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Romano-British Corn-Drying Oven: An Experiment

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In 1975 during excavations of a multi-period occupation site in Redlands Gravel Quarry, Foxholes Farm, Hertford, four structures commonly known as corn-drying ovens were discovered. All of these structures could be firmly dated to the fourth century A.D. Three were badly damaged but one was found to be almost intact and standing to virtually the original height of the drying floor at one metre high although the floor itself and superstructure had disappeared. The substructure was in such an excellent state of preservation it was decided to lift it in its entirety and to remove it to Hertford Museum for conservation and display (Partridge 1976).

The area plan and elevation of the oven can be seen in Figure 1. The walls were constructed mainly from chalk blocks and field flints set in a puddled clay and chalk matrix. Clear indication of burning was discovered in the stoke-hole area and a peak of sooting was observed on the south-east corner of the inner chamber (pers. comm. C. Partridge).

In 1977 an approach was made by Mr C. Partridge to the Butser Ancient Farm Project Trust to conduct a research programme to test the validity of the interpretation that this specific structure and by analogy others of its type could be corn-drying ovens. Financial support for this project was generously provided by the Robert Kiln Trust. The project was undertaken and this paper presents the results both of the reconstruction and the testing of its potential function. Throughout, every assistance in the provision of field data was given by Mr Partridge and the resultant structure in so far as the original is concerned is a faithful replica.

The same precepts as those normally employed at Butser Ancient Farm Project Trust were used throughout the programme (Reynolds 1979).

At this point, however, it is worth noting that the normal interpretation of these structures as corn-drying ovens despite a considerable variety of flue design was initiated in the early part of this century (Cocks 1920). It was further reinforced by Goodchild (1943) in his survey of 'T'-shaped corn-drying ovens in Roman Britain who regarded the problem posed by these structures as being satisfactorily solved. It would seem that the interpretation was inspired by the regular discovery of carbonized seeds recovered from the flue and stoke-hole areas of such structures and a few classical references which seem to allude to the process (Pliny, Virgil). Indeed the interpretation has gathered such support that 'the corn-drying oven is probably the most easily identifiable agricultural structure found in Roman Britain' (Morris, publication forthcoming). By way of a cautionary note it is perhaps unwise to allow such a determined interpretation upon evidence which could well sustain alternative hypotheses.

For example, in general discussions with farmers it has regularly been suggested that carbonized grain and indeed other weed seeds could have found their way into the flue

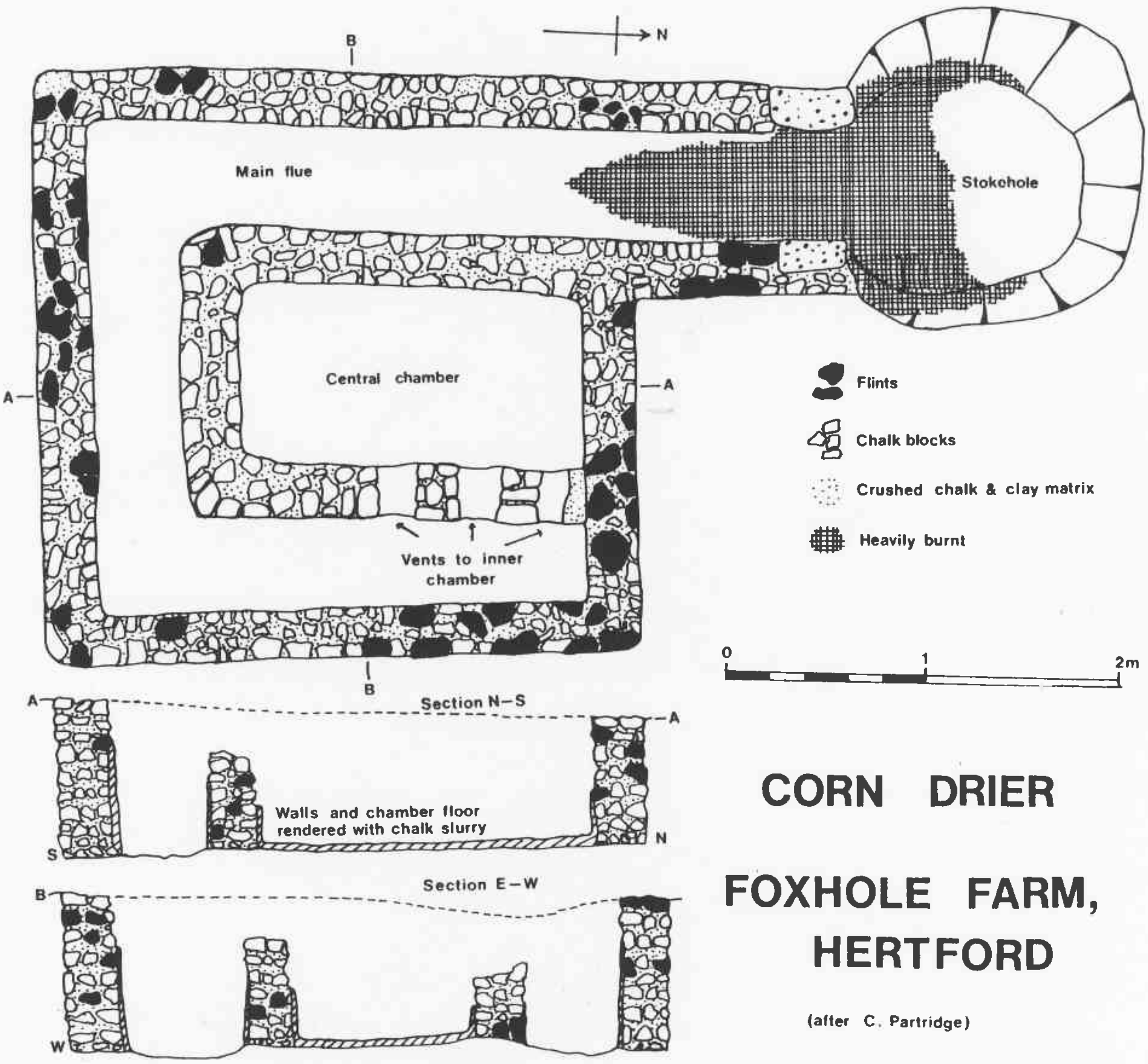

Fig. 1

and stoke-hole areas of such structures when they were lit. It was normal practice to start a fire using dry straw for the purpose. Yet another hypothesis is offered in the conclusion. However, it is not the intention of the authors nor within the scope of this paper to discuss the range of design of corn driers, their distribution or frequency. A survey of the extant evidence is shortly to be published (Morris, publication forthcoming).

The Reconstruction

The evidence afforded by the excavation is remarkably good in that the extent of the firing on the floor of the flue is clear and the presence of an upper chimney or extractor flue is simply argued by the peaks of sooting in the corner of the central chamber. None the less, as so often in such structures, there was a total absence of evidence for the position of joists or flooring supports. One can only presume that the floor level was immediately above the surviving foundations and on a rough level with the ground surface. That there was a plank floor covered with a chalk and soil slurry is attested by several surviving fragments bearing plank impressions. Such a covering making a solid impervious floor accords well with the double stone floor recovered at Atworth Roman villa (Shaw-Mellor & Goodchild 1942).

In order to build any reconstruction, several important hypotheses drawn from the overall interpretation that the structure is a grain drier must be mounted. If one assumes that the flue system is specifically designed to heat uniformly a wooden plank floor covered with a chalk slurry, then the boundaries of that floor are contained within the area set by the outside wall of the flue system itself. This hypothesis is heavily influenced by the sooting marks within the central chamber in the corner. Such a flue is necessary to draw the hot gases from the fire throughout the system and thus only the area above the flue is subjected to heating. Secondly, since the laws of heat exchange determine that the temperature of the lesser mass is directly affected by the temperature of the greater mass, for the floor to have any value for heating and, therefore, presumably drying material placed upon it, it must be set within a totally enclosed structure. Similarly that structure must either have a chimney protruding through a solid roof or alternatively a flue venting into a structure with a roof made from permeable material like straw thatch. There are a number of concomitant arguments in favour of a totally enclosed building. Principle amongst these is the time at which a 'grain drier' is normally used. If the interpretation is correct the introduction of the grain drier is most probably in response to inimical climatic conditions. Other suggestions implying a political pressure for their introduction is referred to below. In modern practice grain driers are in operation immediately after the harvest and for several months thereafter in order to market the grain at the most profitable moment or alternatively store it at the most suitable moisture content. Usually greatest profits are earned immediately after the harvest and at the end of the selling season when scarcity increases the value. In contrast it is more probable to suppose a functional requirement in the Romano-British period. The grain needs to be artificially dried because it is either difficult or impossible to dry it naturally. Given hostile weather conditions normally encountered in autumn and winter an open floor without any protective covering is nonsense and an open-sided roofed structure only marginally less so. An even more persuasive argument is urged by the analysis of the matrix or mortar bonding the flint and chalk blocks in the flue walls. This proved to be a mixture of powdered chalk, soil and clay, and probably lime. Even if lime was a major constituent, any moisture penetrating into the mixture renders it unstable and the pressure exerted by the weight of the wall itself squeezes it out and thereafter the wall quickly collapses. Extensive trials to test this effect during the reconstruction of the flue both with and without lime in the matrix proved conclusively that the introduction of moisture even laterally through the surrounding soil caused wall collapse within hours rather than days. Further, in this connexion, had the weather not been hostile the need for a grain drier would not have existed. The amalgam of the above hypotheses indicates a closed roofed structure with an integral flue and a solid floor.

The nature of the walling in the flue, irregular blocks of chalk and field flints, in itself is quite interesting. Clearly it survived as a structure simply because it was built in a deep foundation which was subsequently undisturbed. However, a superstructure made of these materials would disintegrate into its component parts and it would be virtually impossible to identify those parts as once belonging to a building of any kind. Given normal agricultural activity including stone picking, a common enough practice even today to remove flints from fields, the evidence would disappear entirely without even a concentration of flints around the original location. The chalk blocks would suffer swift degradation by frost action.

There was indeed no clear evidence for any superstructure to the flue system at all. The post-holes and timber slot shown in Figure 1 have seemingly little relevance to a load-bearing structure and are perhaps best explained as wood stack supports. The two post-holes to the north-east of the stoke-hole would seem ideally placed for a pair of upright posts between which could be stacked the timber for immediate use on the fire. The three post-holes set approximately 0.30 m away from the western wall of the flue could similarly be considered as devices for the retention of stacks of timber. Indeed this system of stacking timber against the walls of structures and protected by the eaves of the roof from the worst of the weather is commonly found throughout northern Europe even today. It has one added benefit in that the wood stack itself also protects the wall from the worst of the weather. Finally the timber slot positioned as it is around two sides of the stoke-hole area could be thought of as a windbreak. Alternatively all these elements may ante- or even post-date the structure.

Given the above hypotheses and the nature of the flue walls it was decided to continue building the outer wall of the superstructure in exactly the same way as that of the flue and with exactly similar materials. It was found in the experiment with the flue system that lime added to the matrix provided a stiffer and harder 'mortar' and consequently for the rest of the building lime was added to the mix at a proportion of 1:6. In any reconstruction the major element of guesswork is the height of the wall. In arriving at a figure of 1.60 m the major argument consists of the provision of adequate headroom within the building. A second argument, however, had also to be considered. If the floor of the structure was to be covered with grain, either in the ear or threshed, the doorway would necessarily have to be raised above floor level to avoid spillage from the floor outside and also to facilitate the opening of the door itself. A simple enough point but an important one in that the doorway, now raised some 0.50 m from the ground surface, still had to be functional not only for human passage but also for loading and unloading the floor.

A comparison of Plates IIIA and IIIB with Plate IIIC shows the faithful replication of the basic evidence as provided by the excavation. At this stage of the building the stoke-hole has not been excavated. In order to set a floor into the structure, timber joists were necessary to give adequate support for the floorboards especially across the central chamber which has a span of over 1.0 m. Sawn oak timbers 100 cm × 100 cm cross section were used. The butt ends were built into the outside walls and set on top of the central chamber walls (Pl. IVA). A second and more persuasive argument in support of timber joists built in this way is that they absorb shock much more successfully than plank floorboards. It is important that the foundation walls in the flue should not be subjected to shock waves simply because of the nature of their construction. Similarly the joists were set across the narrowest span of the central chamber. The chamber walls were built up between the joists to a level just below that of the floorboards. The floorboards, sawn oak planks 25 mm thick and 150 mm wide, were set at right-angles across the joists and nailed into position using hand-made iron nails. The nails, made in the latter half of the nineteenth century, were provided by Ironbridge Gorge Museum for this experiment.

An opening and trapdoor were constructed to coincide with the corner of the central chamber for the ultimate provision of a chimney or extractor flue. The nature of the roof is a matter of pure conjecture. However, since the building is square and the nature of the walls such that disproportionate loading on two of the four walls should be avoided, a roof comprising four equilateral triangles pitched at 45° was decided upon. During the excavation no evidence of roofing tiles was recovered and their total absence would suggest a thatched roof. This certainly provided a minimum weight thrust in contrast to pottery tiles. The joinery utilized can be clearly seen in Plate VA and a detail of the corner in Plate IVB. Effectively a wall plate secured at the corners with nailed half-lap joints was set on to the top of the walls. The rafters were notched and nailed on to the wall plate allowing a half-metre eave projection beyond the outer edge of the wall. At the apex of the roof all the rafters, previously sawn to the correct angle, were nailed to an eight faceted length of upright timber. Thereafter purlins were nailed at 20 cm intervals across the rafters. Throughout sawn oak was used in the construction except for the purlins which were strips of ash. The final thatched roof can be seen in Plate VB. This particular design of roof provided one clear advantage in that the thermal patterns within the structure concentrated the smoke within the apex area and gave a smoke-free atmosphere up to 2 m from the floor. Half a tonne of straw was required to thatch the structure. This construction technique where all the timbers are tied into a square plan only exerts a vertical pressure provided its base is horizontal. Thus virtually all lateral thrust was avoided on the relatively fragile wall construction.

The stoking point provided some difficulties of interpretation. The walls of the flue projected over a metre from the building line on to the stoke-hole area. This was faithfully replicated including the provision of cheek pieces. However, some kind of roofing across the two walls was clearly necessary otherwise the fire would fail to draw into the flue system itself. Consequently an arch was constructed of interlocking field flints with minimal chalk packing. Unfortunately it was not possible to analyse the relative quantities of flint to chalk block in the collapse material in the stoke-hole area. It is unlikely that chalk blocks would have predominated in this part of the structure since the intense heat generated by the fire would serve to break them down rapidly. In future on similar sites it would be a useful analysis to make. In the construction of the arch a section of hardboard was used to provide the necessary curve. Detail can be seen in Plates VA and VB. This device was employed simply to save building time rather than a denial of the normal construction technique.

The completed structure (Pl. VB) is a sturdy building and fulfils the working hypothesis outlined above. The ultimate stage of the building was the provision of a flue extractor over the trapdoor set above the corner of the inner chamber of the flue system. This comprised four planks nailed together to form a simple box chimney standing 1.50 m above the plank floor. The base was caulked with clay to seal it to the floor.

Finally a slurry of chalk and clay about 30 mm thick was laid over the whole of the plank floor. The proportions of chalk to clay was at a ratio of 10:1. The high proportion of chalk, copying the original material, is simply to avoid contraction during heating and the inevitable cracking. During the initial heating and drying out of the structure, especially the underground flue system, any cracks which appeared in the floor-covering were repaired until a solid smooth floor was achieved.

The Experiment

The building as such represents simply the extension of the archaeological evidence. In order to test its efficiency in carrying out its ascribed role the following *caveats* should be considered and evaluated.

The decision to continue the same type of walling as the flue is explained above. However, the question whether another type of walling might affect the performance of the structure must be considered. Given the premise that a solid wall is necessary the options of type are fairly limited. It would seem that provided the wall is solid it matters little what its precise nature may be. Wattle and daub, cob, brick or tile are all basically similar materials to the flint and chalk blocks as used.

The roof, on the other hand, does seem to represent an important *caveat*. Any one of several designs could have been used although cladding materials can be divided into two basic types, permeable and impermeable. The principle of operation is arguably to heat the floor area of the structure to a sufficient temperature to dry a material laid upon it. An even distribution of temperature from the flue gases is assured by the design of the flue and the location of the chimney. Given this principle the design of the roof would appear to be unimportant. Hipped, ridged and gabled or as selected for the structure the importance of the roof is to provide an adequate cover to protect the walls and activities within them. The cladding material, the choice between tile or thatch or even turf which shares the characteristics of tiles in this case, is important. A solid roof would inhibit the release of the heated atmosphere within the structure whether a chimney were provided to allow escape of flue gases or not. By definition of the building's function, this heated atmosphere would become charged with the moisture released from the grain and without ready release from the structure this moisture would be re-absorbed into the grain extremely quickly. Similarly a tile roof would present an ideal surface for condensation. One of the major problems of the modern farmer in controlling bulk storage of cereals is the ready acceptance by grain of atmospheric moisture. Most bulk storage units are today fitted with ducting systems to blow cold air through the grain prior to its final drying. Consequently a thatched roof which allows ready escape of the heated atmosphere already under slight pressure by virtue of the normal effects of a thermal would seem the only acceptable choice.

The variables, therefore, now seem to be isolated to the actual operation of the structure. In the following experiments the major variable examined is related directly to the depth of grain, a modern threshed barley, on the floor of the drier. Clearly there are a number of other variables to be taken into account in due course including the examination of cereals dried in the ear or spike as opposed to threshed grain. Further experiments designed to test these variables will be reported in due course.

The firing process in turn would seem to present a considerable variable which in practice proved not to be the case. During the drying-out period various types of timber cut to various sizes were used. Although different woods certainly have different heat-yield properties, for example, thorn burns hotter than any other native timber, the over-all effect on the floor of the structure was virtually unaffected. In order to standardize this element of the experiment, information was drawn from a recent excavation at Barton Court Farm, Oxfordshire (pers. comm. M. Jones). In the stoke-hole of a 'T'-shaped corn-drier carbonized timber remains were discovered. These proved to be of brushwood with an average diameter of some 50 to 100 mm. Consequently throughout the experimental firings this material was used. The small quantities of timber actually required to fire the flue and to maintain the fire are of particular interest.

In order to monitor exactly the temperature levels within the flue and over the surface of the floor and at the exit of the flue extractor chrome-alumel thermocouples were located at seven fixed positions (see below). In order to check the varying moisture content of the grain spread evenly over the floor, a standard Grain Moisture Meter was used. For the experiments modern threshed barley, variety Tara, was used. The following table gives the precise location of the thermocouples. The numbering of the thermocouples is repeated in the tabulated results of each of the series of trials.

Thermocouple No.	Location in Drier	
1	Suspended 0.20 m below floor level into the flue	0.30 m × 0.30 m from NW. corner
2	Set in floor surface	0.30 m × 0.30 m from NW. corner
3	Set in floor surface	0.30 m × 0.30 m from SW. corner
4	Set in floor surface	0.30 m × 0.30 m from SE. corner
5	Set in floor surface	0.30 m × 0.30 m from NE. corner
6	Set in floor surface	Centre of floor
7	Set on top of flue extractor	

The first trial took place over a three-day period at the end of September 1979. The threshed barley was spread evenly over the whole of the floor area of the drier to a standard depth of 150 mm. This represented an overall weight of some 450 kg of grain. In all trials the fire was started half-an-hour before any records were taken. The

TABLE 1

Thermocouple No.	Temperatures in degrees Centigrade													
1	127.0	152.0	172.0	152.0	159.0	184.0	147.0	182.0	167.0	208.0	192.0	127.0	207.0	122.0
2	59.0	62.0	66.5	79.0	78.5	76.0	83.0	80.3	88.0	89.0	83.0	86.0	86.0	88.0
3	49.5	53.0	59.0	61.0	64.5	64.0	72.5	74.0	78.5	88.0	83.0	83.0	88.0	81.0
4	35.0	38.5	42.0	44.5	46.5	48.0	52.0	55.0	55.5	57.0	55.0	59.0	57.0	58.0
5	35.0	38.5	39.0	43.5	43.5	45.0	45.0	48.0	53.0	54.5	54.5	59.0	58.0	60.5
6	29.0	30.0	32.5	35.0	36.0	36.0	42.0	42.0	43.5	45.0	47.5	50.0	49.5	52.0
7	71.0	78.5 *	86.0	76.0	88.0 *	93.0	94.0 *	98.0	98.0 *	101.0	105.0	83.0 *	110.0	78.5
Moisture Content Sample	**Percentage**													
1		17.5		20.8		22.4		20.3		21.5		23.0		24.75
2		17.0		20.4		22.0		21.75		21.0		23.5		26.0
3		16.5		18.4		20.95		19.5		19.5		19.0		20.4
4		17.0		19.0		17.7		17.75		18.8		19.0		18.4
5		17.5		18.4		19.25		17.75		19.4		18.5		20.0

General Weather description: Fine dry day with light northerly wind veering south in late afternoon

TABLE 2

Thermocouple No.	Temperatures in degrees Centigrade																							
1	41.0	100.0	137.0	123.0	114.5	137.0	132.0	132.0	123.0	122.5	101.0	115.0	137.0	137.0	157.0	147.0	124.0	132.0	98.9	120.6	137.0	110.0	130.0	98.6	98.0
2	43.0	44.0	51.5	64.0	69.5	74.0	76.0	78.5	75.0	84.5	65.0	63.0	66.5	83.0	88.0	92.0	90.5	92.0	88.0	80.1	87.4	84.3	83.1	80.0	78.0
3	36.0	44.0	49.5	59.0	69.0	66.5	70.0	71.5	66.5	74.5	72.6	72.5	69.5	74.0	74.0	79.0	78.5	74.0	73.5	73.1	74.3	71.2	70.2	71.1	70.0
4	33.5	35.1	35.0	39.5	41.0	45.0	46.0	47.0	72.5	47.0	44.7	49.7	48.0	49.5	49.5	41.0	52.0	59.5	55.0	59.3	55.7	51.7	52.3	52.0	50.0
5	38.5	38.5	40.0	42.0	38.5	41.0	44.0	45.0	48.3	46.5	47.0	47.0	47.0	45.0	47.0	45.5	47.0	40.0	55.0	48.0	49.3	49.0	49.7	50.0	48.5
6	39.0	39.0	40.0	40.0	41.0	42.0	44.0	45.0	47.0	47.0	47.0	47.0	47.0	48.0	50.0	50.0	51.0	60.0	55.0	51.3	55.0	55.0	55.1	54.7	53.1
7	30.0 *	52.5 *	63.0	70.0	72.5 *	74.0	71.0 *	73.0	75.0	74.1	67.0 *	66.5	71.0	78.5 *	74.0	74.0	78.5 *	74.0	64.0 *	72.3	75.4	70.1 *	73.1	62.7	60.4
Moisture Content Sample	Percentage																							
1	17.0		16.3		20.9		22.4		20.5		22.0		20.4		18.5		23.1		23.7		23.6		23.1		23.7
2	22.5		25.2		21.9		22.25		22.0		22.5		20.4		26.0		21.25		24.5		24.1		23.7		24.2
3	22.0		20.9		21.5		19.7		20.2		20.3		23.1		22.0		20.4		22.0		21.8		21.0		21.7
4	19.7		20.9		21.1		20.0		20.2		20.0		19.75		19.75		19.5		21.5		21.4		21.5		21.0
5	19.7		17.5		19.4		20.9		20.9		20.7		20.4		21.50		22.4		19.7		20.0		21.0		21.4

General Weather description: Fine dry day with light winds from south veering south-easterly

TABLE 3

Thermocouple No.	Temperatures in degrees Centigrade																				
1	37.0	110.0	112.0	78.0	172.0	144.0	137.0	108.0	88.0	129.0	129.0	147.0	169.0	132.0	147.0	156.0	147.0	203.0	147.0	146.0	152.0
2	37.0	50.0	57.0	57.0	61.0	74.0	74.5	74.0	80.0	76.0	76.0	83.0	93.0	96.0	98.0	96.0	99.0	105.0	107.0	107.0	112.0
3	35.0	39.0	47.5	55.0	61.0	71.5	69.0	69.0	74.0	72.5	74.0	55.0	86.0	88.0	96.0	90.5	99.0	102.5	98.0	98.0	102.5
4	32.0	32.5	38.0	42.0	44.5	47.0	47.0	56.0	52.0	52.5	53.0	55.0	58.5	88.0	73.0	60.0	86.0	68.0	58.0	66.5	68.5
5	37.0	35.0	36.0	40.0	41.0	42.5	45.0	47.5	49.5	52.0	51.0	51.0	50.0	55.0	51.0	55.0	51.0	59.0	57.0	56.0	51.0
6	37.0	34.0	36.0	38.5	39.5	38.0	42.0	43.5	46.0	47.0	47.5	47.0	48.0	48.0	50.0	49.0	53.0	55.0	52.0	54.5	52.5
7	33.0 *	53.0	58.0	51.0 *	73.0	75.0 *	73.5	66.5	59.5 *	76.0	67.0 *	93.0	97.0	75.0 *	83.0	96.0	82.0 *	101.0	83.0	98.0 *	88.0
Moisture Content Sample	Percentage																				
1	25.1		23.25		19.1		21.0		22.75		23.1		21.4		21.4		23.7		23.7		21.5
2	21.0		22.6		17.7		22.4		21.7		23.75		21.4		22.5		24.0		27.0		25.25
3	20.7		20.9		20.9		21.8		22.3		19.7		19.0		21.4		22.5		23.7		21.5
4	20.3		22.6		21.2		20.6		22.1		20.3		17.6		21.4		20.2		20.9		21.5
5	20.4		17.5		19.7		19.8		20.8		19.7		19.0		20.9		21.1		20.9		19.4

General Weather description: Fine dry day with light winds from south veering south-easterly

In this test the grain was regularly turned with a shovel at hourly intervals thermocouples were read at thirty minute intervals and in the tables an asterisk indicates the times of stoking. The moisture content of the grain was tested hourly. Five sample points, 1 to 5, correlating to thermocouple positions 2, 3, 4, 5, and 6 were used for determining moisture content. In each case the surface layer of the barley was sampled. Tables 1–3 give the results of this first trial.

From the results it can be seen that the structure works extremely well in terms of heating the floor area successfully. By comparing thermocouple number 1 with thermocouple number 7 it is possible to calculate the heat loss between source just beyond the fire in the stoke-hole and the flue extractor. The range of temperature difference averages some sixty degrees which is absorbed by the structure itself. Despite the high temperatures achieved in the stoke-hole neither the timber joists nor flooring planks were affected by burning throughout the trials.

On the other hand the moisture content of the grain is significantly increased in all three of the tests. The problem is one of moisture transfer. The moisture is driven off the grains in contact with the heated floor but is immediately accepted by the grains directly above. The temperature was not great enough to drive off the moisture from the grain completely. Turning the grain regularly as carried out in the third test simply reversed the process of moisture exchange.

The first test lasted some six and a half hours, the second and third twelve and ten hours respectively. The length of the second and third tests were simply to check that the time element itself had been thoroughly explored. The results, however, indicate that given this depth of grain on the floor the time element was not significant.

The next phase of the trials, acting on the results shown in Tables 1 – 3 was to halve the depth of the grain on the floor to a standard of 70 mm. The results of this action can be seen in Tables 4 and 5.

In Table 4 the results of the moisture content sample mirror exactly the patterns of Tables 1 – 3 indicating that a layer averaging 7 cm in depth was still too thick to dry properly. This, of course, includes the whole floor operating with a load of about 200 kg. In the next trial the following day it was decided to change the depth of grain over the hottest areas of the floor served by thermocouples 2, 3, 4 and 6. The area in the north-east corner, thermocouple number 5, is predictably the coolest area of floor since the flue gases are drawn through the vents in the inner chamber wall short of this area. This factor is further support for locating the doorway in this, the least effective part of the floor area.

After starting the trial and sampling the moisture content at the three significant points this sector of grain was reduced to about 25 mm in depth. From the results in Table 5 it can be seen that the moisture content reduced rapidly from 23.1% to 12% over a period of three and a half hours. Thereafter the grain was increased in depth to 70 mm with a resultant increase in moisture content rising from 12% to 19.6% within an hour.

The third and final series of tests held over a further two-day period sought to test the findings indicated in Table 5. Again only the hottest area of the floor was used covered by thermocouples 2, 3, 4 and 6. However, in order not to increase heat loss the grain from the previous trial was heaped over the remainder of the floor. The results of these trials shown in Tables 6, 7 and 8 are self-explanatory. The grain spread at a depth

TABLE 4

Thermocouple No.	Temperatures in degrees Centigrade															
1	45.0	111.0	122.0	97.5	103.5	127.0	157.0	177.0	197.0	169.0	246.5	243.5	204.0	243.0	247.0	234.0
2	41.0	50.0	59.0	58.0	74.0	74.0	79.0	92.0	100.0	110.0	117.0	132.0	137.0	142.0	152.0	162.0
3	41.5	42.5	45.0	52.0	64.0	64.0	73.0	86.0	97.0	98.0	107.0	117.0	119.5	122.0	126.0	112.0
4	49.0	50.0	50.0	44.5	50.0	50.5	52.0	58.0	67.0	66.5	73.0	79.0	81.0	81.0	78.0	84.0
5	35.0	35.0	43.0	30.5	30.7	30.5	30.0	42.5	50.0	52.0	57.0	62.0	62.0	61.0	75.0	60.0
6	37.0	37.0	45.0	37.5	41.0	41.0	45.0	48.0	50.0	52.0	56.0	62.0	62.0	65.0	66.0	69.0
7	31.0	50.0	70.0	54.5	63.5	70.0	86.0	86.0	98.0	91.0	116.0	112.0	107.5	122.0	122.0	122.0
	*			*		*		*		*			*			

Moisture Content Sample	Percentage							
1	19.5	20.7	22.5	25.0	26.5	21.5	20.9	28.0
2	19.0	21.0	23.0	24.5	25.3	23.0	25.2	28.9
3	20.5	22.5	24.5	23.8	23.8	22.7	24.4	27.0
4	20.0	20.4	20.7	21.7	22.8	20.5	23.1	26.0
5	19.0	20.7	21.0	21.7	22.1	21.6	20.3	23.5

Weather conditions: Dry and dull with southerly wind force 1 strengthening force 3 in afternoon

TABLE 5

Thermocouple No.	Temperatures in degrees Centigrade											
1	45.0	133.0	183.0	147.0	148.0	140.0	123.0	110.0	124.0	138.0	147.0	171.0
2	35.0	65.0	74.5	74.0	75.0	75.0	80.0	69.0	72.0	75.5	74.2	67.0
3	30.0	62.5	72.5	73.0	75.0	75.0	75.0	59.5	64.0	67.0	72.0	63.0
4	38.0	57.0	60.0	60.5	75.0	75.0	75.0	57.0	62.0	61.0	69.0	70.0
5	30.0	55.0	55.5	56.0	53.0	52.0	52.5	53.0	51.0	54.0	57.0	54.0
6	36.0	55.0	61.0	61.5	61.0	60.1	59.5	58.0	59.0	58.5	57.0	84.0
7	31.0	75.0	88.0	74.5	74.5	78.0	73.0	52.0	71.0	68.0	75.5	69.0
	*	*		*				*		*		
Moisture Content Sample	**Percentage**											
1	23.1	17.0	15.5	14.0	13.5	13.0	12.0	12.5	13.5	13.5	13.9	14.5
2	23.1	17.5	15.0	14.0	13.0	12.5	12.0	14.0	19.6	17.0	17.0	16.4
3	23.1	17.5	13.5	14.0	13.0	12.5	12.0	14.5	17.7	17.0	17.5	18.4

Weather conditions: Dry, dull with a light southerly wind of about 25 mm was successfully dried. Moisture content samples were taken every half-hour in these trials.

To achieve a moisture content level of about 10% the trials lasted respectively six hours, three and a half hours and four hours. In each case only half the floor was used. None the less a grand total of seventy-six kg of grain was dried in three tests. Assuming that the whole floor was utilized and accepting the lowest time figure, the capacity of the structure would seem to be about fifty kg in three and a half hours.

In the light of all the above results it is indeed possible to reach the conclusion that such structures can be used to dry grain. However, if one assumes a modest harvest of ten tonnes overall, it would require at optimum operating levels some 700 hours or 70 man-days to dry such a harvest. At the other end of the scale 1200 hours is a ludicrous prospect. Such levels of efficiency seem to be totally unacceptable. Consequently the broad conclusions that must be drawn from these tests is that the structure is most unlikely to be a grain drier at all.

The point at which the structure fails is the floor upon which the grain is spread. There is clearly nothing wrong at all with the underfloor heating system. Indeed the flue design is admirably suited to heating the whole floor area with but one cool spot. Because the floor is solid, even without the chalk and clay slurry, leaving only the planks exposed, the same situation would obtain, there is no passage of hot air through

Table 6

Thermocouple No.	Temperatures in degrees Centigrade										
1	130.0	98.0	153.0	147.0	147.5	147.0	152.0	150.5	147.0	150.0	147.0
2	42.0	50.0	59.0	74.5	73.0	73.5	86.0	80.0	97.0	98.0	96.0
3	40.0	47.0	56.0	56.0	57.0	74.0	74.0	74.0	74.5	76.0	75.5
4	36.0	38.0	44.0	47.0	50.0	64.0	54.5	60.0	60.5	69.0	68.0
5	36.0	40.0	43.5	47.0	48.0	44.0	54.5	55.5	51.0	53.0	52.0
6	45.0	54.0	62.5	67.0	69.0	74.0	76.0	74.0	74.0	68.0	67.0
7	57.0	55.0	73.0	75.0	75.0	77.0	88.0	78.0	78.0	79.0	78.0
		*		*		*			*		
Moisture Content Sample	**Percentage**										
1	19.0	17.5	17.5	17.5	16.5	14.5	15.0	16.0	10.5	10.5	10.0
2	19.7	19.7	16.5	17.5	16.5	14.5	15.0	16.0	13.5	13.0	10.0
3	19.7	19.7	18.5	17.5	16.5	14.5	15.0	16.0	13.5	13.0	10.0

Weather conditions: Dull and overcast. Heavy rain storm three and a half hours after start of trial

TABLE 7

Thermocouple No.	Temperatures in degrees Centigrade					
1	170.5	154.0	170.5	181.0	173.0	220.0
2	76.0	82.0	73.0	90.0	93.0	94.0
3	74.0	76.0	77.0	79.0	76.5	92.0
4	72.0	73.0	73.5	77.0	75.0	78.0
5	61.0	58.0	58.5	59.0	58.5	60.0
6	54.0	73.0	73.0	80.5	73.0	73.0
7	91.0	82.0	97.0	96.5	98.0	100.0
		*			*	
Moisture Content Sample	**Percentage**					
1	19.5	17.5	15.5	12.5	11.5	9.1
2	19.5	17.5	15.5	12.5	11.5	9.1
3	19.5	17.5	15.5	42.5	11.5	9.1

Weather conditions: Dry and dull with light southerly wind

the grain to carry the moisture away. Only when the layer of grain is sufficiently thinly spread is the moisture evaporated off. The regularly quoted domestic grain drying activities of the Western Highlands and Islands of Scotland depend upon the passage of hot air through the grain. A general summation of this ethnographic evidence is as follows: a grid of sticks is set well above the fireplace in the chimney recess, over this grid is generally spread a layer of straw and finally a cloth or sack is laid over the straw. The grain is placed on the sacking and watched over carefully in case of fire. Inattention could be disastrous. Quantities of grain dried at any one time are very small. There also is a tradition of corn-drying kilns in the Northern Isles but none of them correlate with the so-called Romano-British corn driers. In general terms they are much smaller and depend invariably upon the passage of hot air through the grain to dry it. A description of drying oats survives from the Orkneys. About four sacks of oats spread to a depth of about 7 cm on a drying floor slightly over 2 m in diameter takes six to eight hours to dry (Fenton 1978). The expectation of output ironically correlates to the results presented in Tables 6–8. In the Western Highlands and Islands, however, there is every need for some system of drying certainly small quantities of grain because the elements are, to say the least, hostile.

The evidence of corn driers happily adduced from the Romano-British period, on the other hand, must now be in some question. Within the confines of this paper there is not the space to examine the obvious implications of these findings. Certainly the theories propounded by Goodchild that corn driers may be 'a deliberate policy initiated by central government' (Goodchild 1943, 152), and by Applebaum who used the evidence of corn driers as representative of socio-economic conditions in Late Roman Britain possibly connected with the *annona* (Applebaum 1972, 164) should be reviewed. This is a theme to be developed independently. None the less these structures, whether of 'T'-plan flues or more exotic designs as the one tested here, seems to represent an anomaly within the Romano-British agricultural system of the second, third and fourth centuries A.D. It would on present evidence appear to overstate their importance to suggest that they are a significant element of change within the overall agricultural economy. There are far too few of them despite the concentrations at Hambleden, Woodcutts and West Blatchington (Cocks 1921; Pitt-Rivers 1887; Hawkes 1947; Norris and Burstow 1951), to suggest a response to a radical climatic change. Indeed there is virtually no other evidence for any dramatic worsening of the climate during these centuries (Stratton 1969). Further, a significant percentage of 'so-called grain driers' are cut into abandoned rooms of villas, a practice which is hardly commensurate to agricultural change. Finally there is considerable doubt that a specific structure is required at all to dry the harvest. Indeed the grain drier as an economic as opposed to a domestic structure is a specific feature of the present century.

Indeed from a farming point of view it is difficult to see the need for a drier at all. Traditional methods of storing sheaves of harvested corn in stacks, in barns or simple covered areas have been successfully employed for hundreds of years. The simple stack of sheaves with heads or spikes of the cereal laid to the centre of the stack will air-dry in a relatively short period of a few weeks. Country lore has it that it can be stacked

TABLE 8

Thermocouple No.	Temperatures in degrees Centigrade						
1	190.0	172.0	172.5	152.5	147.0	169.0	174.0
2	90.5	77.0	79.0	78.0	78.0	79.0	86.0
3	88.0	71.0	78.0	77.0	77.0	78.0	82.0
4	76.0	76.0	78.0	77.0	78.0	77.0	76.0
5	61.0	73.5	74.0	74.5	74.5	72.0	74.0
6	71.0	98.0	97.0	97.5	97.5	96.0	94.5
7	96.0 *	97.5	98.0	98.0	74.5 *	82.5	89.0
Moisture Content Sample	**Percentage**						
1	20.9	19.0	18.0	15.5	15.2	12.5	10.0
2	20.9	19.0	18.0	15.5	12.5	12.0	9.5
3	20.9	19.0	18.0	15.5	13.5	12.5	10.5

in this way with 'water running out of the carts' and still dry (pers. comm. W. F. Budden). Similarly wheat in the ear or threshed, when spread out on a dry barn floor will dry perfectly adequately. Given the results not only of these experiments but also the ethnographic evidence from Scotland and the Northern Isles, the absurdity of the situation is that the farmer would be hard put to dry his corn in a 'corn drier' before it dried naturally.

If these structures are not corn driers and in the light of the evidence to date it is improbable, it is necessary to propose an alternative function rather than provide yet another negative. At the end of the experimental sequence seeking to test the functional viability of the reconstruction, one further trial was made to test the hypothesis that such structures may in fact be used as malting floors. The stimulus for this hypothesis came from two specific sources. The first is from a recent excavation of a Romano-British site at Barton Court Farm, Abingdon, Oxford. There in the flue of a 'T'-plan 'drier' a quantity of carbonized seeds of barley were recovered. On examination it was discovered that these seeds had sprouted or in brewing terms 'chitted' (pers. comm. M. Jones). In effect the seed had germinated and the sprout had reached a length commensurate with the seed itself. In simple terms this is the point at which in the malting process the seed is roasted to terminate the germination, the starch having turned into sugar. The second source is the temperature patterns from the floor of the reconstruction. These, averaging over the floor area some 60–70° centigrade, are ideal for the malting process.

The trials took place over a two-week period in late September. The resultant malt was sampled and analysis was carried out by Briant & Harman, Consulting and Analytical Chemists of London. Their analysis is presented in Table 9 below.

TABLE 9

Moisture %	5.1%
Colour 25 mm cell EBC Scale	43°
Diastatic Power° IoB	2°
Cold Water Extract %	15.7%
Total Nitrogen % on dry basis	1.74%
Total soluble Nitrogen % on dry basis	0.425%
Soluble Nitrogen Ratio	24.2%

The malt was compared to the Amber malts of the period 1935–45. Its percentage of soluble nitrogen is but a fraction below the target figure of 0.45% which was traditionally used by Guinness. Its manufacture into a suitable ale is at present being contemplated. In brief, the malt was regarded as quite suitable for the manufacture of an ale and its production was accepted as quite successful.

In conclusion it would seem that the results from the extensive trials carried out in this reconstruction is that the commonly held interpretation is in some real doubt.

Clearly there is need for more experimentation not only with this structure but also with the more common design of a 'T'-shaped flue. Indeed one of these is at present under construction based upon the evidence from Barton Court Farm, Abingdon, Oxford, and a report will be forthcoming in due course.

However, the principle of operation as generally agreed for all the various types of drier is sufficiently similar to anticipate similar results. An alternative hypothesis, that these structures are malting floors, is offered above as a valid potential function. Yet it must be stressed that while this hypothesis does fulfil the requirement for a specialist structure it is not exclusive of other possible functions.

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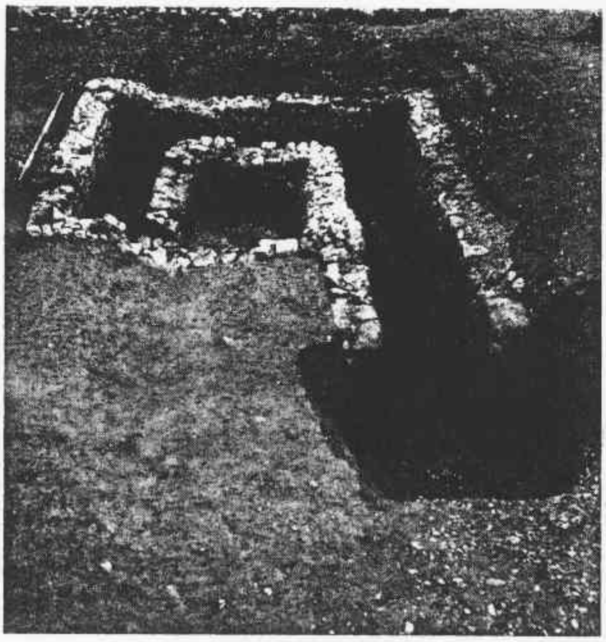
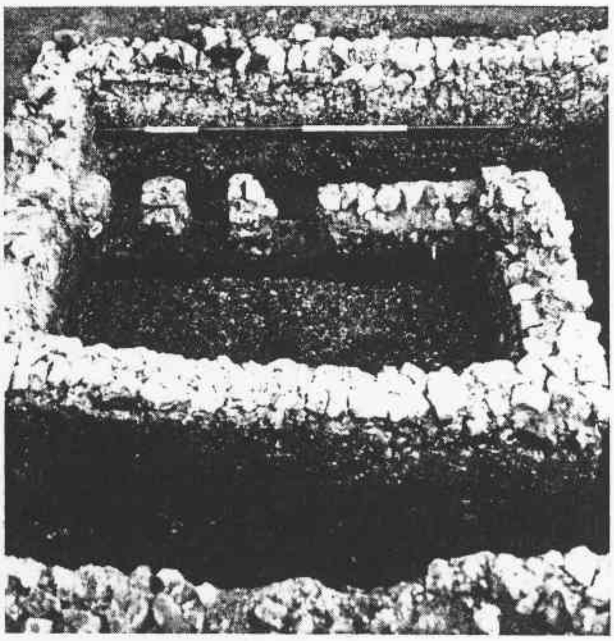


A. The site as excavated from the north
(*photo: C. Partridge*)



B. Inner chamber from the west
(*photo: C. Partridge*)

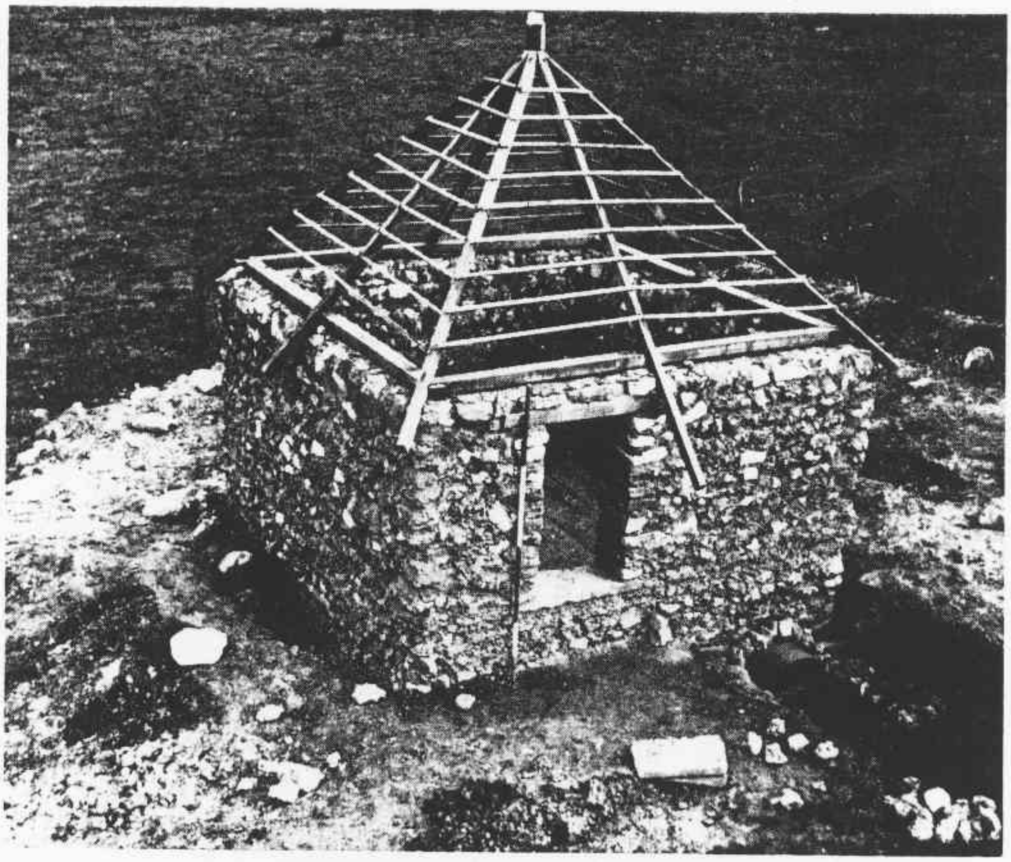
C. The archaeological evidence reconstructed
(*photo: P. J. Reynolds*)

A. Timber joists in position

(*photo:* P. J. *Reynolds*)

B. Joinery detail of wall plate and rafter

(*photo:* P. J. *Reynolds*)

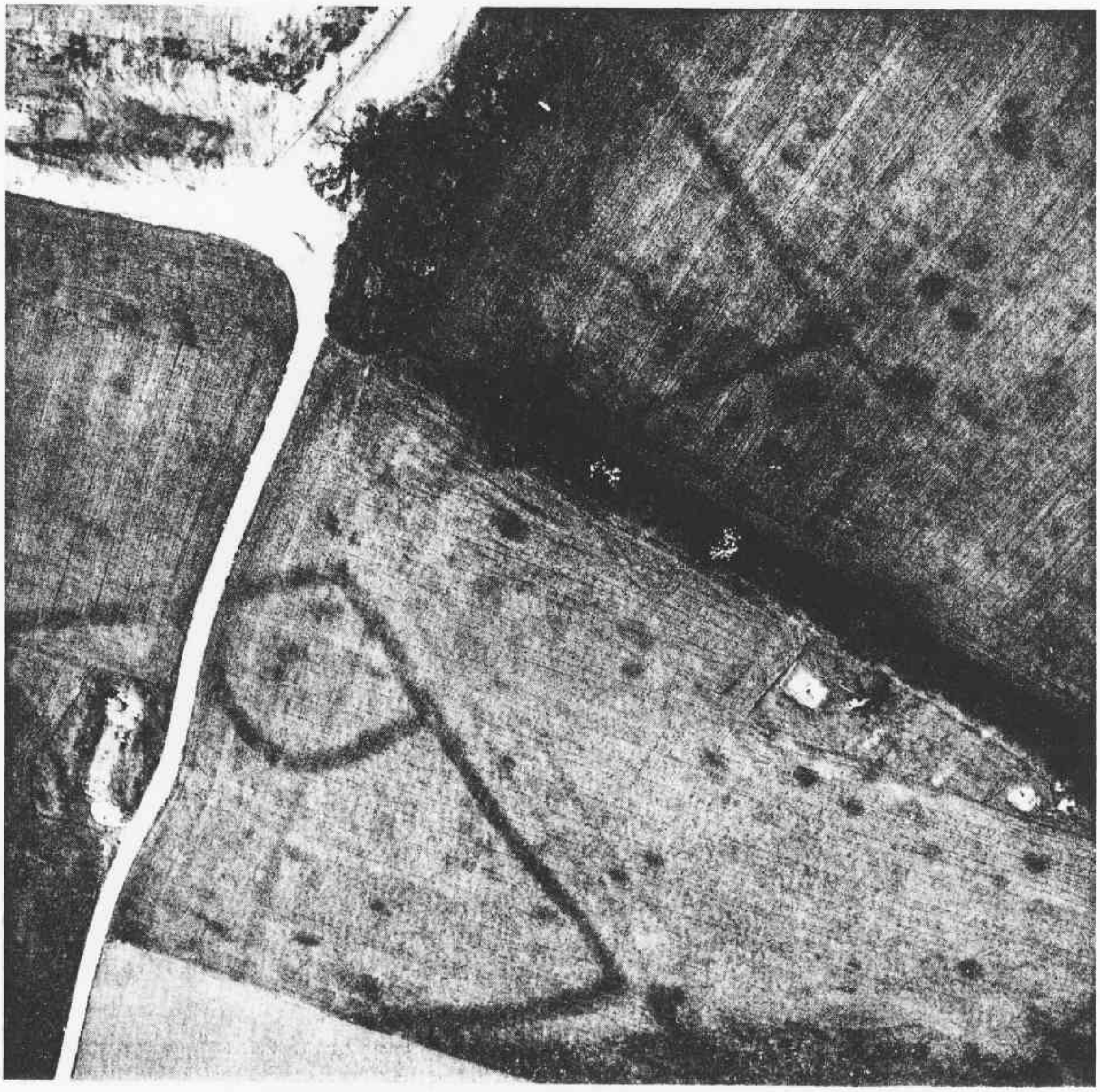


A. The penultimate stage of construction

(*photo: P. J. Reynolds*)

B. The completed structure with lime-washed walls, thatched roof and arched flue

(*photo: P. J. Reynolds*)



Cropmarks in barley of ditches and sunken huts at Mucking, Essex.
Two huts are being excavated in advance of quarrying

(N.M.R. *air photograph*)

Saxon Sunken Huts