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Approaches to the interpretation of the excavated remains of buildings

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10. SUBSTRUCTURE TO SUPERSTRUCTURE

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SUMMARY: This paper considers briefly the implications of stake-holes and post-holes with special reference to their structural and constructional qualities, and those factors which may affect their archaeological form. The case studies of two specific reconstructions of Iron Age round-houses are presented. The first is a post- and stake-built structure based on an excavation at Pimperne Down, Dorset. The second is a stone-built structure based on the excavation of Conderton Camp on Bredon Hill, Worcs. In both studies, emphasis is placed on the problems of evaluating archaeological data, and the implications of those data in terms of material resources and the potential of woodland management as an integral element of the pre-historic agricultural economy.

The presentation of a paper at a conference and the subsequent publication of that paper are necessarily distinct enterprises. The wide-ranging and provocative manipulation of illustrative material and the spoken word allow for greater flexibility, fulfilling the requirements of a forum where argument and debate can focus attention on the grey areas, and lead to more positive appreciation of the problems involved. The written paper, on the other hand, while it can still provoke discussion, enters into a corpus of material which will become a source of reference if not positive substantiation. One's responsibilities, therefore, are significantly changed. Consequently, two specific cases of house construction are described here in slightly more detail than in the conference presentation, which also covered several other constructions. Even this more concentrated contribution is still but a discursive treatment of a complex topic. A full publication of the constructions built by the author is in preparation.

In any discussion of the reconstruction of prehistoric buildings, or indeed any other structure, one is essentially dealing with conjecture and hypothesis. In a sense the word reconstruction is wrongly used; reconstitution would, perchance, be better. Any building which is based on archaeological evidence, and such evidence that we have from the classical authorities, is bound to be an exercise of the imagination. Whether that exercise is justified depends on the motives of the builders and what problems they are attempting to solve. The author's basic premise at the Ancient Farm, and earlier at the Avoncroft Museum of Buildings, Bromsgrove, is not to satisfy public curiosity as to what a house looked like, how it was used or how it fitted into a domestic economy. It is rather to examine the problems posed by the pattern of post- and stake-holes revealed by excavation, and to try to focus attention on the nature of those features as three-dimensional entities which inevitably contained some kind of support or post. That support or post in turn may have sustained the weight of a structure, a roof and the other components of a building.

In a sense post- and stake-holes themselves are structures carefully manufactured to take a particular kind of post or stake. The post-hole and stake-hole revealed by excavation is most often in its final functional phase and bears little resemblance to its original state. Unfortunately this factor is one of the most neglected in considering these features. During the life of a building much happens to the interface between structural element and surrounding soil or rock. This is especially so in terms of animal and insect activity around the base of a post (*q.v.* below). Consequently one must consider the simple mechanics of putting a post into the ground. The basic premise must always be that the post-hole itself is tailored for the post. This assumes the logical objective of the minimum space between the post and the structure of the post-hole, thus ensuring that the post will be firmly lodged. Even the method of packing a post with stones, giving rise in excavation to the post pipe, depends on the minimum interstitial space between post and wall of post-hole. This principle can be observed in a modern context, in the standard method of erecting telegraph poles using a power-driven mechanical borer which screws out a precise hole, and in the use of special narrow curved-bladed post-holing spades. Interestingly, the borer, and the post-holding spade used with the scissor shovel (a device consisting of two narrow opposed shovels hinged together) allow the creation of post-holes significantly deeper than an arm's length. Effectively one can only clear the debris from a hole as far as one can reach. Thus for really large timbers the post pit into which a man can descend was a necessity.

Excavation techniques have steadily improved, and post-pipes, shadow impressions of posts, basal impressions of posts, and collapsed packing material are now generally recorded. All aid our understanding of the principles behind the construction of post-holes, the nature and sizes of the posts, and their location in the hole. Fortunately there has been a move away from the consideration of a post or stake-hole solely as a potential repository for artefactual or carbonised material. This is not to deny the importance of such material, but rather to assert that the fundamental value must be the physical structure of the hole itself. It is the lack of general comprehension of the role of the post-hole which provides justification for empirical research. For example, it is rather facile to suggest that a circle of stake-holes represents a house when knowledge of the effects of the weight and therefore the stress of a house roof on the ground evidence is entirely lacking. Having built many structures, experience has repeatedly shown major stress points to occur, invariably at points of moment, which affect the verticality of a post. This in turn serves to alter and enlarge the post-hole along the line of pressure, and has two basic effects. These are, primarily, the compaction of the upper regions of the supporting soil/rock and, unusually, the undermining of the lower regions of the supporting soil/rock against the line of stress, effectively using the outer lip of the post-hole as a fulcrum point. This occurs more frequently in a packed post-hole than a tailored one, and represents an important variable to be sought by excavators. While this second effect is unusual in a contained structure, it is much more common in the case of a fence set at right angles to a prevailing wind, its fulfilment being engendered by the rocking motion involved and the more regular maintenance of the posts and, therefore, post-holes, from the ground surface.

Stake-holes similarly are not as straight-forward as one might expect. Their manufacture can be divided into two main systems. The simplest to understand is the 'driven stake', when a pointed stake is hammered into the ground with a beetle or mallet. However, this is perhaps not as simple as it may seem. Several fundamental questions need to be raised concerning shock resistance and fissility of various types of wood, given known diameters and lengths, against penetration into different rock types. Nearly all the hardwoods traditionally used as stakes, for example, oak (*Quercus sp.*) and ash (*Fraxinus sp.*), split very easily indeed; the exception is elm (*Ulmus sp.*). The chestnut (*Castanea sp.*) stake is a later introduction. This information could have implications for the evaluation of subsoil rock solution/erosion on the chalk lands of southern England. If one knew the parameters of probable depths for stakes driven into chalk, then by direct comparison with excavated prehistoric examples it should be possible, even with the number of variables involved, to determine whether there has been a significant loss of material by subsoil erosion.

The second and more common method of creating a stake-hole is to prepare it by 'barring a preliminary hole' slightly smaller than the stake. This is now usually achieved with an iron bar or iron-tipped spike. Given the preponderance of stake-holes, there is every possibility that this system was used in prehistory. A timber tipped with a 'handaxe' would be an admirable tool for the purpose. Very simple trials have been carried out by the author using a crudely-fashioned flint axe mounted on the end of a stake to create the primary hole. The nature of the 'bar' was such that the edges of the axe protruded beyond its diameter and left clearly defined grooves in the prepared hole. These were not entirely obliterated by the driving of the fixed stake; subsequent excavation of the hole clearly revealed the grooves. Ordinarily, of course, the stake destroys the primary hole by filling it entirely, and further compacting the 'walls' of the hole to allow its passage. Another regular feature of this system is that the bar frequently leaves evidence of its use with a defined point at the base of the stake-hole. In using a replica hand axe, a clear cross groove remained at the base of the preliminary hole.

This preamble, devoted to a cursory examination of post- and stake-holes, is intended simply to underline that such features are representative of structures, and are not just archaeological devices. Their presence on a site had a significance above ground; this is not just an indulgence in joining up the dots. Once one accepts the structural nature of these features and applies to them the stress-bearing role for which they were designed, the implication, function and meaning of sites may become more readily comprehensible. A combination of close scrutiny of standing structures (especially fences which have a technology all of their own), empirical trials and even more precise excavation is clearly required.

This introduction would not be complete without reference to the effect of 'fur and feather' on stake- and post-holes, and indeed in the creation of post-holes and pits which never were in the

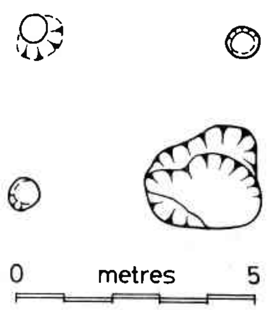


FIG 10.1 A four-post structure? In fact the archaeological remains of a chicken pen. The three post-holes have a common depth of 0.2m; the pit exceeds 0.5m at its deepest point

constructional sense. The classic example always to be borne in mind is the effect of chickens, whether restricted in a pen or allowed to range freely within a farmstead. The former case, as observed and recorded by the author (Fig 10.1), is quite dramatic. Scratching about for food scraps and the creation of dustbaths are well-known gallinaceous activities. In terms of basic archaeology, a four-post structure can have a ground plan of three post-holes plus post-pit and variations on that theme, the structure being tied together by its component parts resting on the ground rather than relying on it for support. Similarly, quite deep pits are regularly created in pens, and given abandonment and destruction of the structures the fill of these contemporary features should not differ greatly. In the case of free-ranging chickens, and for the sake of authenticity one is here quoting the habits of Indian Red Jungle Fowl and Old English Game Fowl (arguably the domestic poultry of the prehistoric period), the creation of dust-baths within house doorways is the norm, especially in those opening to the south-east (as did the majority of Iron Age houses). Such dust-baths can be quite respectable depressions, having shape and form which inspire alternative and remarkable interpretations. Their attentions to the bases of free-standing posts within a house similarly increase the size of the post-hole, and lead one to conjecture on the timing of so called 'packing material'. In practical terms it is quite possible to pack a post several times during its life without the post having actually been moved, removed, replaced or modified.

In this connection rodents rather than chickens are much more likely to 'disturb' the physical entity of the post-hole. This is especially true of mice, both house and field, and the vole. The natural habits of the vole are thought to have changed radically from the prehistoric period to the present day (pers. comm. P.A. Jewell). There is, as yet, no conclusive evidence for the presence of the rat in this country prior to the Roman period. One quite remarkable effect of the rat, whose role in prehistory might well have been filled by the vole, has been recorded by the author. On this occasion a post-built structure was altered to a ring gully structure by rats tunnelling under the wall and living in the space afforded by the wattle work. Field and house mice have regularly been observed building nests in the upper fill of post-holes, and have reduced chalk packing blocks to powder, creating considerable enlargements in the process. The vole has not affected the test structures simply because it has been ousted from its conjectured original habitat. Fur and feather therefore have a significance, quite considerable in certain cases, in our consideration of post- and stake-holes. They should not be discounted as an unimportant variable.

In concluding this section, mention must be made of fungus and insect attack on timbers. While such attack does not necessarily have a direct bearing on the physical evidence of the hole, its effect is important in assessing functional life spans. The nature of the closed structures examined to date, and it must be emphasised that experience is short-term in relation to the likely life of these structures, is such that insect and fungus attack is observed to be minimal. External use is altogether different, and will be the subject of another paper. It seems that once the roof is clad and the structure is used functionally, all fungal infestation is severely arrested if not completely stopped. Virtually no insect activity has been observed apart from the occasional wood wasp which affected the timber before its utilisation in the structure. Similarly, worm infestation of timber is ordinarily associated with the pre-utilisation period, usually before the bark has been stripped.

The primary object of this paper is to present detailed case studies of two specific round-house constructions. The cases are chosen to give as great a contrast as possible, and neither study is exhaustive. In both, the objective is to examine the three-dimensional nature of the structures which is implied by the archaeological evidence. There are arguments for and against the practical reconstruction of prehistoric structures, with the negative being in the ascendancy, on the assumption that there are no secrets inherent in such structures given the abundance of ethnographic parallels on the one hand and the plethora of imaginative line drawings on the other. The negative approach is the most comfortable, since there is virtually no way of testing the imaginative creation short of building, and the creation is designed specifically to deny this process. It is remarkable, on close examination, how little detail is offered in most reconstruction drawings. Timbers represented by single lines comfortably cross other lines, indicating major load-bearing joints but without elucidation of the nature of the joint. Smoke is shown billowing cheerfully from holes in the apex of conical thatched roofs without any detailed reference to complex engineering design, let alone any self-respecting thatcher who fears weather penetration. But then, where else could the smoke gain egress? Indeed the normal, the negative, approach, is neatly summed up in the accepted nomenclature of 'hut', defined in the *Oxford English Dictionary* as 'small mean house of rude construction'. Iron Age 'huts' by implication allow us an insight into a rude mean peasant economy. Yet the facts, the archaeological data, the classical references, clearly indicate the reverse. Thus the physical reconstructions described below, while never assuming authenticity in that they are most probably ruder and meaner than the originals which stood on the same data, are a positive attempt to examine the basic technology and manipulation of materials of the Iron Age in terms of buildings. In one sense they differ radically from any line drawing in that they are both validated hypotheses. The structures actually stood as practical, space-containing, buildings. The most positive contribution of this empirical approach is simply to focus attention on the archaeological data with especial note being made of the missing data. In other words, by selecting two particularly good examples and remaining specific in application, fine detail which may be present but unobserved in other similar cases can be isolated and sought in future excavations. To be content with one's comprehension of the archaeological data is to cease thinking about it.

THE PIMPERNE HOUSE

This example is based directly on the limited area excavation carried out by Prof. D.W. Harding at Pimperne Down, Dorset (publication forthcoming). The author is greatly indebted to him for providing all the available data for study, his support and encouragement throughout, and for answering the inevitable multitude of uncomfortable post-excavation questions. The basic data and building plan extracted from that data can be seen in Fig 10.2. There is clear evidence of two large round-houses, each comprising a stake outer wall and inner post ring, the two structures sharing common porch post-holes in the south-east quadrant. The artefactual evidence suggested a continuous occupation of this area for approximately 450-500 years. Unfortunately it was impossible to determine which house was the earlier, since only two of the stake-holes in the western quadrant actually cut other stake-holes. What is most remarkable is that only two were thus affected; this is a persuasive argument in favour of deliberate destruction or dismantling and immediate rebuilding. The builders of the second structure were either aware of the precise location of the timbers of the first building or amazingly fortunate. From this one could further hypothesise that the porch structure, or at least its major components, were common to both structures.

The real problem in 'paper reconstruction' lay in the scatter of shallow scoops beyond the close-set perimeter of stake-holes. These had even been surmised to comprise a third wall element, despite their infrequency. Initially they were discounted in the planning of the structure, the argument resting on the clarity of the stake-holes. Primarily, the close juxtaposition of the latter suggested a wattle or basketwork wall, further supported by daub, fragments of which were recovered in the excavation.

The fundamental principle of building a circular structure is to transfer the weight thrust exerted by the roof into circular form around and around the building. This is achieved by building vertical walls in a circle and setting a conical roof on the walls and any intermediate support system, for example an inner ring of posts. Any break in the vertical wall is a significant weak point in the design. A house without a door, however, is a pointless exercise. In the case of the Pimperne house there seemed to be clear evidence of two principal doorways, the porch itself and a rear door set in the north-eastern quadrant, but not quite diametrically opposed to the porch. The former, *c* 3m wide, represents the major weakness, exacerbated by two gaps in the stake wall on either side of the inner porch uprights. The weakness presented by the rear door is simply solved by the use of a lintel across the bounding stakes or door frame uprights. Such a lintel is sufficient to maintain the strength of the circle. The porch itself is, by definition, the most massive element of the whole structure, leading one to the hypothesis that the necessary counter-thrust is simply provided by inert weight. Since the porch is in

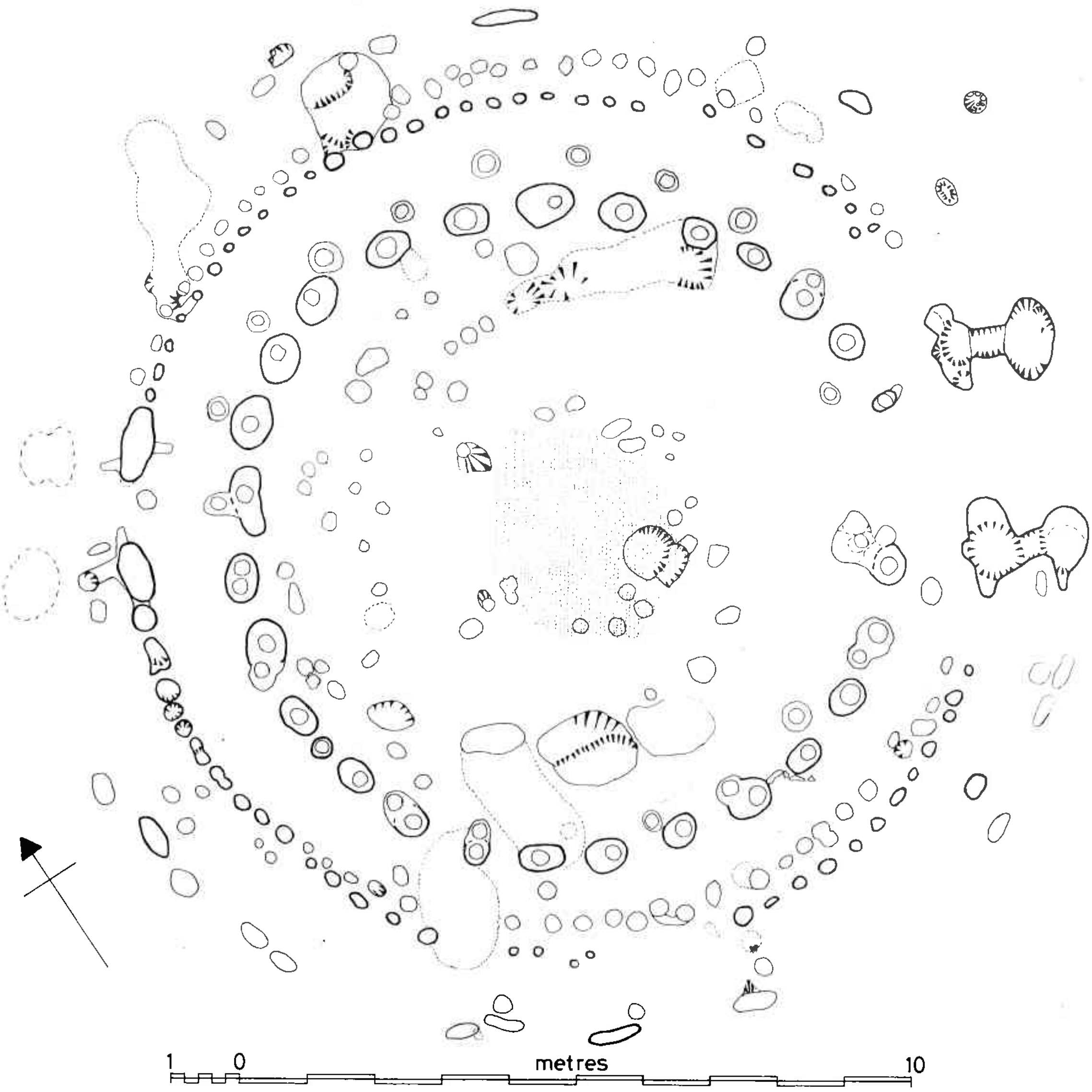


FIG 10.2 Plan of the excavated site at Pimperne Down, Dorset. The postholes used in the reconstruction are shown in heavier outline

width exactly twice its depth, the logical inference is a pair of doors which open inwards, flat against the side walls of the porch. The two gaps on either side of the porch presented an almost insurmountable difficulty. Given previous experience of construction, it was well appreciated that even the wattle work would cause the end stakes to 'spring' outward. The method of attaching these stakes to the inner porch was critically important.

An answer lay in archaeological evidence from a group of similar houses near Pimperne, at Longbridge Deverill Cow Down (pers. comm. relayed by Prof. Harding from Dr. J. Hawkes). The evidence comprised a groove between the end stake and the porch post in question. This groove was tentatively thought of as a timber slot, implying a frame filling the space. In the reconstruction this device was successfully employed, but the base timber was set on the ground rather than into it. However, this provision of a frame on either side of the porch begs the question of their function. The only logical explanation so far raised, and in fact expedited in the construction, is that the spaces were subsidiary doors. This depends on the premise that the great doors of the porch would not necessarily be the normal access-egress point. The implication, of course, lies in the potential status of such a structure. The side doors could be for normal traffic, paired for symmetry of appearance, and the great doors for special occasions. A very simple alternative is that the structure was a great barn and the doors were barn doors allowing loaded carts to be driven inside, side doors in this case replacing the 'small door in a great door' of later barn-building tradition. The argument against this evaluation is the presence of a hearth, oven, and general domestic debris, in addition to the scatter of interior post-holes which might represent screens or partitions in the house.

The construction process itself is unremarkable. All the basic evidence was replicated exactly, with the major *caveat* expressed in the preliminary discussion (p.174) that the preparation of post-holes and stake-holes was for primary use. All the upright timbers were oak (*Quercus sp.*). The average depth of post-holes was a mere 0.38m, and of stake-holes 0.20m.

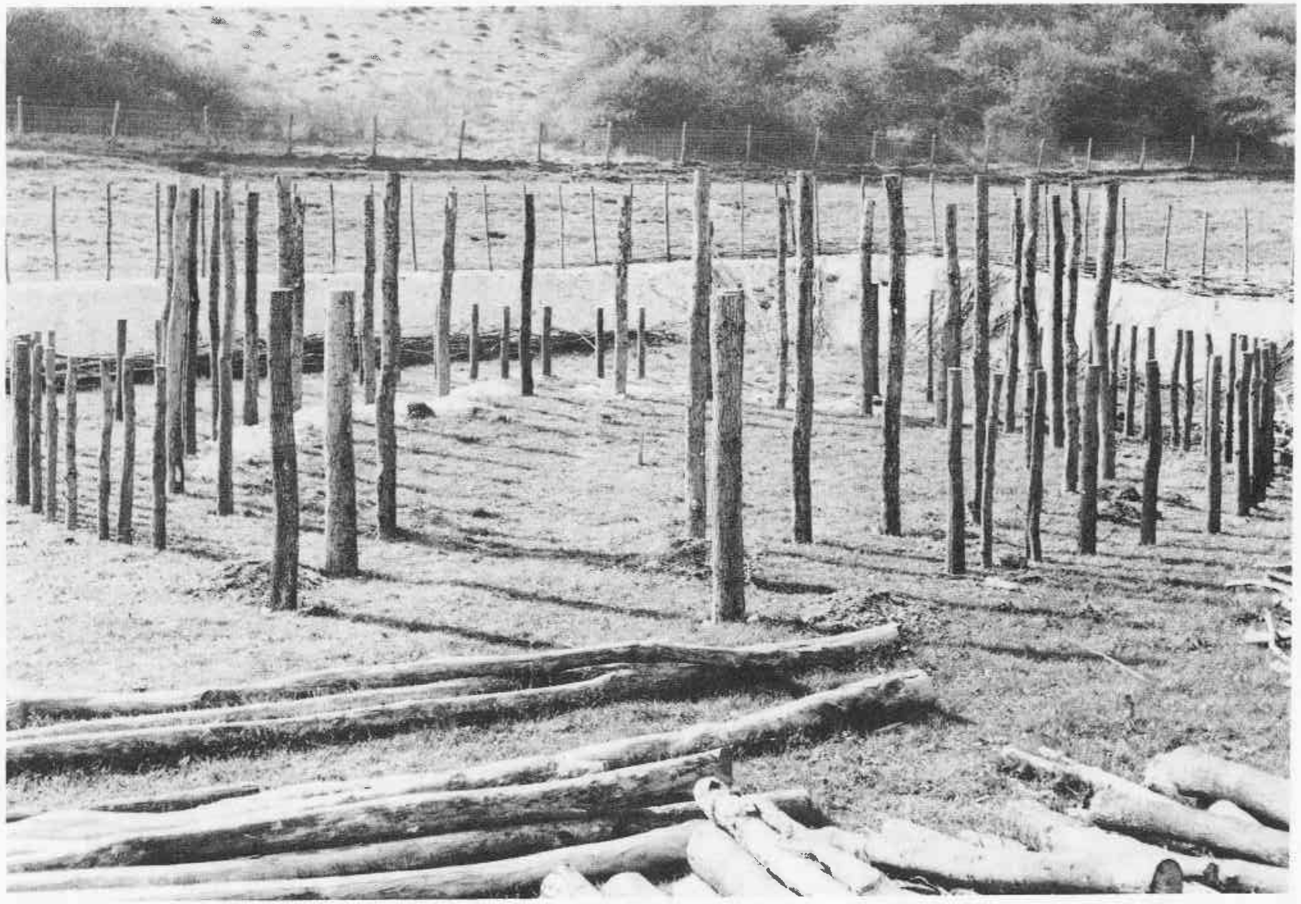
Given the principle of round-house construction depending upon the completed circle and the clearly-defined ring of post-holes, as opposed to the interrupted stake-hole outer wall, it was judged that this ring was the major support element and basic transfer point of roof weight thrust. Consequently, a continuous ring of timber was set in the horizontal plane on top of these posts, the method of attachment being mortice and tenon joints or rather stub tenons. Individual lengths of the ring were scarf-jointed and wooden pegged.

The major conjecture of the whole enterprise, as of almost any construction of this kind, lay in the wall height. On this occasion an educated guess of 1.50m was chosen for no other reason than comfortable access to the interior wall for a (modern) man of average height. As will be shown, this proved to be an inspired decision; much depends upon it. The roof pitch, which dictates the height of the inner ring of posts, is equally critical but much easier to determine. There is little doubt but that the normal roof covering was thatch, and this itself provides close parameters of pitch for waterproof cover, ranging from a minimum of 45^{o} to a maximum of 55^{o}. Further considerations of pressure on a point of moment as expressed by a diagonal upon a vertical returning least thrust at 45^{o}, with maxima at 22.5^{o} and 67.5^{o}, eliminate any extreme. In terms of economy a pitch of 45^{o} yields the minimum requirement of materials to provide a weatherproof cover, which is a totally persuasive argument in itself. Thus there are three basic reasons for selecting a pitch of 45^{o}, the practical, the mathematical and the economic.

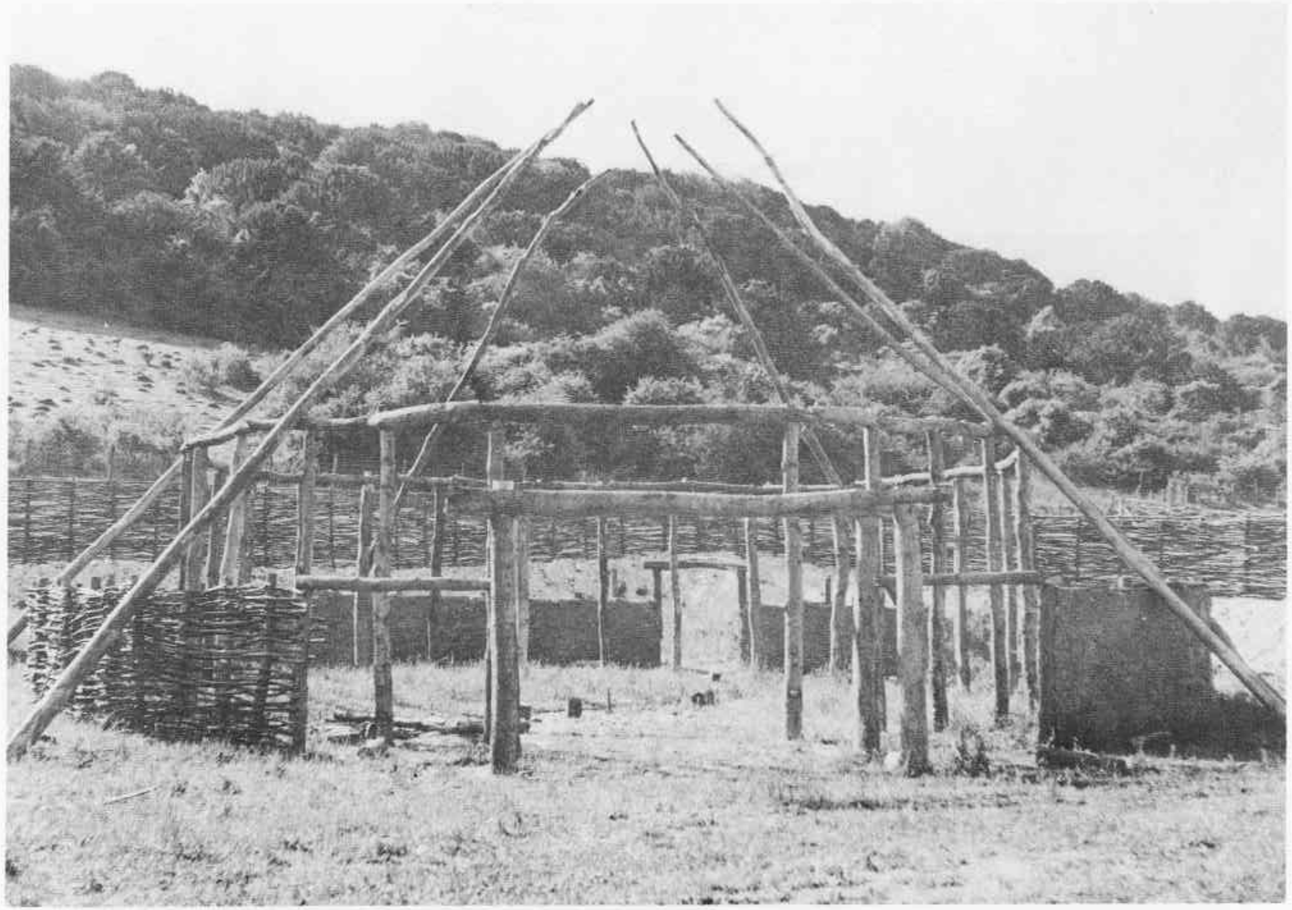
Having selected a wall height of 1.50m, the remainder of the geometry of the structure is straightforward. The phases of construction can be clearly observed in Pls 10.1-4. However, the crucial phase of the construction, indeed the whole justification for the undertaking, is represented in Pl 10.2. The logic of the construction process is relatively easy to understand. Once the wall and inner ring are *in situ*, the rafters are placed in position in pairs diametrically opposed and equidistant from the succeeding pair. Logic and practice, however, frequently do not accord, usually because the former is not thoroughly processed. Such was the case when the first rafter was raised on the framework. All the necessary pythagorean calculations had been executed with the omission of the consideration of weight distribution along the length of the rafter, and the fulcrum point expressed by the inner ring. In spite of prepared joinery the rafter was still effectively top heavy. It was at this point that the previously-disregarded features referred to above suddenly came into focus. If one extends a line from the ring to the wall top set at 1.50m and continues it to the ground surface, the point of contact exactly correlates with the strange elongated curved scoops. The rafter resting on the ground surface, wall top and inner ring is stable, the fulcrum being some 0.50m below the ring on the slant height. Careful examination of the archaeological data suggested that six such slots or features belonged to each structure, and consequently the hypothesis is raised that there were six major rafters whose butts initially penetrated the ground surface. The requirement for principal and subsidiary rafters is beyond question in a roof of this magnitude, simply because of the nature of timber and the location of the fulcrum point. In effect the length of unsupported timber will sag under its own weight and, therefore, in order to maintain the building line of the roof the rafters must be stressed apart. This stress point for timber roofs of all periods, including the present, is one third down the slant height from the apex. Such a point was selected for this structure. The resultant hexagonal ring beam with cross braces was attached to the original six rafters and formed the support for all the subsidiary rafters which form the actual apex of the roof (Pl 10.5). The purpose of the oddly-shaped slots, however, became apparent on completion of the ring beam and prior to the insertion of the subsidiary rafters.

During the construction process the ring beam inevitably moved off centre and required readjustment. It is critical that the cone of the roof is exactly centred. In order to achieve this, the butts of the major rafters were moved at ground level; a movement of 0.20m at this point led to almost a full metre movement at the height of the ring. Any movement effectively replicated the original evidence even to the extent of disparity of result. Some rafter butts, for example, required less adjustment than others. The substantiation of an educated guess in fixing the wall height is seen, therefore, to be elegantly conclusive as a validated hypothesis. Once the structure is completed principal rafters butting onto the ground are redundant. In fact they have not yet been removed, since they are used firstly to determine if there is any movement in the structure, all load bearing surfaces having been removed, and secondly to monitor any incidence of rising damp in them. In due course they will be removed to the level of the subsidiary rafters at the eave of the roof. The reverse argument can thus be advanced for determining wall height: Given similar trace evidence the distance between the feature and the outer wall is the same as the wall height.

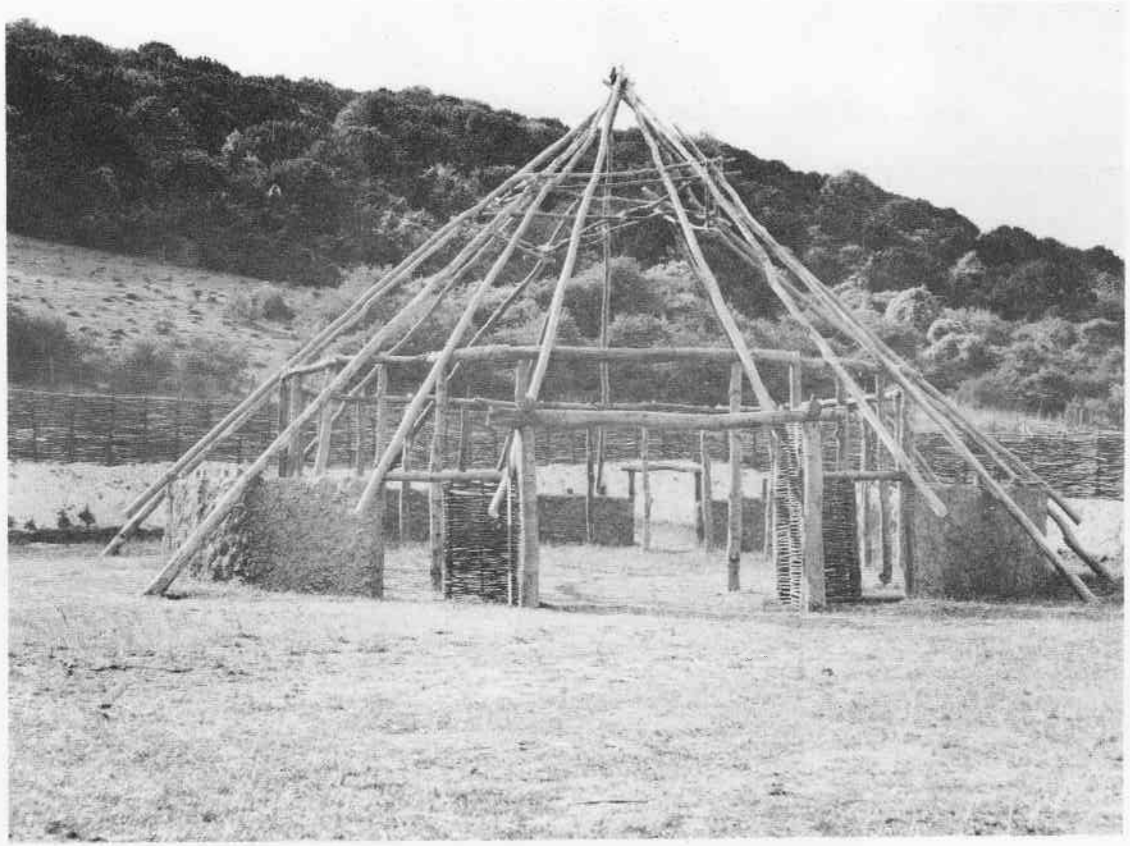
The completed structure is represented in Pl 10.6. The porch, of necessity, has a different roof line but still observing the critical 45^{0} minimum angle, and allowing the opposition of 'dead' counter weight to the 'live' thrust of the roof. Since the completion of the building in July 1977, it has not moved significantly, certainly not as much as 10mm. Naturally the whole structure flexes in extreme conditions; were it not to do so, collapse would be imminent. Thus there is in existence a replication of a prehistoric structure which at least accords with the archaeological evidence. Careful observation of its lifespan should afford considerable insight into the nature of such archaeological evidence in terms of its functional life.



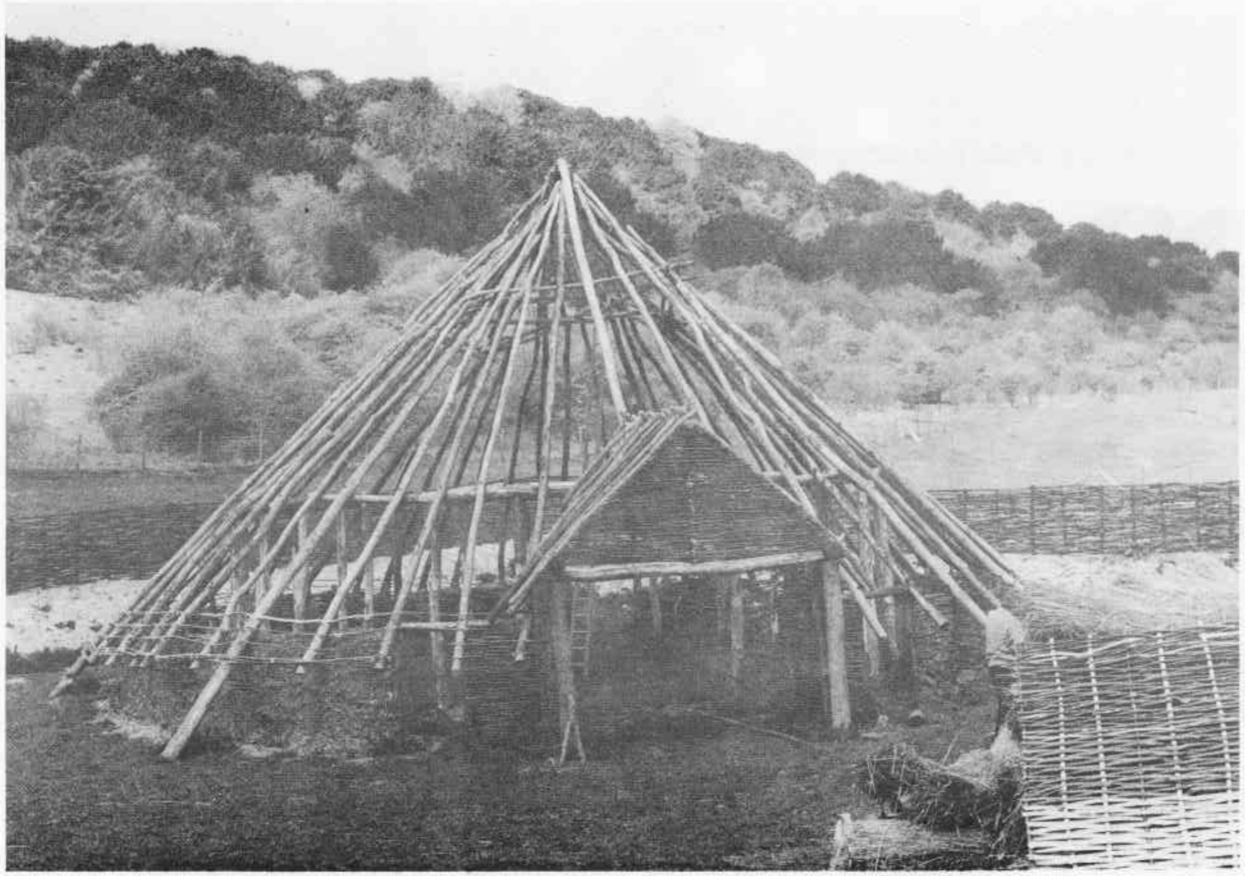
PL 10.1 The Pimperne House: The archaeology in three dimensions



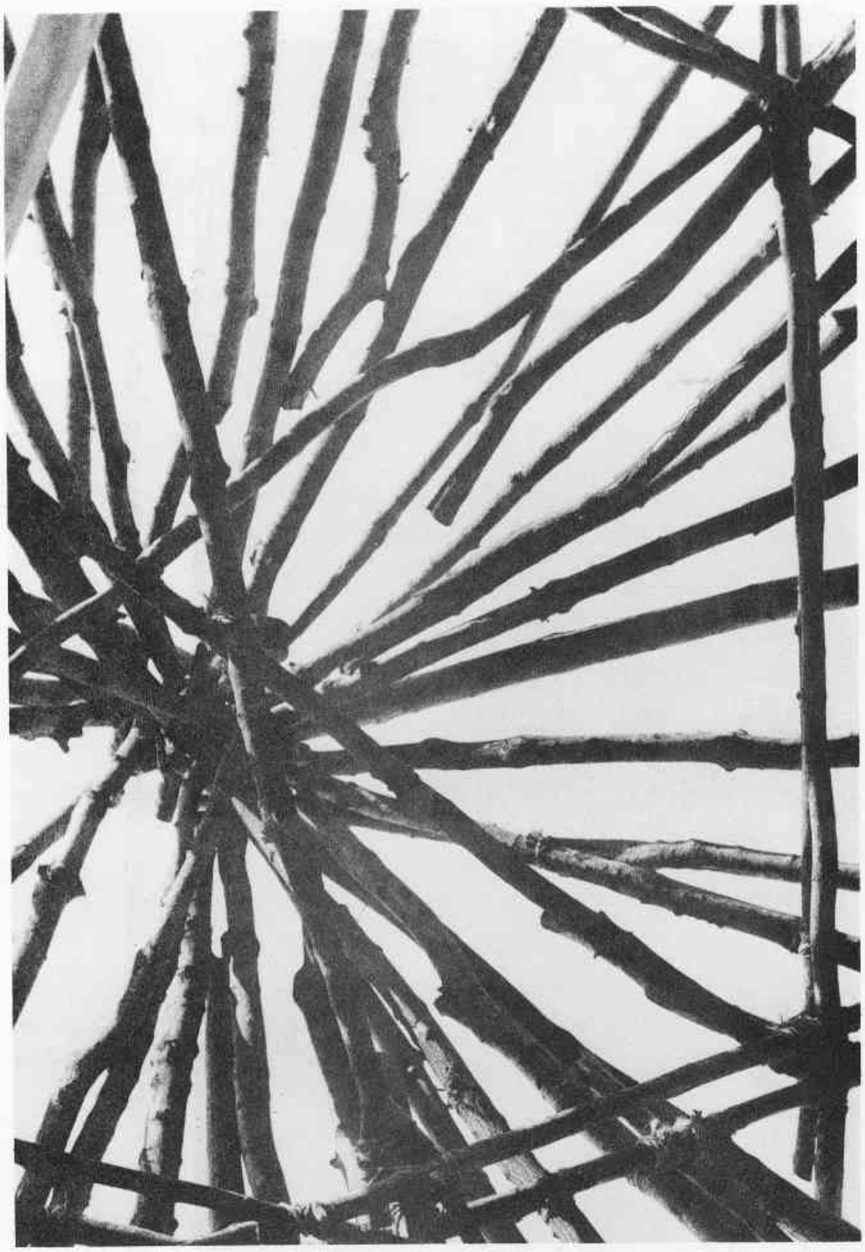
PL 10.2 The Pimperne House: The six principal rafters in position



PL 10.3 The Pimperne House: Ring beam and apex



PL 10.4 The Pimperne House: Timber superstructure complete



PL 10.5 The Pimperne House: Interior view of ring beam and apex

PL 10.6 The Pimperne House completed; diameter 12.5m

Drawn reconstructions of prehistoric houses have traditionally shown smoke trickling out of a hole in the apex of the conical thatched roof (eg. Sorell 1981, 36). Smoke is, of course, a useful device to obscure the uninterpretable details of a reconstruction, but this aspect had always been assumed to be a necessity. The alternative was a vision of prehistoric man with rheumy eyes groping about his smoke-filled home. It was in the Conderton house (*q.v.* below) that this myth was finally exploded. In the Pimperne house, the evidence clearly indicated a central hearth, and this evidence has been replicated. Indeed a fire has been burned inside the house for an average of some 180 days each year since completion. To date the ash, none of which has been removed, is only 0.20m deep. The smoke from the fire rapidly spirals in a predictable thermal pattern into the roof space and percolates out through the straw thatch. It keeps the insects and rodents, anxious prospective settlers in thatched roofs, at bay, and also serves to dry out the straw from the inside outwards. Were there to be a hole in the roof apex, even allowing the complex technology to create it, the thermal spiral would be accelerated and sparks would inevitably reach roof height at the first appreciable draught. The conflagration which would ensue would be similar to that of a simple blast furnace. Indeed vandalism on a previous smaller structure at Avoncroft Museum of Buildings (*q.v.* below) demonstrated how swiftly total conflagration is achieved, in terms of seconds rather than minutes. In addition, given such a hole and location of hearth, the normal British climate would hardly encourage culinary creation on the one hand, and inhibition of timber and straw degradation on the other.

Whatever debate there may be over the details - the joinery, the binding agency, the precise positioning of the ring beam, the manner of thatching - the volume the structure contains and the materials with which it is contained are logically accurate. There are obvious facilities for the insertion of a first floor, based on the horizontal plate surmounting the inner ring of posts. Such a floor would not only increase the available floor area, but also strengthen the structure by striking chords across the circle. In this way the function of the structure would be considerably enhanced without further physical support being likely to penetrate the 'archaeological surface'. Similarly, there can be little argument about the quantities of materials necessary for the construction. Their physical collection would have been no mean undertaking, and says much for the resources which were normally exploited. In the case of clay required for the manufacture of daub there is no doubt that considerable tonnages were moved from natural deposits to building locations devoid of them. It is but a small step to postulate a number of simple service industries including a builder's yard and timber merchant, clay purveyors and haulage contractors. It is extremely unlikely that such building was the result of the potential inhabitants' solitary efforts, or indeed the oft-hypothesised communal enterprise. One contribution that the structure makes is to focus attention on these potential subsidiary industries, and the need to seek ways of either denying them or isolating them with archaeological evidence. Their supposition is born of necessity rather than the hollow proposition requiring impossible disproof.

The implications of this structure are many and varied. The depend upon a guarded technology, which at best is a tenuous argument, at worst one substantiated by ethnological taboos.

The quantity of timber required for the completion of the structure is perhaps the most startling discovery. Over two hundred trees were required and this, it must be emphasised, was a minimum. The implication, however, is concerned with the nature of the trees. All the upright timbers were oak, with the inner ring of load-bearing posts averaging forty years old, the porch posts sixty years. The trees themselves needed to be tight-grained and straight for at least 3.0m before the first branch. Such trees are the normal product of careful management allowing the right distance between the growing crop before the long term harvest. These emotive terms are used quite deliberately, in that the requirement of timber within the normal Iron Age farmstead was necessarily huge. Even in terms of stakes for fences deliberate timber management was required. This management is in contrast to normal hazel coppicing, and presumably willow pollarding, which began in the Neolithic, since a greater time-span is required before maturation of the timber. One is effectively postulating timber management as a major component of the overall agricultural economy. Given the intensity of settlement pattern now known to have obtained and the growth cycle of timber, one can further postulate that such management was designed to provide for the next generation. Perchance it was born of peace and stability. It is a topic which requires careful analysis of pollen spectra, in that heavily-wooded valleys, normally imagined to have been undeveloped landscapes, may well have been carefully controlled and organised ones.

Finally, the most sobering implication must relate to the post-holes and stake-holes. In contrast to the original site, the topsoil at the Demonstration Area of the Ancient Farm averages some 0.30m deep. None of the post-holes or stake-holes of this extremely large structure penetrate significantly into bedrock chalk. One suspects that after a single ploughing, and certainly after five seasons of normal modern agricultural activity, no trace of its presence would survive. All that might exist beyond a scatter of sherds would be a soil area with a potentially enhanced susceptability to induced magnetism.

THE CONDERTON HOUSE

This reconstruction is offered as a direct contrast to the Pimperne house. It explores the problems of stone-built structures which necessarily combine the utilisation of stone, timber and thatch. As an exercise it has great relevance to many areas of prehistoric Britain where building in stone was the traditional mode. The original excavation was carried out in 1958-59 at Conderton Camp (SO 972384), an Iron Age hill fort on Bredon Hill, Worcs. (Thomas 1960, 146-7). Bredon Hill is an outlier of the Cotswolds, and overlooks the confluence of the Avon and Severn valleys at Tewkesbury, some 10km away. The abundance of prehistoric occupation in these valleys is attested by aerial surveys and frequent excavations in advance of sand and gravel extraction (Hobley & Webster 1965; Oswald 1970-2). The excavation has not been fully published, but the author is indebted to Mr N. Thomas for the generous provision of all the relevant excavated data and for his further advice and support during the construction period.

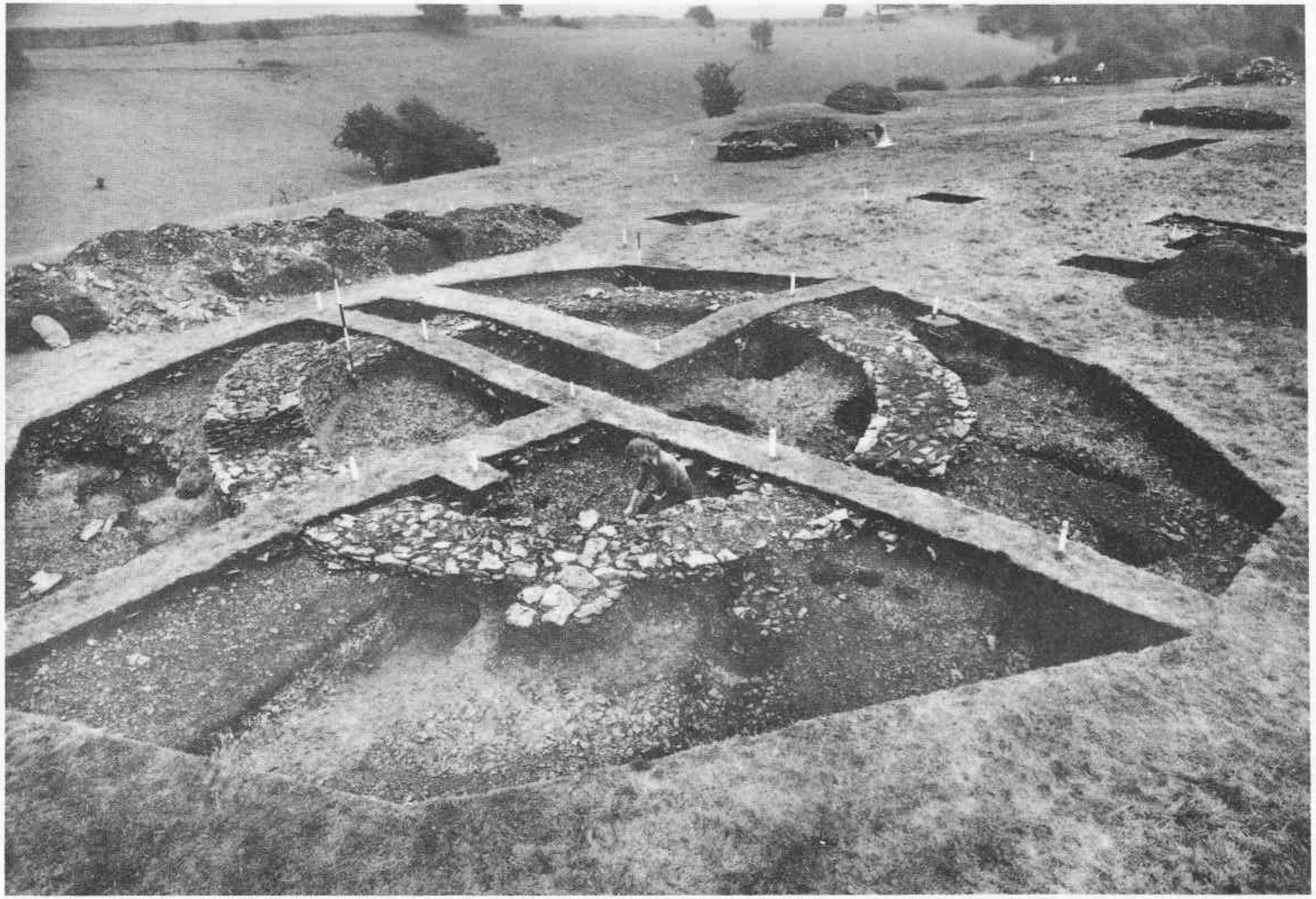
depend upon a guarded technology, which at best is a tenuous argument, at worst one substantiated by ethnological taboos.

The quantity of timber required for the completion of the structure is perhaps the most startling discovery. Over two hundred trees were required and this, it must be emphasised, was a minimum. The implication, however, is concerned with the nature of the trees. All the upright timbers were oak, with the inner ring of load-bearing posts averaging forty years old, the porch posts sixty years. The trees themselves needed to be tight-grained and straight for at least 3.0m before the first branch. Such trees are the normal product of careful management allowing the right distance between the growing crop before the long term harvest. These emotive terms are used quite deliberately, in that the requirement of timber within the normal Iron Age farmstead was necessarily huge. Even in terms of stakes for fences deliberate timber management was required. This management is in contrast to normal hazel coppicing, and presumably willow pollarding, which began in the Neolithic, since a greater time-span is required before maturation of the timber. One is effectively postulating timber management as a major component of the overall agricultural economy. Given the intensity of settlement pattern now known to have obtained and the growth cycle of timber, one can further postulate that such management was designed to provide for the next generation. Perchance it was born of peace and stability. It is a topic which requires careful analysis of pollen spectra, in that heavily-wooded valleys, normally imagined to have been undeveloped landscapes, may well have been carefully controlled and organised ones.

Finally, the most sobering implication must relate to the post-holes and stake-holes. In contrast to the original site, the topsoil at the Demonstration Area of the Ancient Farm averages some 0.30m deep. None of the post-holes or stake-holes of this extremely large structure penetrate significantly into bedrock chalk. One suspects that after a single ploughing, and certainly after five seasons of normal modern agricultural activity, no trace of its presence would survive. All that might exist beyond a scatter of sherds would be a soil area with a potentially enhanced susceptability to induced magnetism.

THE CONDERTON HOUSE

This reconstruction is offered as a direct contrast to the Pimperne house. It explores the problems of stone-built structures which necessarily combine the utilisation of stone, timber and thatch. As an exercise it has great relevance to many areas of prehistoric Britain where building in stone was the traditional mode. The original excavation was carried out in 1958-59 at Conderton Camp (SO 972384), an Iron Age hill fort on Bredon Hill, Worcs. (Thomas 1960, 146-7). Bredon Hill is an outlier of the Cotswolds, and overlooks the confluence of the Avon and Severn valleys at Tewkesbury, some 10km away. The abundance of prehistoric occupation in these valleys is attested by aerial surveys and frequent excavations in advance of sand and gravel extraction (Hobley & Webster 1965; Oswald 1970-2). The excavation has not been fully published, but the author is indebted to Mr N. Thomas for the generous provision of all the relevant excavated data and for his further advice and support during the construction period.



PL 10.7 The Conderton House as exposed by excavation

The structure in question (Pl 10.7) survived as two courses of drystone footings of an Iron Age house with a paved porch. The internal diameter was 6.09m, the external 7.91m, the walls averaging 0.91m thick. The doorway itself was quite narrow, just 0.90m wide. There was evidence of a collapse of some 2.80m of the wall around the circumference in the north-east quadrant. During the excavation, an experiment was carried out to attempt to establish the original wall height. Stone collapse was carefully gathered from a segment of the excavated area centering on the middle of the house and extending to the limits of the excavation. All the remnant stone rubble was gathered and rebuilt onto the section of wall contained within the segment. The resultant height of the wall was about 0.80m. This trial begs a number of questions, not least of which is the potential re-utilisation of fallen stone in local field walls, which are a common feature of the field boundaries on the hill. It is likely that any collapse material would have been thoroughly overgrown had it been left *in situ* originally, forming a mound of which a large number remain to this day (Thomas 1960, 146-7), and to which was ascribed local suspicious tradition (Lloydd 1967). More importantly, the kind of stone used in both the house and in the field walls of two millenia later can be found simply by digging into the hillside, especially on the oolite limestone capping. The large number of quarry pits on the hill suggest that the field walls were created from freshly-quarried stone. The exercise, therefore, had considerable value and allowed one to suggest that the original wall could have been but a little higher than the trial showed.

As in any reconstruction, all the specific data as they survived were carefully replicated after detailed study. This reconstruction followed the pattern of all such exercises, in that the major benefit to accrue emerged from those very aspects which were assumed to be simple, yet when faced with the physical problem, proved the most difficult to solve. The original walls were built of the loose upper layers of limestone, the general size being small. It would appear from Pl 10.7 that the wall was built with two faces and then infilled with rubble. This, while commonly suggested as a method of building, is an illusion. The advice of a local stonemason, Mr. Hopkins of Tewkesbury, was sought, who, after some persuasion, taught the author the rudiments of building dry stone walls. This examination of the photographic evidence rather disabused the lay conjecture that one simply built up two face walls and then filled the interior with rubble. In practical terms such a wall would be inherently unstable and would readily collapse if any pressure were exerted it, especially any lateral thrust such as one would expect from a roof.

The original wall was in reality carefully laid throughout. The edging stones were laid first, usually two courses at a time. The interior was then laid so as to lock in as many of the edging stones as possible. The whole exercise is like a heavyweight interlocking jigsaw puzzle. The mason was quite adamant that 'rubble-filled walls' was an extremely poor description misunderstood by the general public, in that the degree of skill required and the nature of the construction was not far removed from the seemingly superior solid stone wall. Simple lessons and adages were passed on to the author and need to be repeated here. 'No one stone is handled twice - there is always a perfect place for it in the section of wall within reach of the builder'. 'One stone never sits upon one stone'. 'Locking stones should be used as frequently as possible'. A brief apprenticeship gave some facility to the author and these adages were found to be fundamental.

The structure was built at the Avoncroft Museum of Buildings near Bromsgrove in Worcestershire. The author is indebted to the Director of the museum, Mr. M. Thomas, for his help and support and for the provision of an area of land in which 'empirical testing of archaeological theories' could be carried out. The construction of the stone wall was, in a sense, the easiest element. It required no less than 50 tonnes of limestone, and was built up to accommodate a doorway just 1.30m high.

The major difficulties began when the alliance of disparate materials had to be forged. It was appreciated that the roof would exert considerable lateral thrust on a drystone wall, which is generally regarded as unstable in such conditions. Indeed the original showed clear evidence of a collapse. Mathematically the lateral pressure exerted on a point of moment is least at 45^{0} and most at 22.5^{0} and 67.5^{0}, but nonetheless there is still pressure. A series of trials was carried out to seek the best system of sustaining that pressure. The obvious method was to spread the load along a length of wall rather than allowing a pressure focus on the area of the butt of a rafter - some $0.02m^{2}$. The obvious was recognised after the first tripod of rafters caused three points of wall collapse. Thereafter a series of trials was carried out with baulks of timber of differing lengths being forced against the top of the wall with pressure being exerted at 45^{0}. The motive force employed was a Land Rover. The objective was to replicate the 2.80m wall collapse of the original excavation. This was achieved with a baulk length of 2.40m set just 0.30m from the inside face of the wall. This trial was repeated only three times instead of the more usual five because of the wall rebuilding each trial involved. Twelve trials were executed to achieve this answer. Given the circumference of the structure at this position on the wall (21.0m), the length of 2.40m neatly allowed eight baulks with a gap left for the lintel over the doorway. The ends of the baulks either side of the doorway were built into the wall as it increased in height to accommodate the doorway.

By placing the baulks of timber at this position on the wall, achieved by simple trial and error, the pressure line from the roof passes more or less diagonally through the wall mass, allowing the outer element to act as a simple weight buttress. Similarly, the trials focus attention on the detail of the excavated data and of their value in interpretation allied to empirical trials. The baulks themselves were connected with simple half-lap joints. No attempt was made to fasten the timbers together since this would have denied the possibility of the observed wall collapse.

The rafters, on the other hand, were jointed to the horizontal baulks of timber which effectively formed a wall plate. Again the joinery was as simple as possible. A prepared face was cut into the wall plate at approximately 1.50m intervals, with the angle of this face at 45^{0} to the horizontal. The butt of each rafter was similarly prepared by a half lap joint at right angles to the line of the wood,

PL 10.8 The Conderton House: walls and timber superstructure complete

PL 10.9 The Conderton House eave; scale in feet

PL 10.10 The Conderton House completed; internal diameter 6.10m, external diameter 7.92m

thus allowing the face to lock by weight alone onto the wall plate. The rafters were erected in a precise sequence. Initially a tripod was set in place, with a further three rafters set into the cross-trees afforded by the tripod. A tripod was utilised because it is the simplest stable structure. Once six rafters were in place the apex of the roof was effectively full of timber, and a ring beam was inserted to support the eight subsidiary rafters. This ring beam, of willow withies bound together to form a circle around the six principal rafters, was set one third of the way down the slant height of the roof from the apex, as in the Pimperne House, to stress the rafters outwards.

When all the rafters were in place willow withies were interwoven between them to support the thatch (Pl 10.8). The next problem to emerge again concerned the wall. Trials had shown that the thickness of the wall was necessary to buttress the weight thrust of the roof, and that the wall plate needed to be positioned no more than 0.30m from the inner circumference. This left a flat surface *c.* 0.5m wide which had to be protected from the weather. Limestone is especially friable when subjected to frost action in the horizontal mode.

Various means of overcoming this problem were considered, especially since the normal system of thatching includes flying rafters to bridge this gap. Finally the obvious conclusion was reached from another contemporary experiment examining the crop yield of Emmer wheat (*Tr. dicoccum*). One element of this experiment was to assess the relative stand heights of Emmer against the modern hybrid varieties. An average of just over 1.10m was recorded from the crop of 1970 after the ears or spikes had been harvested. When bundles of this straw had been laid flat on top of the wall an appreciable eave was created which adequately protected the wall from frost action (Pl 10.9).

The thatching was carried out by Mr. Bendall from Somerset. The system employed was to cover the roof structure with a thick layer of hay which meshed into the interwoven willow withies and formed a support into which the straw thatch could be pegged. Over a tonne of hay and two tonnes of straw were used. The total dry weight of the roof was in excess of 5.5 tonnes. Thus a roof with a free span of over 6.0m and weighing almost 6 tonnes was supported by a drystone wall. The completed structure can be seen in Pl 10.10.

Apart from the conclusions drawn from the construction process, further observations were made from the completed building. The first concerned an element of the original which was not replicated, the paved porch. Since the building was in a museum, it was visited and entered by several thousand visitors in the three seasons it was monitored. This accelerated a process which would have inevitably occurred in normal conditions. A hollow caused by the 'splash factor' was formed at the entrance to the structure. Given the nature of the British climate and the intrepid attitude of the museum visitor the house was entered in wet weather. The passage of feet in a restricted area first destroyed the grass cover and then began to wear away the soil by splashing soil particles in water droplets from the puddle which formed in the contained patch of bare earth. In a remarkably short space of time an appreciable hollow was formed just outside the building line of the doorway.

The second observation of import was the effect of the eave on the ground surface immediately beyond the wall line. Because a protected habitat was provided for the grass at this point it flourished. No passage of feet and plentiful moisture allowed verdant growth. This was in direct contrast to the expected and indeed predicted drip gully. Regularly the grass had to be cut back from the walls to protect them from accelerated damp penetration and potential frost damage.

This building, however inaccurate it may have been, focussed attention on the details of an excavation and how those details can be used to hypothesise a physical structure. Further, it demonstrated how a perfectly sound building can be created without a pinned joint, relying entirely on the weight thrust and counterthrust of the different building materials employed. Unfortunately it no longer exists, since the museum needed to exploit the area for other purposes.

CONCLUSION

These two case studies, the Pimperne and Conderton houses, are offered as examples of how the empirical approach to archaeological data can increase our appreciation not only of the need to refine excavation techniques still further, but also to indicate the sophisticated nature of building technology which perforce was the norm in prehistory. In both cases the data were exemplary and the author is indebted to the excavators both for their initial skills in excavation and recording, and for their enthusiastic support of the detailed analysis of those data which the reconstructions occasioned. Given that the best available examples were used for the structures, the information gleaned is of considerable value in providing analogue material for less well preserved archaeological data, and in focussing attention on the fundamental requirements of such structures which might otherwise pass unobserved.

ACKNOWLEDGEMENT

All photographs are by the author except Pl 10.7, reproduced by permission of the City of Birmingham, to whom my thanks are due.

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