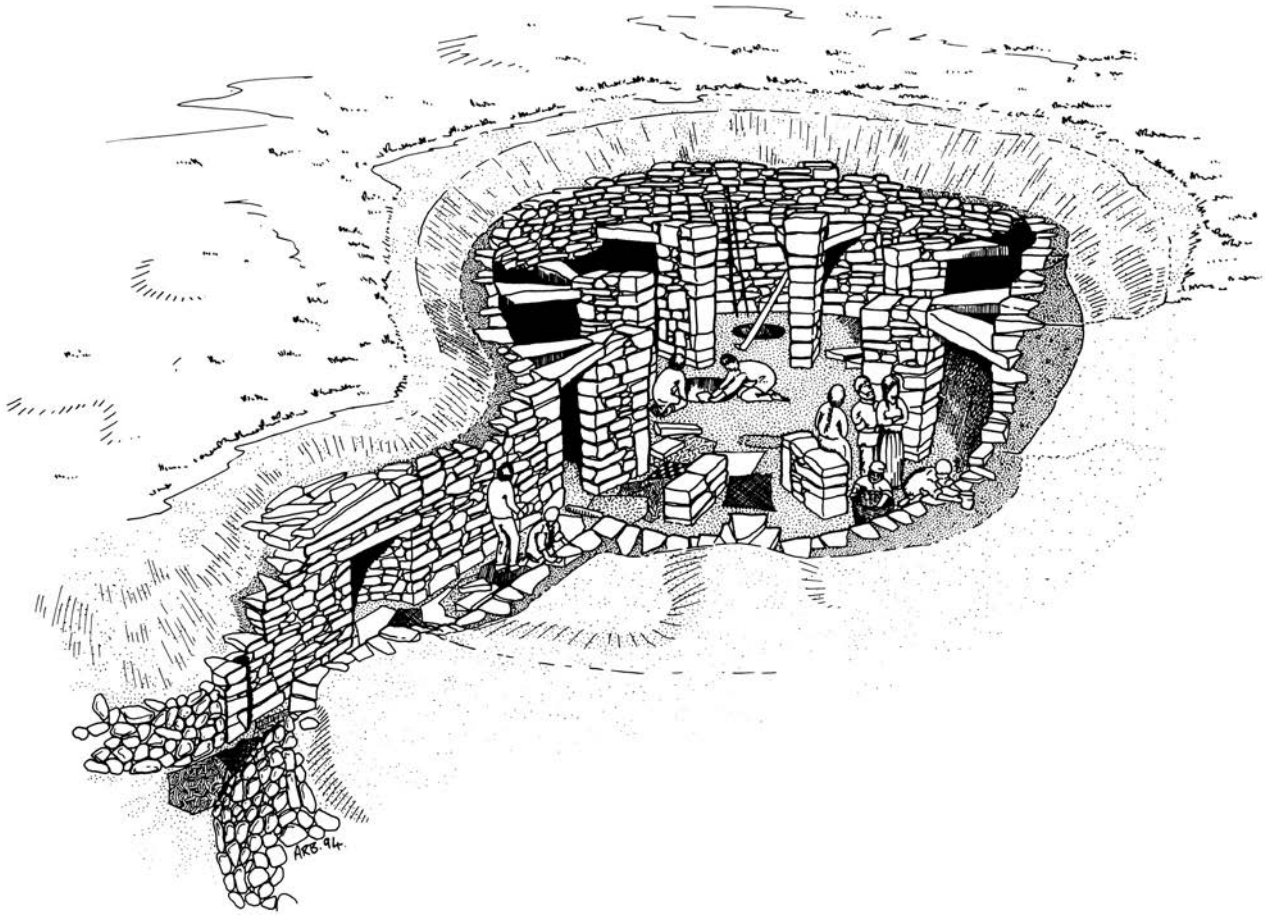

ILLUSTRATION 5.1(b)
Wheelhouse construction: Drawing Two.

access to a passage or cell behind, but the latter was never subsequently constructed. In the present context it is important to note that this 'false entrance' was built in its entirety before the proposed cell or passage was even dug out of the sand.

On balance, therefore, Version 2 is probably more likely to have been used at Cnip than the method shown in Version 1 (Ill 5.1a).

It is perhaps significant that Version 2 could have been achieved by a single skilled dry-stone mason, with non-specialist assistance for sand removal and manoeuvring of stone. Version 1, by contrast, would inevitably have been a rather frantic exercise which would have called for a larger skilled labour force if it were to be completed without major sand collapses. Indeed, assuming a method of construction similar to Version 1 at Sollas, Campbell stressed that the process of construction would have been carried out in 'a short space of time with a large workforce' (Campbell 1991, 126), and that it was, therefore, a 'communal effort' (ibid, 167). This is certainly true for Version 1, but clearly not the case for Version 2, although the less skilled parts of the operation, such as the initial stone gathering, might have been performed communally. The nature of the construction process is, therefore, important to our understanding of the nature of the societies that built and used wheelhouses, as it would seem to relate closely to the question of specialization of labour and the nature and organization of communal activity.

It is worth stressing that the confirmation of the use of Version 2 at Bostadh came from practical experiment, that is, the full-scale reconstruction of the cellular structures at Bostadh (Jim Crawford pers comm). Until someone tries to build a full-scale wheelhouse, using the original materials and technology, it is unlikely that we will have a true grasp of the complexities and practicalities involved.

5.3.2 STAGE 2 (ILL 5.1B)

1. Whichever method was favoured for the initial excavation, the dry-stone walls were clearly constructed reasonably rapidly against vertical sand sides of up to around 1.5m. Above this the sides of the sand pit sloped back at around 45 degrees, although the maximum total depth of the original pit is not clear due to later sand erosion. In Version 1, the stone could have been stacked in the centre of the roughly excavated pit ready for construction. In Version 2, it would have been brought in along the entrance passage as needed.

A section through the wall of Wheelhouse 2, just to the south of its entrance, shows the nature of this walling (Ill 5.2). Although only one stone in thickness, the wall widened as it rose, through the use of progressively larger stones. The inner face at this level appears to have been essentially vertical. No packing is visible in the section, although it is possible that some of the excavated clean sand was replaced to pack the stones securely. This is unlikely to be detectable archaeologically, but it could explain the position of the small stone, angled steeply downwards, to the rear of the wall, visible in the section (Ill 5.2). This must either have been forced into clean sand, or else held in a matrix of re-packed sand indistinguishable from the natural sand dune backing.

In reconstructing the later Iron Age house at Bostadh, Jim Crawford (pers comm) found that the liberal application of water, and the compression of the clean sand packed behind the walls, added immeasurably to the stability of the construction. This form of mortar used to secure the stones of the wall, set against a face of undisturbed clean sand, would be entirely consistent with the evidence in the wall section of Wheelhouse 2 at Cnip.

None of the walls contained any evidence for clay coatings or mortar such as have been sporadically reported from other wheelhouse sites.

During the construction of this initial, relatively low wall, a series of apparently votive deposits were inserted behind the dry-stone walling against the side of the sand dune. These have been mentioned briefly in Chapter 2 (see Section 2.3.2.2), and comprised cattle vertebrae, the head (not skull) of a great auk and a small but complete pot, all within the limited area (a length of some 1.2m) excavated. The large pit in the centre of Wheelhouse 2 also appears to have been excavated at this time, as a substantial stack of building stone had subsequently been placed over it. There may well be other such deposits behind the walls or beneath the floors of the unexcavated parts of the complex.

ILLUSTRATION 5.2
Section through the wall of Wheelhouse 2 (*c* 1.2m south of the main entrance).

When this initial, lower walling had been emplaced, the part-built structure would have been relatively stable. It would by now have appeared as a stone-lined circular pit and entrance passage up to 1.5m deep, set into a rather deeper hole in the sand dune. The depth would of course have varied around the circuit and along the entrance passage, depending on the surface contours of the original sand dune. At the entrance to Wheelhouse 1, and along the entrance passage, for example, it may have been as low as 0.5m at this stage (judging from the

height at which the stone piers were joined to the enclosing wall, see below, this section). Above the level of the walls, the sides of the cut into the sand dune would have sloped back at a shallower angle, to allow a degree of stability while the later stages of construction progressed.

As an aside, it is interesting that even in wheelhouses where the piers are generally not bonded to the enclosing wall, the piers at the entrance often are, eg Kilpheder in South Uist (Lethbridge 1952, fig 2) and Eilean Maleit in North Uist (Armit 1998). This may reflect a tendency for the entrance to face the lowest part of the sand dune, where the outer wall needs to be built only a few courses at most to stabilize the sides of the cut in the sand dune.

ILLUSTRATION 5.3
The marker stone for the 'missing pier' in Wheelhouse 2, seen from the interior.

2. Once this stage had been reached, quantities of stone seem to have been brought into the interior of the wheelhouse and stacked ready for the construction of the upper levels. The lower part of the passage of Wheelhouse 2, when excavated, was found to be entirely filled with a closely packed but unstructured deposit of building stone, including substantial slabs, such as would have been used for the construction of lintels and weight-bearing corbels. A further such stack was identified over the central part of the interior of Wheelhouse 2. The periphery of Wheelhouse 2, where actual construction of the upper levels would have taken place, was free of stone, presumably to provide a clear working area.

3. The next stage appears to have been the construction of the lower parts of the stone piers which divided the periphery of the building into a series of bays. Each was around 1.4m long, and as narrow as 0.2m wide at the base, which was often only one stone wide. The lower parts of these piers were free-standing, up to a height of between 0.5–1.5m. At this level the rear of each pier was linked to the enclosing wall by a pair of stone lintels (note that on the reconstruction drawing, the lintels are set rather too high).

The lintels tended to be large stones, some over 1m in length, but all could probably have been lifted into position by two or three people working from the interior of the building. They are unlikely to have required any specialized equipment for this stage of construction.

It seems that the intention at this stage was to build each of the piers up to the height at which it was joined to the enclosing wall, before embarking on the construction of the upper levels. This was the stage, however, at which the construction of Wheelhouse 2 was abandoned. Indeed at least one of the Wheelhouse 2 piers was apparently never built at all, its position being marked by a single boulder (Ill 5.3). Indeed, it is possible that the positions of all of the intended piers were marked in this way during the early stages of construction.

Once the lower parts of the piers had been built and linked to the enclosing wall, the structure would again have been relatively stable, and ready for what was probably the most demanding of all of the building stages: the construction of the stone superstructure.

5.3.3 STAGE 3 (ILL 5.4A)

1. Seen in plan view, once each pier had been connected to the enclosing wall, each individual bay was now effectively semi-enclosed by a 'horseshoe'

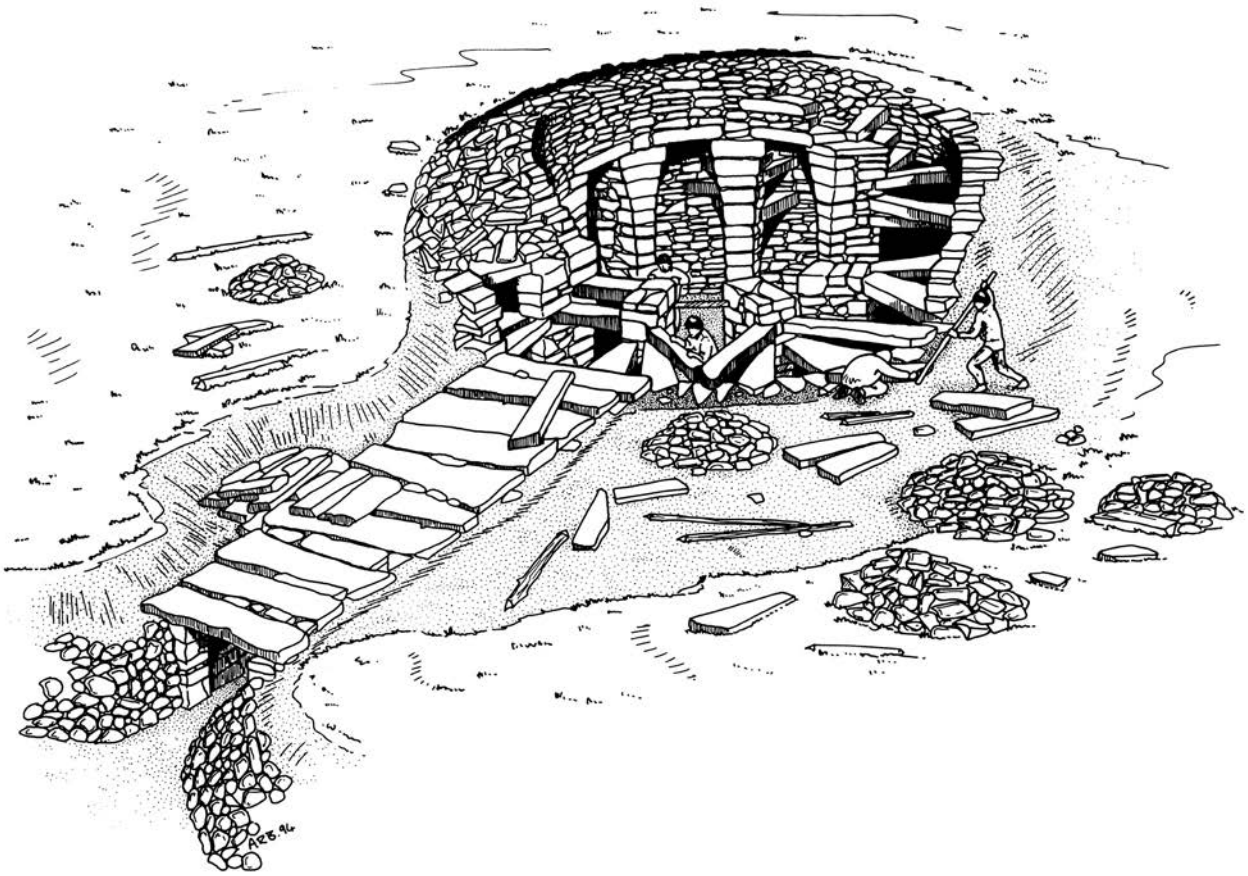

ILLUSTRATION 5.4(a)
Wheelhouse construction: Drawing Three.

of walling, open to the interior. The 'horseshoe' was formed by the piers, the lintels which linked the pier to the enclosing wall, and the enclosing wall itself.

The next stage in construction was to progressively raise the level of the walls around this 'horseshoe', each course over-sailing the one below, in order to gradually reduce the open area above the bay. This process was represented at Cnip by the two surviving corbelled bays (Bays 4 and 5), and can be reconstructed with reference to the other bays and piers which survived to expose various stages in the construction process. The stones used for corbelling were generally among the best on the site in terms of shape and size, but were still by no means ideal for this intricacy of the construction. The stones which formed the interior of the walls and roofs were of all shapes and sizes, and generally used only to provide sufficient weight to hold the structure together.

John Barber provides a useful discussion of the principles of corbelling in the context of Neolithic chambered tombs in Orkney (Barber 1992), and many of the same principles can be applied to wheelhouse construction. In order to maintain the stability of the corbelled bay roofs as they rose, it would have been necessary to build up the walls behind and between them in tandem with the corbelling itself. It was the weight of stone in this wall-backing and core which held the corbels in place, with the mass of the sand dune absorbing the weight of this stone superstructure through the piers and the outer wall. As the stability of each bay roof depended on the existence of the adjoining bays, it seems probable that the mason would have had to work in a more or less continuous circuit, raising each bay only a couple of courses before moving around to the next one.

By this stage many of the stones could not have been emplaced by anyone working from the floor of the structure. It is possible that the corbelling was set in place from above, working from the top of the enclosing wall, or else that wooden scaffolding was

used. An alternative, and perhaps more attractive possibility, is that mounds of sand were used to provide support for the rising piers and corbelling. Vast quantities of sand were certainly readily available from the initial excavation of the pit to contain the wheelhouse; mounds and ramps could have been established at various points as required during construction. Similar use was made of sand quarried from the reconstructed house at Bostadh (Jim Crawford pers comm) thus avoiding the need for any timber scaffolding or bracing.

Following the principles expounded by Barber for megalithic corbelling (Barber 1992) it seems probable that the corbelling was built up in such a way that it would have been stable at each level. Clearly, this stage of construction was one which required great familiarity with dry-stone construction and consummate skill in its execution.

2. Eventually, the open area above each bay was reduced sufficiently to be capped by lintels, creating a ring of conjoined and individually corbelled bays around an open central area. The walling would probably have been taken several courses above the level of this stone capping in order that the weight of stone could produce a sufficient downward pressure to keep the roofs of the corbelled bays in place.

This elaborate stone superstructure would have risen substantially above the level of the initial pit dug to receive the wheelhouse (contra the impression from Ill 5.4a), although the extent to which this was the case is impossible to reconstruct at Cnip due to later soil erosion around the wall tops. Above the vertical, stone-lined cut which formed its lower courses, the enclosing wall increased in thickness and was packed behind with midden material apparently brought from off-site.

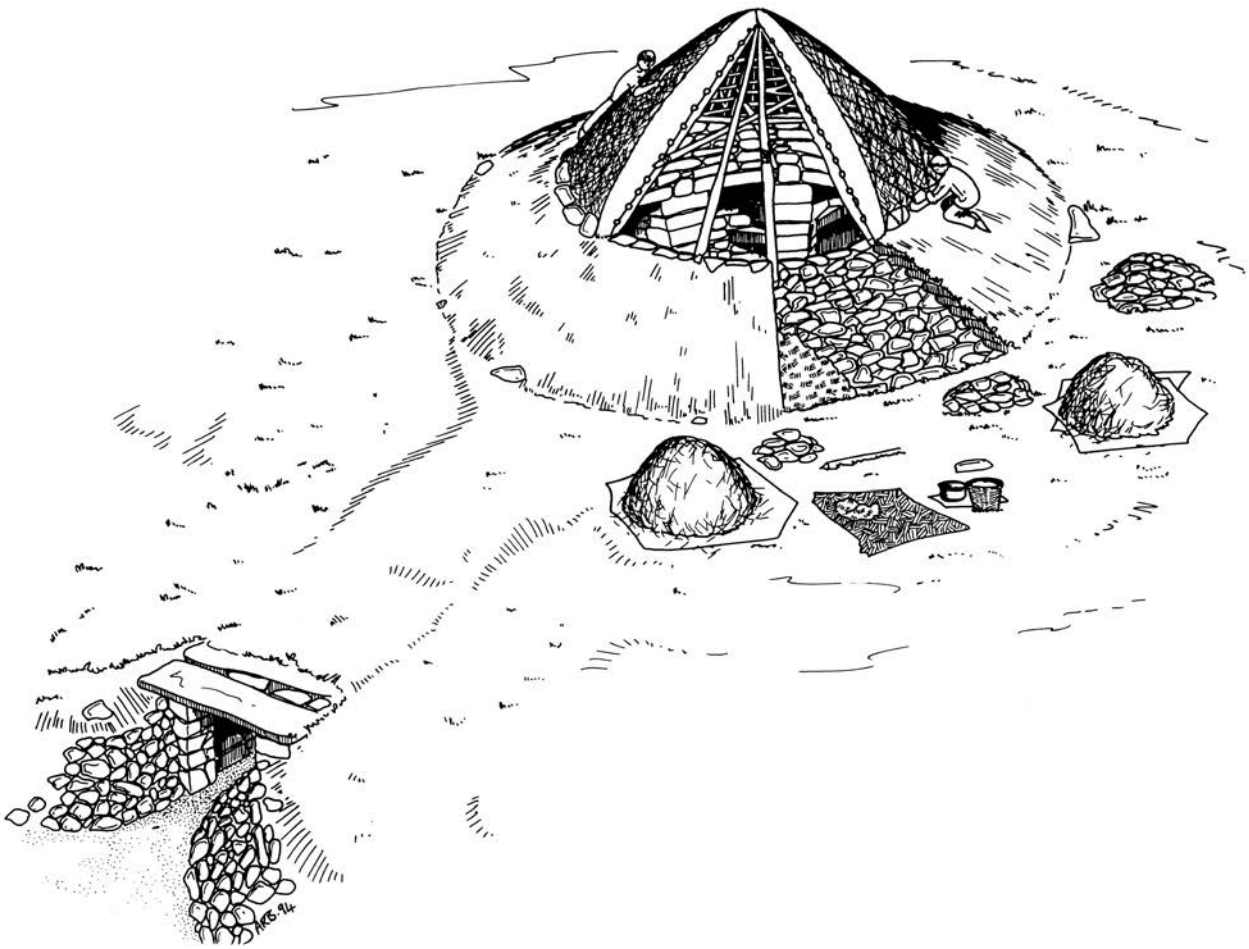

ILLUSTRATION 5.4(b)
Wheelhouse construction: Drawing Four.

The upper sides of the sand pit were angled back to receive this widened wall and its packing, although it would not have been possible to record this feature in section without the partial dismantling of Wheelhouse 1. The wall-packing material, excavated only partially in the upper levels of the Wheelhouse 1 wall, contained quantities of metal-working debris entirely uncharacteristic of the occupation debris found within the structures on the site. This material was presumably derived from occupation or midden deposits associated with a settlement or specialist activity area nearby. The prehistoric metal-working site of Cnip 2/3, just along the beach from the wheelhouse complex, is an obvious candidate (Armit & Dunwell 1992).

One element of this superstructure which remains vague is the form of the fronts of the bays at the level of closure. The open side of the bays should have made them inherently unstable by creating a major weak point within the structure of each corbelled segment. The frontal parts of Bays 4 and 5 had fallen away before excavation and were highly unstable (Ill 5.5). Piers D and F showed clear signs of angling inwards in their upper levels, but this could have been due to instability and movement.

If the inner ends of the piers in their original form rose vertically, corbelling only laterally, to be capped with a lintel at their inner end, this would seem to create a situation whereby the weight pressures from the stone corbels over the back and sides of the bay were not counteracted by any corresponding pressure from the front (ie from the interior of the building). The implication would appear to be that the bays should have collapsed forwards into the interior.

ILLUSTRATION 5.5
Bays 4 and 5, Wheelhouse 1: the frontal portions of the bays had not survived (although a few stones which had been preserved had fallen away before this photograph could be taken and are visible in Ill 1.5).The internal deposits shown are elements of the post-abandonment sand infill of Structure 8.

Clearly this did not happen, but unfortunately the missing frontal portions of the surviving bays make it impossible to tell how this apparent flaw was overcome. It is possible that the outward thrust of the timber central roof (see Section 5.3.4) was important in counter-acting the inward thrust of the corbelled bays, but this would presumably have made the whole structure highly unstable during periods of re-roofing and roof maintenance. Again, it is likely that, with a structural form so alien to modern constructional techniques, only practical experiment will clarify the issues and illuminate likely solutions.

3. The final act in this stage of construction was probably to render the roofs of the bays water-tight. The careful arrangement of the upper stones to cast off water into the surrounding dune would probably have been complemented by some form of capping or caulking, perhaps of clay, although there is little direct evidence to support this, other than a series of individually thin 'midden' deposits recorded in section above the surviving corbelled bays. Clay sealing layers some 0.1–0.05m thick were used to render the wall-heads of Hebridean blackhouses water-tight into recent times (Walker & MacGregor 1996, 4).

4. The entrance passage is shown on Ill 5.4a as lintelled, although in fact there is no evidence, either positive or negative, for this from Cnip itself. It is possible that the passage could have been covered using a timber-framed roof. Given its narrow dimensions, however, a capping of stone lintels, perhaps on a partly corbelled upper wall, would have been relatively easily achievable and in keeping with the rest of the building's stone architecture. The lintels would probably have been rather smaller than those shown on Drawing 3.

5.3.4 STAGE 4 (ILL 5.4B)

1. So far, there has been archaeological evidence from Cnip to support each stage in the reconstruction. This is not the case for the roofing of the central area, although the stone superstructure arrived at as a result of the above stages limits the possibilities available. The internal deposits within Wheelhouse 1 clearly demonstrate that it was a roofed building throughout its occupation.

There is no indication whatsoever of the collapse of any stone roofing into the central area, and it is extremely unlikely that stone corbelling would have been used to roof such an expanse. The evidence for stone corbelling over the central area of wheelhouses is restricted to a rather speculative early drawing by Captain Thomas of a wheelhouse at Usinish in South Uist (Thomas 1870). The main difficulty with this drawing is the elevation which shows a stone corbelled roof over the central area as well as over the individual bays.

Although Lindsay Scott took this reconstruction drawing at face value (1948), justifiably claiming that Thomas' experience as a surveyor made him hardly likely to invent such features, the evidence suggests otherwise. The state of preservation at Usinish, even when Thomas visited, was such that had such a roof ever existed, it could not have been observable at that time. Thomas was used to recording the beehive sheilings of the Hebrides (cf Thomas 1857) and therefore quite likely to invoke a similar roofing method to interpret such an unfamiliar structural form as a wheelhouse. The remains of corbelling in the bays would have encouraged such a reconstruction. All in all, it seems highly improbable that Usinish, or any other wheelhouse, ever had an interior spanned by a stone corbelled roof.

As with other excavated wheelhouses, therefore, it is probable that the central area at Cnip was covered by a timber-framed conical roof, of the type familiar from Iron Age roundhouses throughout the British Isles (although we should not forget the possible use of whale bone for roofing purposes). A good deal of work has been done on the structural reconstruction of Iron Age timber roundhouses, in southern Britain in particular, and the work of Peter Reynolds in reconstructing the Pimperne roundhouse has been especially instructive. Stressing that a roundhouse is, in essence, a cone supported by a cylinder, Reynolds has proposed that:

> The essential requirement of a cone set upon a cylinder in building terms is for the cylinder to be in itself a powerful and complete entity. The upper rim of the cylinder must be itself level, whatever the contours of the ground may be like. (Reynolds 1993, 94)

Wheelhouse 1 at Cnip, as has been discussed, seems to fulfil this basic requirement. Despite its revetted construction into an undulating sand-hill, the completed stone superstructure presented a level ring of masonry, supported by the radial piers and by an enclosing wall held in place by the natural sand accumulations behind it. It was clearly an extremely elaborate cylinder but it seems to have been quite capable of supporting a conical timber roof.

2. The roof would have been supported by a series of rafters which could have rested on, or been bedded into, the upper part of the ring of masonry

which formed the roofs of the individual bays. Peter MacDonald has suggested that the principal rafters would have been set into open sockets in the upper masonry to restrict rotation of the roof (pers comm). A ring beam would have been required around the base of the principal rafters. An alternative might have been to attach the ends of the rafters to a timber wall-plate resting on the upper masonry, thus spreading the weight of the roof rather than concentrating it at specific points at the base of each principal rafter. This technique was used successfully in the reconstruction of the Conderton roundhouse in Worcestershire (Reynolds 1982, 195).

The rafters would presumably have had to have been positioned above the piers to avoid increasing the pressure over potential weak-points such as the open fronts of the bays. As has been suggested above (see Section 5.3.3), the weight directed downwards and outwards from these timbers would have helped to hold the corbelled bay roofs in place. With a pitch of around 45 degrees, the main rafters need have been only some 2.8m in maximum length. This method of construction, therefore, was well suited to communities where high quality structural timber was a scarce resource.

From the interior, the apex of the roof would have risen around 5m above the central hearth in the primary phase of occupation of the wheelhouse. The constructional techniques do not appear to allow for an upper floor of any kind, and thus the interior would have taken on a markedly monumental aspect, with a roof rising higher even than the width of the central area.

3. The roof would have been thatched at an optimum pitch of around 45 degrees (for the reasons identified by Reynolds (1982, 180) in reconstructing the Pimperne roundhouse at Butser Farm). If we invoke techniques common in Hebridean vernacular architecture of more recent centuries, we might expect that the finished roof would have appeared as a slightly domed or flattened cone (as indicated in Ill 5.4b), which is better suited to the escape of smoke than a pure conical roof.

The thatching material may have been heather, although Holden (1998) has described the complex range of materials and techniques that may have been employed. Bruce Walker has suggested (pers comm) that, prior to the growth of the local kelp industry, seaweed would have been a common thatching material in the Hebrides, and one presumably readily available to the inhabitants of Cnip.

It is also probable, although it cannot be either supported or contradicted on the basis of the evidence from Cnip, that the roof had a covering of turf under the thatch, reflecting the form of roofing later found in Hebridean blackhouses like that at Arnol (Walker & MacGregor 1996).

It is most unlikely that the roof, whether turfed or not, would have had a smoke-hole. Experiments at Butser Farm have shown that, in the absence of a smoke-hole, smoke rises gently and percolates through the thatch, keeping the roof dry and free of vermin and insects (Reynolds 1982, 188). Apart from the rather obvious disadvantage of letting in the copious Hebridean rain, a smoke-hole would have created serious dangers of sparks from the central hearth igniting the thatch. The gap of some 5m between floor and apex of the roof in Wheelhouse 1 is such that the interior was probably not unduly smoky, at least no more so than a nineteenth-century blackhouse, although it would undoubtedly have been dark and airless. As in the later Hebridean blackhouses, meat and fish could have been dried and smoked by simply hanging them from the roof timbers in the smoky upper reaches of the roof space (cf Walker & MacGregor 1996, 27).

The reconstruction at Bostadh incorporates a series of small vents at the base of the thatched roof, which could be opened or closed by moving blocks of turf. As well as letting a modicum of light into the house, these vents also act to provide some circulation of air, although the majority of the smoke from the central hearth still rises into the roof space. Hebridean blackhouses incorporated similar vents for similar purposes, and there seems no reason to suppose that this simple expedient was not also adopted in wheelhouse architecture. It cannot, however, be demonstrated archaeologically.

4. Finally the thatch would probably have been held in place with a series of ropes weighted by stones. This method was common in the Hebrides until relatively recently when the use of netting became more common for this purpose.

5. It is unclear whether the thatch would have carried down over the roofs of the bays. If it did not, the bays may have required some form of slanted turf capping to prevent the percolation of water from the roof into the interior of the building. The reconstruction at Bostadh has demonstrated that turf could be relatively easily secured even on slopes of around 50 degrees, so it would have been quite possible to have carried the turf roof covering over the sloping backs of the corbelled bays at Cnip.

Assuming that Wheelhouses 1 and 2 at Cnip were intended to be roofed contemporaneously, it seems most likely that the thatch would not have been brought down over the bay roofs, as insufficient room would seem to have been available between the two roofs. The issue is probably not resolvable on the present evidence but, whatever the precise mechanism, water must somehow have been directed into the body of the sand dune.

6. The final appearance of the structure would probably have been quite unimposing; little more than a conical roof, and perhaps a metre or so of upper walls, projecting above the natural sand dunes.

5.4 HOW TYPICAL IS CNIP?

Although the wheelhouses at Cnip are among the smallest in the Western Isles, with mean internal diameters of around 7.5m, they are nonetheless strikingly similar on plan to the largest Hebridean wheelhouses, such as Sollas, with an internal diameter if around 11m (Campbell 1991). Indeed all of the wheelhouses within the Western Isles are remarkably close in overall proportion and design, suggesting similar modes of construction and similar patterns of use (Armit 1992).

The principal observable distinctions among excavated examples relate to the nature of pier construction (ie whether the lower parts of the radial piers are bonded to the enclosing wall, or separated, as at Cnip, by a gap or 'aisle') and to whether the building is revetted or free-standing. Data on wheelhouse structural features were collated in Armit 1992, Chapter 11, and will not be rehearsed in detail here. Nonetheless, it is worth outlining some key points relating specifically to the Hebridean examples.

5.4.1 PIERS: BONDED AND UNBONDED

In the majority of Hebridean wheelhouses, as at Cnip, the lower parts of the radial stone piers are not bonded into the surrounding wall, but are linked at various heights by paired lintels, leaving a gap or 'aisle' around the periphery of the structure. It is not clear to what degree this aisle was used for movement around the building. In some cases it was so low as to be virtually impassable, at least by the time at which deposits had begun to accumulate within the structure. At Cnip, the aisles of Wheelhouse 1 seem to have gone out of use by the start of Phase 2 and were in some cases blocked with rough walling (as was common on other wheelhouse sites, eg Sollas (Campbell 1991), A' Cheardach Bheag (Fairhurst 1971), and Allt Chrisal, T17 (SEARCH 1998)). It has been suggested above (see Section 5.3.2) that the gaps between the pier and enclosing wall were essentially a constructional device to enable the completion of the enclosing wall to the surrounding ground level or thereabouts, before work began on the piers. This may in some cases account for the variability in the height at which the piers are joined to the enclosing wall. From a structural point of view the aisles would appear to be serious weak points within the structure and indeed they often display indications of cracking or collapse.

Two excavated Hebridean wheelhouses appear to have been built with piers which were bonded into the outer wall from the outset; Foshigarry A (Beveridge 1930) and Bac Mhic Connain (Beveridge 1931), both in North Uist. At Foshigarry there appears to have been a progression from wheelhouses with unbonded piers to one with piers which were bonded into the enclosing wall from ground level (cf Armit 1992, Chapter 11). A similar progression is even more obvious at Jarlshof in Shetland (Hamilton 1956). At A' Cheardach Mhor, in South Uist (Young & Richardson 1960), the piers abutted the outer wall but were not bonded in, suggesting perhaps a transitional design.

While there are indications of a chronological change from unbonded to bonded piers, however, this transition need not have been uniform across Atlantic Scotland, and may reflect local expediency. The adoption of bonded piers need not have changed the construction process to any great extent: it is easy to see how the lower parts of the piers could have been built in tandem with the lower parts of the enclosing wall without necessarily leaving the sand-face exposed for any significantly greater length of time. In terms of the finished 'product' it would seem that wheelhouses with bonded piers, built according to the methods set out above, should have been more stable than those with unbonded piers.

That being the case, however, the initial use of unbonded piers seems even more peculiar, particularly since they appear to have been a deliberate design choice rather than a necessary by-product of wheelhouse construction. It might have been expected that masons sufficiently expert in dry-stone construction to build something as elaborate as a wheelhouse, would have been well aware of the likely pitfalls involved in leaving such glaring stress points in the structure.

It has been suggested that the original design of wheelhouses reflects a translation into stone of conventional timber roundhouse design and that the piers, therefore represent the timber posts, and were thus kept separate from the enclosing wall (cf Hamilton 1956). Whilst this idea is superficially attractive, the long history of dry-stone construction in the Hebrides prior to the adoption of wheelhouses perhaps makes it seem a little unlikely that such an apparently unstable form would be adopted without modification.

If on the other hand access between the bays had been desired, this function of the aisles seems quickly to have been abandoned as most excavated wheelhouses have produced evidence for the early blocking of the bays. Similarly, evidence for the blocking of bays from the central area of the wheelhouse (which would of course necessitate access through the aisles) has generally been shown to be spurious where closely examined (cf Campbell 1991 for Sollas, contra my own earlier discussion of this phenomenon (1992, 71) which pre-dated publication of Sollas, and re-excavation of Eilean Maleit (Armit 1998).).

On present evidence, then, it appears that the wheelhouse 'aisles' were a deliberate design choice, perhaps reflecting a combination of aesthetic and/or symbolic factors, but which do not seem to have been particularly important for movement around the structure. Instead, the bays seem to have been entered primarily (and perhaps only) via the central area. Generally, as at Cnip, the aisles were blocked or obstructed long before the wheelhouse itself went out of use, and on some (perhaps the latest) wheelhouses they were omitted from the design altogether. The implications for the use of space within wheelhouses caused by the postulated change from unbonded to bonded piers are discussed in Chapter 7.

5.4.2 REVETTED VERSUS FREE-STANDING CONSTRUCTION

Wheelhouses sited on the Hebridean machair appear, as at Cnip, to be uniformly revetted into pre-existing sand-hills. Others, such as Garry Iochdrach (Beveridge 1931) and Eilean Maleit in North Uist (Beveridge 1911; Armit 1998), are revetted into the remains of former structures, including Atlantic roundhouses. Those which are free-standing, Tigh Talamhanta (Young 1952) and Allt Chrisal, T17, in Barra (SEARCH 1998) and Clettraval in North Uist (Scott 1948), occupy inland locations where options for creating a revetted structure were limited.

While revetting into a suitable site was apparently the preferred technique, then, the builders of wheelhouses clearly did not allow themselves to be restricted by such locational factors. Away from the machair and the ruins of former buildings, it seems to have been preferable to build a free-standing structure, rather than to excavate into ill-drained or otherwise unsuitable ground.

There is no particular reason why the same structural principles could not have been used in these free-standing wheelhouses, as were used at Cnip. Instead of using the natural sand dune, or the collapsed masonry of ruined structure, to bear the weight of the corbelling and timber roof, the free-standing enclosing wall would have performed essentially the same function.

This may have placed greater constraints on the potential size of the finished structures: free-standing wheelhouses tend to be rather smaller on average than the revetted examples (cf Armit 1992), and Allt Chrisal, T17, is the smallest of all recorded Hebridean wheelhouses with an internal diameter of only 6.3m (SEARCH 1998). It should be noted, however, that there is considerable overlap between the two groups, and that the free-standing wheelhouses at Tigh Talamhanta and Clettraval are larger than those excavated at Cnip. The free-standing wheelhouses all have unbonded piers.

In conclusion, therefore, it appears that the methods of construction proposed for Cnip have broad applicability to Hebridean wheelhouses as a whole, although the free-standing examples, of which three have been excavated, would have required the addition of a weight-bearing enclosing wall to replace the sand-hill or masonry mass used by the revetted examples.

5.5 MATERIAL RESOURCES

The principal resources required for the construction of the Cnip wheelhouses would have been a large quantity of stone, including a significant number of relatively high-quality lintels, and a supply of timber, thatch and rope for roofing.

The timber requirements of a wheelhouse would have been relatively modest (even discounting the possible use of whale bone to provide roof supports), particularly when compared to the roof and floor requirements of Atlantic roundhouses. The main structural timbers would have comprised a likely maximum of eight principal and eight secondary

rafters, each around 2.8m long, and a ring beam formed of eight timbers each around 1.8m long (59.2m of timber total). The remainder of the roof frame would have been more akin to wattle-work in terms of the size of timbers used.

It is difficult to estimate the amount of thatch required, particularly since it is unclear how far over the roofed bays the thatch would have extended, and doubly so since the nature of the thatching material is itself unknown. Reynolds has suggested a usual thatch depth of 0.3m for straw (1982, 189). Given a central timber roof area of approximately 17.6m^2, a layer of 0.3m would equate to a minimum of 5.3m^3 of thatch, if straw or an analogous material was used. Using figures based on Reynolds' reconstruction of the Conderton roundhouses (ibid) this would give a dry roof weight of approximately three tonnes (figures based on extrapolations of roof weights by Dave Lynn pers comm). Again using figures for Iron Age arable production derived from Butser Farm this might equate to the annual yield of around 1.5ha of arable (ibid, 189), or perhaps rather more given the harsher environmental regime of the islands. Analogy with the roof of the reconstructed house at Bostadh, however, suggests that somewhere around one tonne of heather and two tonnes of turf may have been required to roof the Cnip wheelhouse (Jim Crawford pers comm), had these materials been used.

The life-span of the thatch would also play a role in determining how onerous the task of replacement and maintenance was for the household. Blackhouse thatch, for example, was traditionally taken down annually to spread on the potato crop as a valued fertilizer. As with the timber requirement, the design of the wheelhouse seems to have kept the requirement for thatch to a minimum, and the amounts needed would have been significantly less than for Atlantic roundhouses, or even for the much later Hebridean blackhouses.

Overall, the material resources required to construct a wheelhouse do not seem particularly great when compared to Atlantic roundhouses or even the more apparently modest blackhouses of the past two centuries. What wheelhouses did require in abundance, however, was skill in dry-stone construction.

5.6 SKILL AND LABOUR REQUIREMENTS

It is possible to envisage the unskilled parts of wheelhouse construction, such as the gathering and transport of stone, and the initial digging out of sand, as being carried out by a large section of the community. The most highly skilled parts of the job, such as the corbelling of the bays and raising of the piers, however, were a different matter. These were immensely skilful operations with tremendous potential for disaster: both structural collapse and serious injury. It seems almost inconceivable that they could have been carried out by anyone who did not spend a great deal of their time working with dry-stone masonry. Thus the dry-stone masonry element of wheelhouse construction would almost certainly have required a specialist mason, albeit with unskilled or semi-skilled assistance.

It is interesting to note, by way of comparison, that the large timber roundhouses characteristic of the Iron Age in southern England 'can only have been built by few people working for a long time' rather than by large teams of communal labour (Reynolds 1982, 106). Indeed Reynolds has suggested that a team of only two people was required even for very large roundhouses like that at Pimperne (Harding, Blake & Reynolds 1993), with larger groups becoming involved only during daubing and the preparation of straw for thatch (and presumably for assembling materials prior to construction).

It is less clear whether there would have been any need for specialist or semi-specialist thatchers. In many parts of Scotland in recent centuries, the repair and maintenance of thatch at least were carried out by tenant farmers without recourse to specialist assistance (cf Holden 1998, 5) and thatching itself was seen as a communal activity (Walker & MacGregor 1996, 11). Similarly the timber components of the central roof do not seem to have necessitated specialist work. The joinery need not have been complicated and the roof spans were rather limited. As Barber (1992) has suggested for chambered tombs, the principles of wheelhouse construction must have been thoroughly embedded within society, or at least within the knowledge of a group of specialist or semi-specialist dry-stone masons.

5.7 THE MONUMENTAL HOME

The final structure which resulted from the various structural operations described above, while inconspicuous and unobtrusive from outside, would have been extremely impressive when experienced from the interior. Visitors crouching along the entrance passage could hardly have failed to be impressed by the high soaring space which met them as they entered

the central area; a near symmetrical forest of graceful stone piers rising towards a roof space which had its apex more than 5m above the central hearth.

Despite being among the smallest wheelhouses, Wheelhouse 1 at Cnip was still far grander in design and calculated in its visual impact than could have conceivably been necessary to provide the necessities of warmth and shelter. It was a monumental building and must therefore have had made a considerable social statement. The social context of this monumental domestic architecture will be discussed further below (Chapter 7).