

Experimental Kiln Firings at Barton-on-Humber, S. Humberside 1971

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TECHNIQUES ASSOCIATED with the firing of replica medieval open-topped, double-flued, and multi-flued updraught kilns have been investigated and are reported here. Particular interest has been taken in the method of forming a cover for the loaded kiln oven, and various solutions are discussed. The experimental open-topped kilns were capped rather than built with a permanent dome.

DETAILS of the substructure of Romano-British and medieval pottery kilns are well known from excavations, and it can be stated with confidence that they were all either intermittent updraught kilns (with one, two, or — in the late medieval and post-medieval periods — up to six flues) or clamp kilns.¹ Details of the superstructure of the updraught kilns is difficult to recover archaeologically, and where evidence does seem to be present it is all too often annoyingly enigmatic. The kiln superstructure is necessary in order to form an oven in which the unfired pottery can be stacked and in which the necessary high firing temperature and required atmosphere, oxidizing or reducing, can be subsequently produced. This can be accomplished in two ways: either, a free standing dome is built over the oven and can be used for successive firings; or, the pottery is loaded into an open-topped oven and supports the weight of a layer of capping material which is removed at the end of the firing.

KILN SUPERSTRUCTURES

Musty, in his latest statement on kiln superstructures, warns that “excavators should approach the excavation of a site with an open mind on the question of kiln superstructure and test for one of three possibilities, any of which might apply to the site, i.e. permanent dome, temporary dome, or open-topped”.² Further consideration of these alternatives is necessary.

¹ The most useful summaries are: for Romano-British kilns, P. Corder, ‘The structure of Romano-British pottery kilns’, *Archaeol. Jnl.*, cxiv (1959), 10-27; for medieval kilns, Musty (1974); and for post-medieval kilns, P. C. D. Brears, *The English Country Pottery* (Newton Abbot, 1971), 137-51.

² Musty (1974), 56.

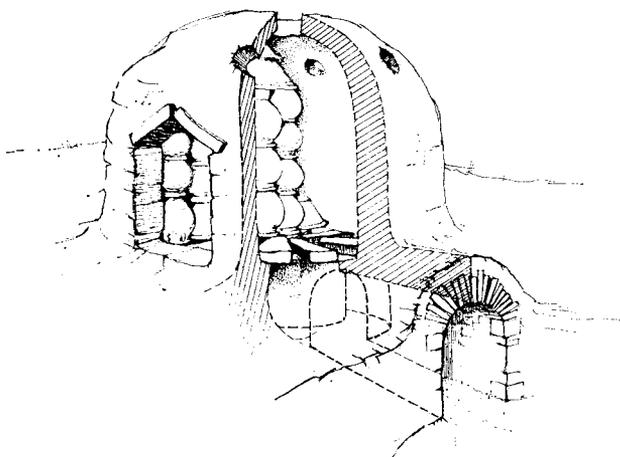


FIG. 37

SUGGESTED RECONSTRUCTION OF DOMED KILN

Door into oven is more likely to have been present in larger domed, multi-flued kilns. *Drawn by David Morris*

- i) *The domed kiln.* This involves the construction of an igloo-type roof which is an integral part of the kiln oven, and whose great advantage is that it can be used for many successive firings. There is clear evidence that this type has been used by potters for at least five millenia: it was known, for example, in Mesopotamia, *c.* 3500 B.C., among the Greeks *c.* 500 B.C.,³ and is still in widespread use in the Mediterranean today.⁴ The building of a permanent dome will involve the potter in an initial outlay of much time and effort but, once completed, much time saving should ensue. Many of these kilns are seen to have a door in the oven wall to facilitate loading.⁵ Having described these domes as of igloo form it is tempting, but wrong, to think that all pottery kilns were like igloos, i.e. that their height was about equal to their diameter. Clearly some had high, vertical oven walls on top of which the dome was built; thus the small diameter oven pit revealed in some excavations may have been the substructure of a kiln capable of firing hundreds of pots. Permanently domed single, double, and multiflued kilns have now been fired experimentally for archaeological purposes on many occasions and reports are available of the firings at Leeds,⁶ Barton-on-Humber,⁷ and Kettering.⁸

³ Hodges (1970), 57-9, and figs. 172-3.

⁴ I have been informed by J. M. Steane that there are numbers of these kilns still being fired at Old Cairo, and many others are illustrated in Hampe and Winter (1962). A domed kiln at Shigaraki, Japan, is shown in *Ceramic Review*, xxxi (1975), 10: it is loaded through the flue.

⁵ In experimental firings at Leeds and Barton-on-Humber, where permanently domed kilns were loaded through the vent, the task proved time-consuming, uncomfortable, and, as far as the quality of the pottery stack was concerned, somewhat unsatisfactory. See Musty (1974), 54; Bryant (1973), 154.

⁶ *Current Archaeol.*, iv (1967), 94-7; P. Mayes, 'Notes supplied with Medieval Pottery Teaching Unit' (unpublished).

⁷ Bryant (1970), 1-16; G. F. Bryant and J. M. Steane, 'Excavations at the deserted medieval settlement at Lyveden', in *Jnl. Northampton Museum and Art Gallery*, ix (1971), 77-85.

⁸ Bryant and Steane, *op. cit.* in note 7, 84-9.

- ii) *The open-topped kiln.* Here the kiln wall would be carried up vertically to form an open-topped oven, rather than corbelled inwards to form a dome. This oven is subsequently loaded with pottery which is then made to bear the weight of a capping of suitable material: broken sherds, tile, sand, earth, or turves. Such a capping will adequately fulfil its intended role of retaining heat within the oven, and when the firing is completed it is merely thrown aside before the pottery is removed. Open-topped kilns appear also to have a very

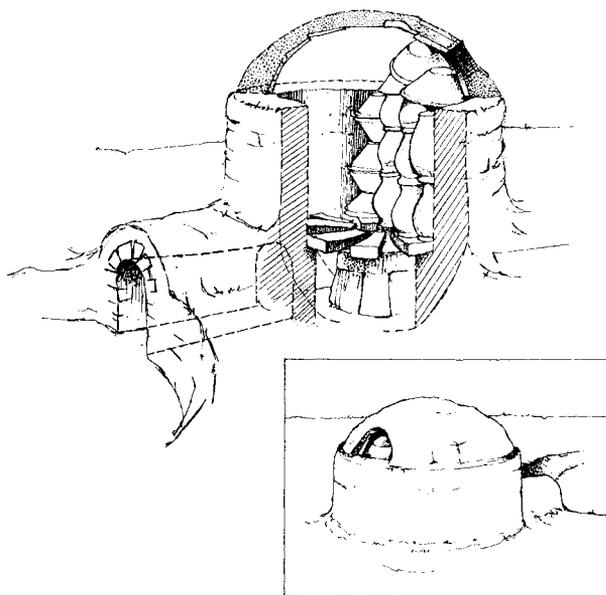


FIG. 38

SUGGESTED RECONSTRUCTION OF OPEN-TOPPED KILN

with rear exhaust vent. *Drawn by David Morris*

long antiquity and have been used by potters since at least 3000 B.C. Hodges has published a kiln reconstruction based on a number of Egyptian tomb paintings of that date which clearly show tall, chimney-like, open-topped kilns. At Derby Racecourse Brassington found a Romano-British pottery kiln with "evidence of a moulded oven-lip" indicating that the kiln was open-topped;⁹ similar kilns, of medieval date, have been suggested at Lyveden.¹⁰ More recently Musty describes an open-topped kiln fired at Verwood, Hants until c. 1920,¹¹ and they are at present in use in many parts of the

⁹ M. Brassington, 'A Trajanic kiln complex near Little Chester, Derby, 1968', *Antiq. Jnl.*, LI (1971), 40, and fig. 2.

¹⁰ J. M. Steane and G. F. Bryant, 'Excavations at the deserted medieval settlement at Lyveden, Northants', *Jnl. Northampton Museum and Art Gallery*, XII (1975), 53, fig. 7.

¹¹ Musty (1974), 55.

world including the Mediterranean¹² and Central America.¹³ There seem to be two forms which this type of kiln can take: a tall, chimney-like structure¹⁴ where the load rises slightly, if at all, above the lip of the oven wall; and a lower, squatter kiln where the load forms a mound well above the height of the lip.¹⁵

iii) *A temporary dome.* As described these domes are free-standing structures built over an open-topped kiln oven after it has been loaded with green pottery, and are rebuilt for each individual firing. The archaeological and ethnological evidence for such domes is hard to find. Such a dome would be justified if it were easier to build than a permanent dome, and or more efficient to fire than a capped, open-topped kiln: as neither of these would seem to be the case, it is hard to see any potter wasting his time building one. Jenkin's proposed superstructure for the Romano-British Kiln 2 at Canterbury¹⁶ is well known, but hardly convincing. He suggested that the potter was prepared to go to considerable trouble in building a dome reinforced with a framework of sticks, ties, and ribs; he further implied that this was rebuilt for every firing. But it is hard to see any potter taking more time and effort to build a temporary structure than is evidenced for the vast majority of permanent kiln domes; this was surely a well-built permanent dome. Temporary domes are suggested for the medieval kilns at Brill¹⁷ and Upper Heaton,¹⁸ and the post-medieval kiln at Potterton, but in each case the available evidence would better fit a capped load. Mayes specifically states that the Potterton dome would have "internal support from the pre-fired saggars",¹⁹ and it would clearly be impossible to build a free-standing dome over a loaded oven of the size found at Upper Heaton.

The use of the term temporary dome, indicating a free-standing structure built over a loaded kiln oven, should be discontinued. The primary terms defining a kiln superstructure are then:²⁰

- A. *Clamp* — in which fuel is an integral part of the kiln load and superstructure.
- B. *Dome* — where a permanent, free-standing, structure forms a roof over the kiln oven. The term dome will specifically apply to the kilns

¹² Information kindly collected by A. Russell in Algeria; and for Crete see Hampe and Winter (1962), pl. 44, figs. 8-9, 20-1, 47, and *Ceramic Review*, xxiv (1973), 15-16.

¹³ For a peasant pottery in Panama firing an open-topped kiln, see *Ceramic Review*, xxxiv (1973), 15-16.

¹⁴ Hodges (1970), figs. 52-3; Hampe and Winter (1962), pl. 23(4) and 44(5). For the Romano-British pottery kilns at Holbrook, Derbs., see S. O. Kay, 'The Romano-British pottery kilns at Hazelwood and Holbrook, Derbyshire', *Derbyshire Archaeol. Jnl.*, lxxxii (1962), 21-9.

¹⁵ D. Rhodes, *Kilns, Design, Construction and Operation* (London, 1969); M. Brassington, op. cit. in note 9.

¹⁶ F. Jenkins, 'A Roman tiler and two pottery kilns at Durovernum (Canterbury)', *Antiq. Jnl.*, xxxiv (1956), 50-3.

¹⁷ E. M. Jope, 'Medieval pottery kilns at Brill, Buckinghamshire: preliminary report on excavations in 1953', *Records of Bucks.*, xvi (1953-4), 39-41.

¹⁸ T. G. Manby, 'Medieval pottery kilns at Upper Heaton, West Yorkshire', *Archaeol. Jnl.*, cxxi (1965), 101.

¹⁹ P. Mayes and Miss E. J. E. Pirie, 'A Cistercian ware kiln of the early sixteenth century at Potterton, Yorkshire', *Antiq. Jnl.*, xlvi (1966), 262, fig. 5.

²⁰ I am grateful to J. W. G. Musty for his help in drafting this section of the report.

with a basically circular ground plan and an igloo-like superstructure. Square or rectangular kilns with a permanent roof in the form of a barrel vault should be referred to as arched kilns.

- C. *Open-topped* — these can have either a circular or rectangular ground plan but in each case the kiln load supports, and is covered by, a capping laid at the beginning and removed at the end of each firing.

FIGS. 37 and 38 show possible, very idealized, reconstructions of the domed and open-topped kilns.

EXPERIMENTAL KILN FIRINGS

The experiments described below were carried out in 1971 by students in a class organized by the Workers' Educational Association at Barton-on-Humber, Lincolnshire, and directed by the author. The purpose of the experiments was to investigate the techniques associated with the firing of open-topped kilns loaded with glazed and unglazed wares to be oxidized.²¹ It was decided that the experimental kilns would be of the double and multi-flued updraught types, i.e. Musty's types 2a and 3. Two double-flued, open-topped kilns were built and were used to investigate: first, whether, for optimum results, the loaded oven should be capped before the firing began, or later in the firing cycle; secondly, methods of stacking a mixed load of glazed and unglazed wares in a kiln of this type. One open-topped multi-flued kiln was built with three flues.²²

It was intended to fire one of the double-flued, open-topped kilns, without any capping until a temperature of *c.* 900°C. had been reached, and then a capping of broken pottery, tiles, and turves would be added to retain the heat for a period of 'soaking' before cooling began. The other double-flued kiln would be given a capping of pottery and tile soon after firing began, and on top of this a layer of turves would be laid at a later time during the firing. This point would be determined largely by the efficiency of the kiln. If the completely open top seemed to result in a waste of fuel, i.e. if the rise in temperature did not seem commensurate with the amount of fuel being used, the turves would be applied immediately and any increase in efficiency noted.

In the Barton-on-Humber experiments of 1970 it was suggested that if the wares were stacked upside down, and with open mouths, each pot would form a small dome within the whole load and thereby retain the heat during the firing.²³ However no glazed wares were fired in those experiments. A particular problem arises in the case of glazed jugs, for examination of medieval examples shows that they were frequently fired in 'bungs', i.e. they were fired inverted, one directly on top of another, and so not having an open mouth to retain heat in the load.²⁴

²¹ Bryant (1971), 1–20; idem, 'A Romano-British pottery kiln at Claxby, Lincolnshire; excavation, discussion, and experimental firings', *Lincs. Hist. and Archaeol.*, xii (1977), forthcoming.

²² *Op. cit.* in note 6 for details of previous experimental medieval kiln firings. These were double and multi-flued kilns with permanent domes.

²³ Bryant (1971), 17.

²⁴ This practise was not universal, for at Laverstock (kiln 6) the jugs were overlapped in the stacking, see Musty, Algar, and Ewence (1969), 90; and for further discussion of kiln stacking see Musty (1974), 53–6.

It may be suggested, however, that if the 'bungs' of jugs are placed in the centre of the kiln oven, and inverted and overlapping cooking pots, pancheons, or similar large-mouthed hollow wares placed around, and particularly over the top of them, these latter would be sufficient to retain large amounts of heat within the oven and so considerably increase the efficiency of the kiln. Successful experiments using this technique produced good quality glazed wares at Leeds in 1967, though here the kiln was a flueless clamp.

It should be remembered that whilst the form of stacking here recommended may produce an efficient firing, i.e. keep fuel consumption to a minimum, it is also possible that it may produce the maximum number of well-fired glazed jugs. Mayes has noted in relation to the stacking of the kiln at Potterspurty that "it is reasonable to suppose that pots putting a great demand on the potter's skill will be placed in positions in the kiln where they are least likely to waste".²⁵ The Leeds experiments seemed to confirm this assumption, and it was hoped that these experiments would add further evidence.

THE DOUBLE-FLUED KILNS (FIGS. 39, 40; PL. VIII, A)²⁶

Kiln 1. Initially three hollows *c.* 23 cm. (9 in.) deep were dug into the subsoil. The centre one, 1.4 m. (4 ft. 6 in.) in diameter, was lined with clay to form the kiln oven pit, and a wall 30 cm. (1 ft.) high was built above the ground surface to give a completed oven wall *c.* 50 cm. (1 ft. 9 in.) high. The flues were built to N. and S. of this oven. Both were 30 cm. (1 ft.) wide, but the S. flue was 40 cm. (1 ft. 4 in.) high and the N. flue only 33 cm. (1 ft. 1 in.) high. Because of the friable nature of the clay when dug straight from the ground it was impossible to use it for the construction of the flue arches, which were built of clay plugged in the nearby mill. The hollows dug to N. and S. of the oven served as stoke pits.

Kiln 2. This was constructed in the same way as kiln 1 but had slightly larger dimensions.

No difficulties were encountered during the building of the kilns. They were allowed to dry naturally for fourteen days before being pre-fired for six hours. The resulting large cracks in the kiln floor, walls, and flues were repaired with slurry heavily tempered with sand. Four thermo-couples were inserted in each kiln. These would record the temperatures around the side walls, and at the centre top and centre bottom of the oven (FIG. 40).

The kilns were loaded with a mixture of wheel-thrown and handmade pottery,²⁷ some of the former being pre-fired plant pots. There was a large variety of sizes, and some of the wares were glazed. In the centre of each kiln were placed 'bungs' of glazed jugs; these were surrounded by cook pots and jars stacked upside

²⁵ P. Mayes, 'A seventeenth-century kiln site at Potterspurty, Northamptonshire', *Post Medieval Archaeol.*, 11 (1968), 71.

²⁶ The kilns were built at the Hoe Hill Tileworks, Barton-on-Humber (TA 038234) where estuarine clays are found immediately below the surface; these were used for building the kilns either in the form of blocks or semi-liquid slurry.

²⁷ Three types of clay were used: for the handmade pottery the local estuarine clay and Podmore's B31 red earthenware clay, and for the thrown ware Potclay's St Thomas's body.

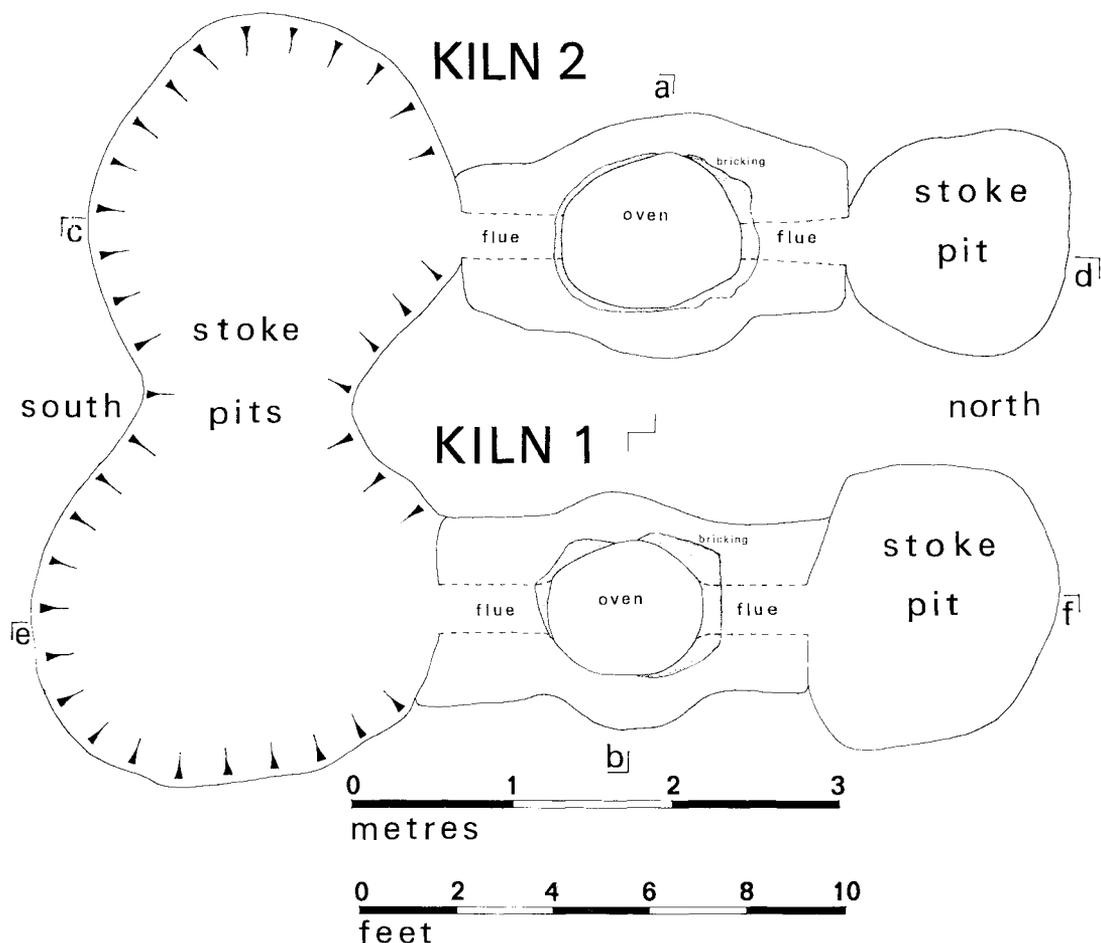


FIG. 39
PLANS OF TWO EXPERIMENTAL DOUBLE-FLUED KILNS

down, but with their mouths open, i.e. the rims were not sealed by being placed directly on top of the base of the pot below. A layer of pancheons and large cook pots covered the whole load (PL. VIII, B).

Sixty-four pots were loaded in kiln 1, of which only three were plant pots, and although the scale of FIG. 42 is only approximate it is possible to see the variety of shapes and sizes. This variety makes stacking difficult but even so the kiln was loaded in just under two hours. Ninety-six pots were loaded into kiln 2. This figure does not include a layer of pre-fired plant pots which were used to cover the oven floor, but does include twelve plant pots in the upper load. All the pots are not shown in FIG. 42 for this load was even more difficult to stack than in kiln 1, and no real layering was possible. Loading took slightly over two hours.

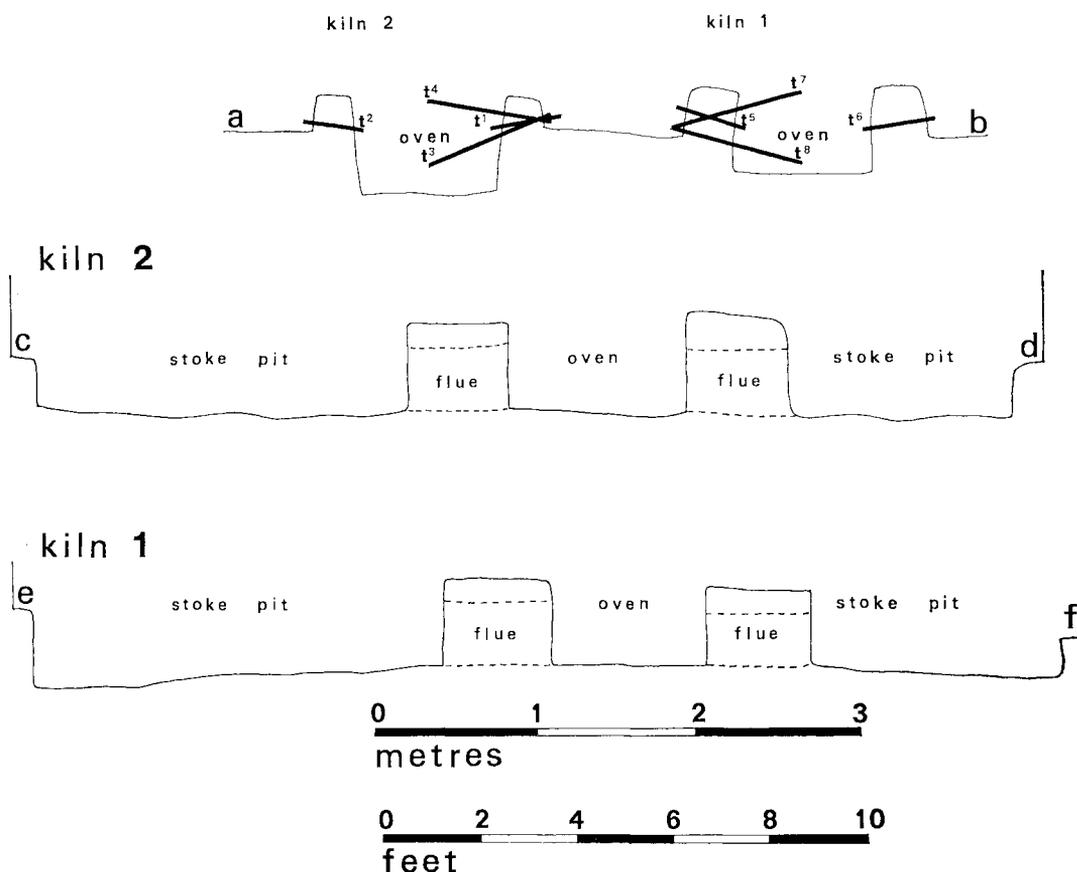


FIG. 40
SECTIONS OF TWO EXPERIMENTAL DOUBLE-FLUED KILNS

The firings

Firing of kiln 1 commenced without any form of cover over the load and in a strong, blustery wind (PL. VIII, B). Immediate difficulty was encountered in keeping a fire of approximately the same size in each flue, and in maintaining a steady rise in temperature within the oven. After firing for about two hours a temperature of *c.* 100°C.²⁸ was reached, many of the top layer of pots had already broken, and there had been other explosions within the load. However it was apparent that heat was retained beneath the inverted pottery, and there was little noticeable heat loss around the kiln wall. During the next one and a half hours of the firing there was a considerable rise in temperature around the oven walls, though the E. wall (t^6), was slightly warmer than the W. (t^5). It was now clear that the cold

²⁸ These are average readings of the four thermo-couples — details of the readings at each point are shown in FIG. 41.

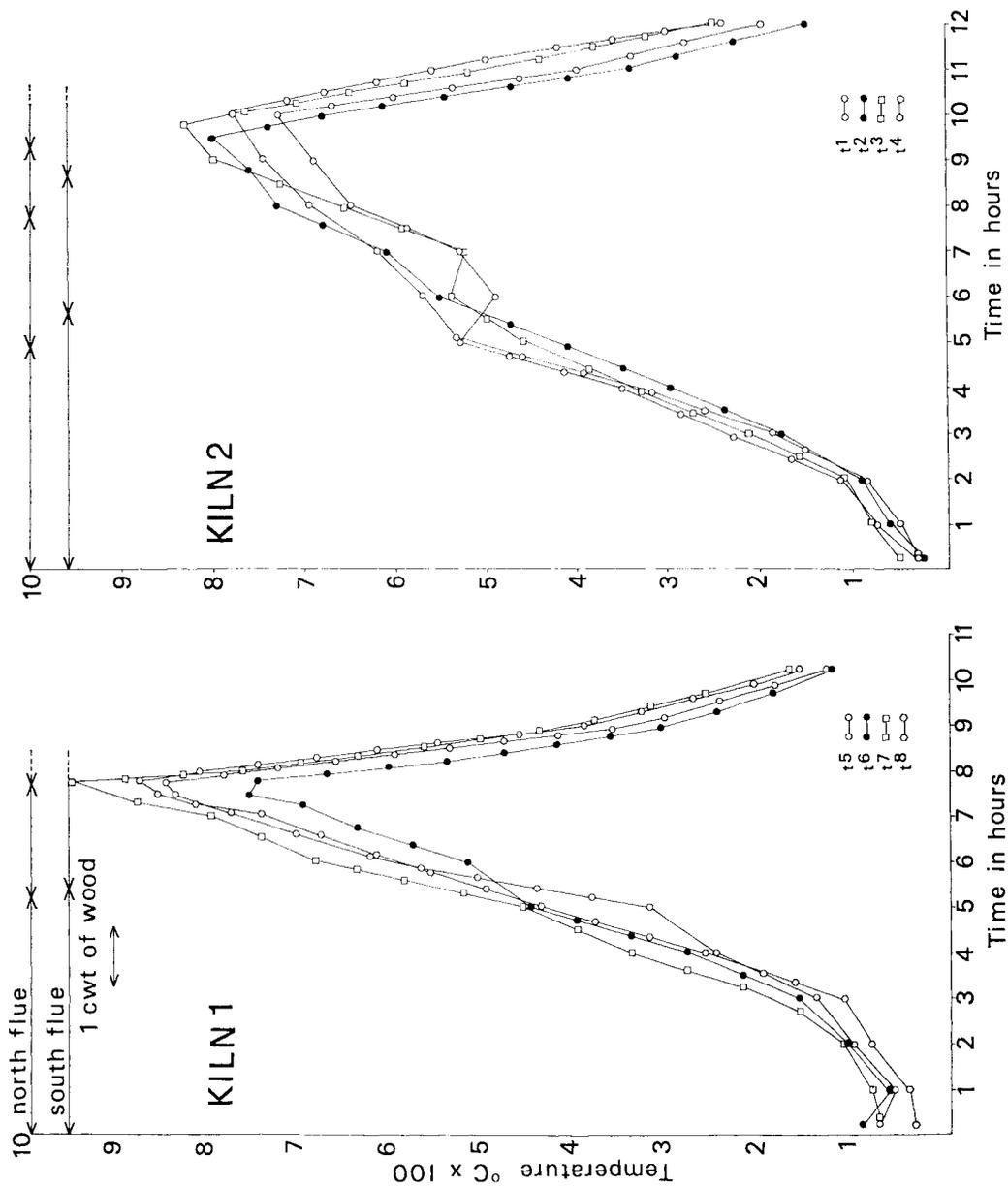


FIG. 41
KILN TEMPERATURE AND FUEL CONSUMPTION GRAPHS

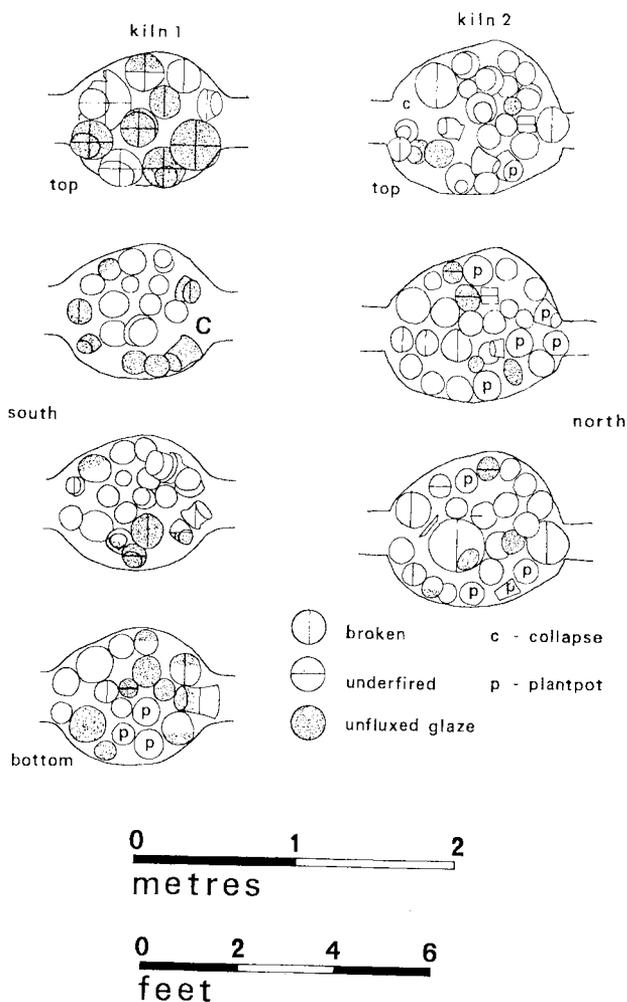


FIG. 42
KILN LOADS AFTER FIRING
Pottery is drawn approximately to scale

spot was developing at the centre bottom of the oven (t^8), and the highest temperature was at centre top (t^7). Further explosions within the load were heard. After three and a half hours firing the kiln seemed to be settling down — the wind had dropped appreciably, only one further explosion within the load was noted, and the temperature rose steadily and easily. The centre bottom cold spot became much less noticeable.

Five and a half hours after firing began, and still with a totally uncovered load, there was a violent thunderstorm. The downpour of cold water on the now red-hot pottery resulted in many breakages and it was felt essential that some cover was placed on the load. Consequently it was covered with a layer of tiles

(PL IX, A). This action had an immediate beneficial effect on the firing. Both flues now pulled consistently, and an hour later glazes were seen to be fluxing in the middle of the load. The last stages of the firing saw a steady rise in temperature within the oven. The earlier tendency for the eastern side to be hotter than the western side was reversed, and by the end of the firing a difference of over 100°C . was noted. The temperature at the bottom centre of the oven always remained lower than the centre top.

After seven and three-quarter hours firing ceased. The thermo-couples read: t^5 : 850°C .; t^6 : 750°C .; t^7 : 955°C .; t^8 : 880°C . The average kiln temperature was 859°C . The amount of wood consumed totalled $5\frac{1}{2}$ cwt. (*c.* 280 kg.), and both flues had burnt approximately the same amount. The first hundredweight (50 kg.) in each flue lasted five hours and ten minutes, and the second hundredweight only two hours and twenty minutes.

The kiln was cooled for two and half hours. For the first twenty-five minutes the kiln was left unstoked and only partially capped. At this point an outer ring of turves was placed over the tiles and five minutes later further turves was placed over the centre of the load to complete the capping. The fires were shortly afterwards raked out of the flues and these were sealed with bricks and turves (PL. IX, B). By this time the temperature within the oven had fallen to about 450°C . Cooling proceeded for a further one hour and forty minutes, during which time the flues were partially opened. The kiln was ready for unloading ten hours, fifteen minutes after firing began.

Firing of kiln 2 commenced without any cover over the pottery load. As in kiln 1 there was an initial cold spot in the centre bottom of the oven which was to last some three and a half hours. The very blustery wind conditions made it difficult to control the fires. After two hours firing a temperature of just over 100°C .²⁸ had been reached and there had been a number of explosions within the load. It was also evident that more fuel was being used in the northern flue than in the southern one. As a result of these observations it was decided to place a row of tiles around the outer edge of the load and, although there were a few further explosions, firing proceeded much faster and it was much easier to control the kiln, maintaining a steady, even rise in temperature. Further tiles were placed over the load at the onset of the thunderstorm (five and a half hours after firing began) and only a small opening was left in the centre to act as an exhaust vent (PL. IX, A). By this time the highest temperature in the oven was at centre bottom.

It proved difficult to raise the kiln temperature during the last five hours of the firing. Attempts were made to do this by reducing the size of the fuel being fed into the flues, and by constant raking out in order to promote an increase in draught. Although a rise to *c.* 785°C . was achieved it was clear that any further progress would be extremely difficult and would use large amounts of fuel. After firing for ten hours five minutes it was decided to cap the load completely for cooling, and this was done as for kiln 1. A total of 7 cwt. of fuel (370 kg.) had been used, with the northern flue burning about $\frac{1}{2}$ cwt. (25 kg.) more than the southern flue. The kiln was ready for unloading thirteen hours after the firing began.

BARTON ON HUMBER

Experimental kiln

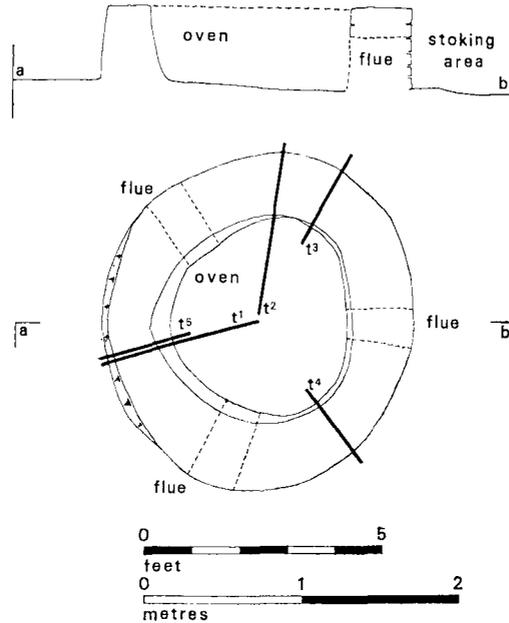


FIG. 43

PLAN AND SECTION OF EXPERIMENTAL MULTI-FLUED KILN

THE MULTI-FLUED KILN (FIG. 43; PL. X, A)

Archaeological evidence is available for the use of permanent and open-topped kilns in the post-medieval period. The evidence for the former has been reported²⁹ and it seems likely that the kiln excavated at Potterton is an example of the latter.³⁰ There is, however, a sad lack of reported evidence for the method of doming used on medieval multi-flued kilns. When such evidence is available it will be surprising if it does not point to the existence of certainly open-topped, and probably permanently domed kilns. The reported presence of walk-in entrances to multi-flued kilns³¹ surely indicates the use of permanent domes and or open-topped kilns with high oven walls — probably both.³²

²⁹ For a discussion of the evidence see S. Moorhouse, 'Kiln superstructures', in K. S. Bartlett, 'Excavations at Potovens, near Wakefield, 1968', *Post Medieval Archaeol.*, v (1971), 13-19.

³⁰ P. Mayes and Miss E. J. E. Pirie, op. cit. in note 19, 259.

³¹ For example at Cowick, W. Yorks, in *Medieval Archaeol.*, viii (1964), 297; Chilvers Coton, in *Medieval Archaeol.*, xii (1968), 209.

³² I am grateful to Musty for this suggestion.

The only previous experimental firing of a multi-flued kiln was at Leeds in 1967,³³ where the ground plan of the kiln excavated at Cowick, W. Yorks. was used as the basis for the replica kiln; it had six flues and a walk-in entrance. The Barton-on-Humber kiln was a far more modest affair, built at ground level, and was no more than a vertical wall of turves and clay, slightly over 50 cm. high, surrounding a circular oven 1.2 m. in diameter. Three flues were built of bricks and positioned symmetrically around the wall. There was no walk-in entrance, and the flues were not stoked from stoke-pits. Five thermo-couples were used to record the temperature along the oven wall midway between each flue, and at the centre bottom and centre top of the load.

The kiln was loaded with pots of many shapes and sizes, some of which were glazed, and all of which were inverted. Loading proved very easy for someone either standing in the oven or leaning over the low walls, and the task was completed in an hour. The load, which hardly rose above the height of the oven walls, was covered with a layer of broken pottery sherds.

The firing

At the start of the firing considerable difficulty was found in making the flues draw at all. It was necessary to have them constantly attended, and even so the fire in one flue went out altogether and had to be relit. Draw shields were used in an attempt to force a draught. Temperature readings (FIG. 44) showed that although the areas around the walls of the kiln were getting hot, little heat was penetrating into the centre of the oven, particularly at the bottom. Some four hours after firing began it was felt necessary to put some further cover over the load in order to increase the draught and attempt to force more heat into the centre of the oven. Accordingly a layer of tiles were laid over the broken pottery, leaving only a central exhaust vent. At the same time the flues were extended with an arch of bricks so that more fuel could be burnt (PL. X, A).

The first hundredweight (50 kg.) of wood was burnt in each flue in about five hours (FIG. 44), and by this time the heat was beginning to penetrate into the centre of the load. After six hours it was felt that further measures were necessary to speed up the rise in temperature. Turves were placed over the tiles in order, it was hoped, to increase the effectiveness of the exhaust vent. This did not prove successful and the temperature failed to rise any more quickly. After firing for nine hours, when it was decided to seal the kiln, the average temperature was 729°C., but it was noticeable that the temperatures recorded in the centre of the oven were, on average, higher than those around the walls. The cold spot in the centre of the oven, so apparent earlier in the firings, had gone. The total fuel consumption was just over 6 cwt. (320 kg.).

The flues were raked out completely thirty minutes after the firing ended, and they were then loosely blocked with bricks. The kiln was opened and unloading began twenty-four hours after the start of firing.

³³ Op. cit. in note 6.

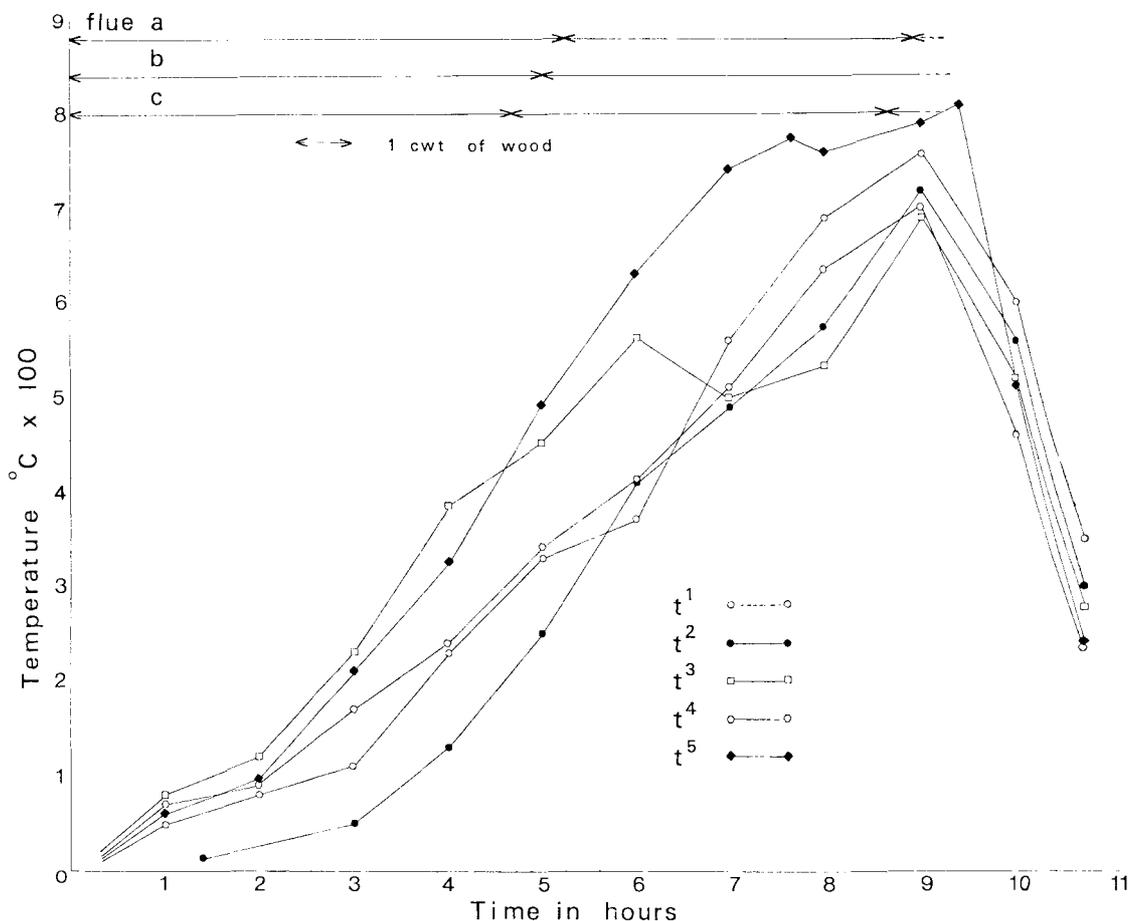


FIG. 44
KILN TEMPERATURE AND FUEL CONSUMPTION GRAPH

DISCUSSION

THE KILN BUILDING AND FIRING

The 1971 experimental firings were the first to be carried out in replica medieval open-topped kilns, and raised many interesting points, some of which should provide a basis for future work. An open-topped kiln is extremely easy to build and avoids all the time-consuming work involved in constructing the permanent clay domes used in previous experiments. The only possible difficulty is the construction of the flue arch, but experience has shown that a practised work force will quickly master the job. There seems no reason then to suppose that the medieval potter would not be able to construct kilns such as these very quickly and that, once built, they would be reusable for many years. It has been estimated

that the Laverstock kilns would have a life of about five years, and be capable of between fifty and 100 firings during this period.³⁴ This may well be an underestimate, for many kilns used by peasant potters today are said to last decades rather than years; an average kiln-life of twenty to thirty years is not unlikely in many cases.³⁵

The loading of the kilns was very easy even though the pottery available was of many different shapes and sizes. The medieval potter would obviously make loads to 'fit' his kiln which would make the task even easier. It was clear that stacking the vessels upside down and, wherever possible, with open mouths helped to retain heat within the load, so facilitating the temperature build-up and conserving fuel.

Firing the open-topped kilns was certainly not as easy as firing previously built domed kilns, but it is likely that alterations in technique would overcome most of the problems which were encountered. It is now very clear that the load must be capped before the firing begins. If the pottery to be fired is well made and well stacked it will easily support the weight of the capping material which will: first, ensure that the pottery on top of the load is protected from violent temperature fluctuations, and is safely and thoroughly fired;³⁶ secondly, conserve fuel by retaining heat within the oven throughout the whole firing; thirdly, promote and direct the flow of gases through the kiln load and out of the exhaust vent(s). Considerable difficulty was encountered in the early stages of the firing of the double-flued kiln 1 and the multi-flued kiln; difficulty particularly associated with an inability to control the fires in the flues. Once the load had got hot, and the gas flow was directed and encouraged by the exhaust vent, the fires began to burn easily and steadily.

The firing of the multi-flued kiln was made more difficult by the low, flat-topped load which did nothing to encourage a draught through the oven, and accounted for the low average temperature achieved. Future kiln firings would certainly be easier if the load were higher and stood, chimney-like, above the top of the kiln walls. As mentioned above, the existence of walk-in entrances in many medieval and post-medieval multi-flued kilns should indicate that in these cases they had high shaft-like ovens which would encourage draught through the load.

The positioning and number of exhaust vents also requires further consideration. It has been the practice at Barton-on-Humber to use one, centre-top, vent. While this may be ideal for some kilns, it is clear that, in many cases, because of the form of the kiln and or the method of stacking the load, more than one exhaust vent would be advantageous. When firing single-flued updraught kilns it certainly has been shown³⁷ that an exhaust vent at the back of the capping avoids the cold spot at the rear of the oven which is found when this type of kiln is fired with a centre-top vent. The use of multiple exhaust vents is probably worthwhile with many kilns.

³⁴ Musty, Algar and Ewence (1969), 92.

³⁵ *Ceramic Review*, xxxi (1975), 10.

³⁶ See the discussion of the pottery, p. 121 below, and FIG. 42 for comparison of the pottery fired on top of the load in kilns 1 and 2.

³⁷ Bryant, *op. cit.* in note 21, 12.

The possible relevance of wind direction and or strength to a successful firing has been noted in numerous reports.³⁸ In previous experimental firings at Barton-on-Humber the wind was found to have no apparent effect on the firings, but during the experiments here reported the wind was very strong and blustery and it was difficult to control the fires in the flues. This was particularly noticeable in the early part of the firing when the gradual build-up of temperature necessary at this period proved difficult to maintain and the fires tended to run-away or go out. It can be seen from FIG. 41 that during the early stages of the firing of kiln 2 the N. flue consumed more wood than the S. flue, and it was felt that the wind conditions accounted for this. Once the pottery and the oven had become completely warmed, the fires began to pull constantly and the problem did not continue,³⁹ but it was felt that no future firings should be started in similar conditions.

THE POTTERY

A careful study of the pottery after the firing (results are shown diagrammatically in FIG. 42) indicated several points of interest, some of which should be noted in future experiments.

- i) Immediately obvious were the far fewer losses by breakage and underfiring in the top layer of pots in kiln 2 when compared with the top layer of kiln 1: 12½% compared with 100% were broken, and 0% compared with 70% were underfired. Clearly the kiln load should be covered before the firing begins.
- ii) The high proportion of pots in kiln 1 with unfluxed glaze was felt to be the result of too tight stacking and the partial collapse of the stack at the northern end of the kiln. In many cases the glaze had only matured on one side of the pot — usually the side nearest the flames, or where there was a good path through the nearby pots for the flames to penetrate. Glazed wares are at risk if placed against the walls of the kiln for here cold spots are likely to develop and will result in unfluxed or underfired glazes.
- iii) The pottery immediately inside the flues is in great danger and in these experiments losses were high.⁴⁰ Whether the medieval potter could produce pots which could withstand the concentration of heat in this position, or whether he used pre-fired pottery to break the flames, it is at present not possible to say. Musty has pointed out the difficulty in understanding why medieval potters persisted in using type 1a, 2a and 3 kilns without raised oven floors when the introduction of the same would have removed their pottery from the greatest danger zone.⁴¹

³⁸ It was suggested, for example, that the Upper Heaton kilns (T. G. Manby, *op. cit.* in note 18,70) were sited in an exposed, elevated position in order to allow "the strongest natural draught to assist the firing of the kilns".

³⁹ A similar conclusion was reached in the firing at Leeds, see Musty, Algar and Ewence (1969), 150 (c); Musty (1974), 57.

⁴⁰ Musty, Algar and Ewence (1969), 150 (c).

⁴¹ Personal communication with the author.

- iv) It would not be valid to draw any firm conclusions regarding wastage rates from such mixed loads. The thrown jars had fired well and there was little wastage — the glazes were all well-matured. The inside of the jugs were noticeably reduced.

CONCLUSIONS

The Barton-on-Humber experiments have shown that open-topped kilns are easily built, loaded, and fired, and can produce good quality glazed and unglazed pottery. The difficulties associated with the building and loading of previous experimental kilns with permanent domes are not encountered, and the firing qualities are comparable. A considerable number of replica Romano-British and medieval kilns have now been built and fired. They have been of many types, shapes, and sizes, and with permanent and temporary domes, or open-topped ovens. In no case has it proved impossible to produce pottery of reasonable quality.⁴² Consideration of wood-fired kilns in use today in all parts of the world shows a similar diversity of kiln types, a diversity which may even be present in a small pottery producing village or region. For example, they can have one, two, or more flues; vary greatly in diameter and oven wall height; have a wide variety of types of oven floor, or no oven floor; and can be domed or open-topped. The reasons for these variations are not immediately obvious from a study of firing techniques or of the pottery produced, and is probably best attributed to the conservatism of a peasant craft.

The medieval pottery industry was obviously equally diverse in its practices and the archaeologist should remember that the kiln substructure revealed in excavation could have supported a wide variety of forms of superstructure. These could be tall, chimney-like ovens with an open-top or permanent dome; or a low, squat oven with a high, rounded permanent dome or capped load; or even a wall-less clamp kiln. Kilns come in all shapes and sizes and attempts to interpret whole kiln forms from partial archaeological evidence are fraught with difficulty.

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⁴² Experimental firings have produced poor pottery when kilns have been fired only partially full. For a successful firing the kiln oven must be full of pots.

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