

weight of 8.81 g accords moderately well with a one-third division of the 25 g/26 g unit suggested by a number of classes of Viking-Age ingots and weights.

These appear to be the first ingots recorded from East Anglia; indeed any ornamental silver or hack-silver is rarely found in East Anglian hoards.<sup>6</sup> Yet it is not surprising that they should occur since 'foreign' coins — Carolingian, Islamic, and West Saxon/English Mercian — do occur as stray finds and as minor elements in some of the late 9th- or early 10th-century hoards. None the less, it seems clear that from as early as the 880s the currency of the southern Danelaw was dominated by locally produced coins struck to a controlled weight standard which was comparable to the former Anglian one.<sup>7</sup> A bullion economy, exemplified by these ingot finds, does not seem to have been employed extensively in East Anglia or to have survived for long after the initial Scandinavian conquest and settlement of the later 9th century.

#### ACKNOWLEDGEMENTS

We are grateful to Mr M. Bone and Mr P. West for making these finds available for study, to Dr Susan Kruse for expert advice, and to Sue White for preparing the drawings published here.

M. A. S. BLACKBURN and A. ROGERSON

#### NOTES

<sup>1</sup> M. A. S. Blackburn and M. J. Bonser, 'A Viking-Age silver ingot from near Easingwold, Yorks.', *Medieval Archaeol.* 34 (1990), 149–50.

<sup>2</sup> Coins from the site include a cut half of a plated forgery of an imitative gold solidus of Louis the Pious, dating from the second half of the 9th century; M. A. S. Blackburn, M. J. Bonser and D. Chick, 'Single-finds of Anglo-Saxon and Norman coins — 4', in M. A. S. Blackburn and D. M. Metcalf (eds.), *Anglo-Saxon Productive Sites* (Oxford, British Archaeol. Repts., forthcoming).

<sup>3</sup> E. Hawkins, 'An account of coins and treasure trove found at Cuerdale', *Archaeol. J.* 4 (1847), 112–30, 189–99; S. E. Kruse, 'The Viking-Age silver hoard from Scotby: the non-numismatic element', *Trans. Cumberland and Westmorland Antiq. and Archaeol. Soc.* 86 (1986), 79–83; G. Webster, R. H. Dolley and G. C. Dunning, 'A Saxon treasure hoard found at Chester, 1950', *Antiq. J.* 33 (1953), 22–32; B. J. N. Edwards, 'Viking silver ingots from Bowes Moor, Yorkshire', *Antiq. J.* 65 (1985), 457–59.

<sup>4</sup> S. E. Kruse, 'Ingots and weight units in Viking Age silver hoards', *World Archaeology* 20 (1988), 285–301.

<sup>5</sup> S. E. Kruse, *Viking-Age Silver Ingots from England and Wales and their Economic Implications* (unpublished Ph.D. thesis, University of London, 1988), 41–42.

<sup>6</sup> The only mixed hoard is that from Laxfield, Suffolk (1819), which is said to have been found near a silver ring; R. H. M. Dolley and K. F. Morrison, 'Finds of Carolingian coins from Great Britain and Ireland', *British Numismatic J.* 32 (1963), 75–87, at 79.

<sup>7</sup> M. A. S. Blackburn, 'The Ashdon (Essex) hoard and the currency of the Southern Danelaw in the late ninth century', *British Numismatic J.* 59 (1989), 13–38.

## A TENTH-CENTURY BELL-PIT AND BELL-MOULD FROM ST OSWALD'S PRIORY, GLOUCESTER (Figs. 3–10; Pl. v)

St Oswald's Priory, Gloucester, is represented by a ruined wall situated north-west of Gloucester Cathedral on the fringe of the medieval town (Fig. 3). The priory has its origins as an Anglo-Saxon minster founded c. 900 by Æthelflæd, Lady of the Mercians and the eldest child of Alfred the Great, and her husband Æthelred, Earl of Mercia. The ruin incorporates several phases of Anglo-Saxon fabric, the earliest of which probably dates to the original foundation; and excavations from 1974 to 1981 established the plan of the Anglo-Saxon church and enabled a reconstruction to be made (Fig. 4).<sup>1</sup>

The earliest phase of the building had no floor levels; the earliest surviving floors, located in patches, could only be assigned a *terminus ante quem* of the early 11th century. However, immediately above the construction levels and scaffolding pits of the earliest church (Period 1A) and beneath the earliest surviving floors, there was evidence of industrial

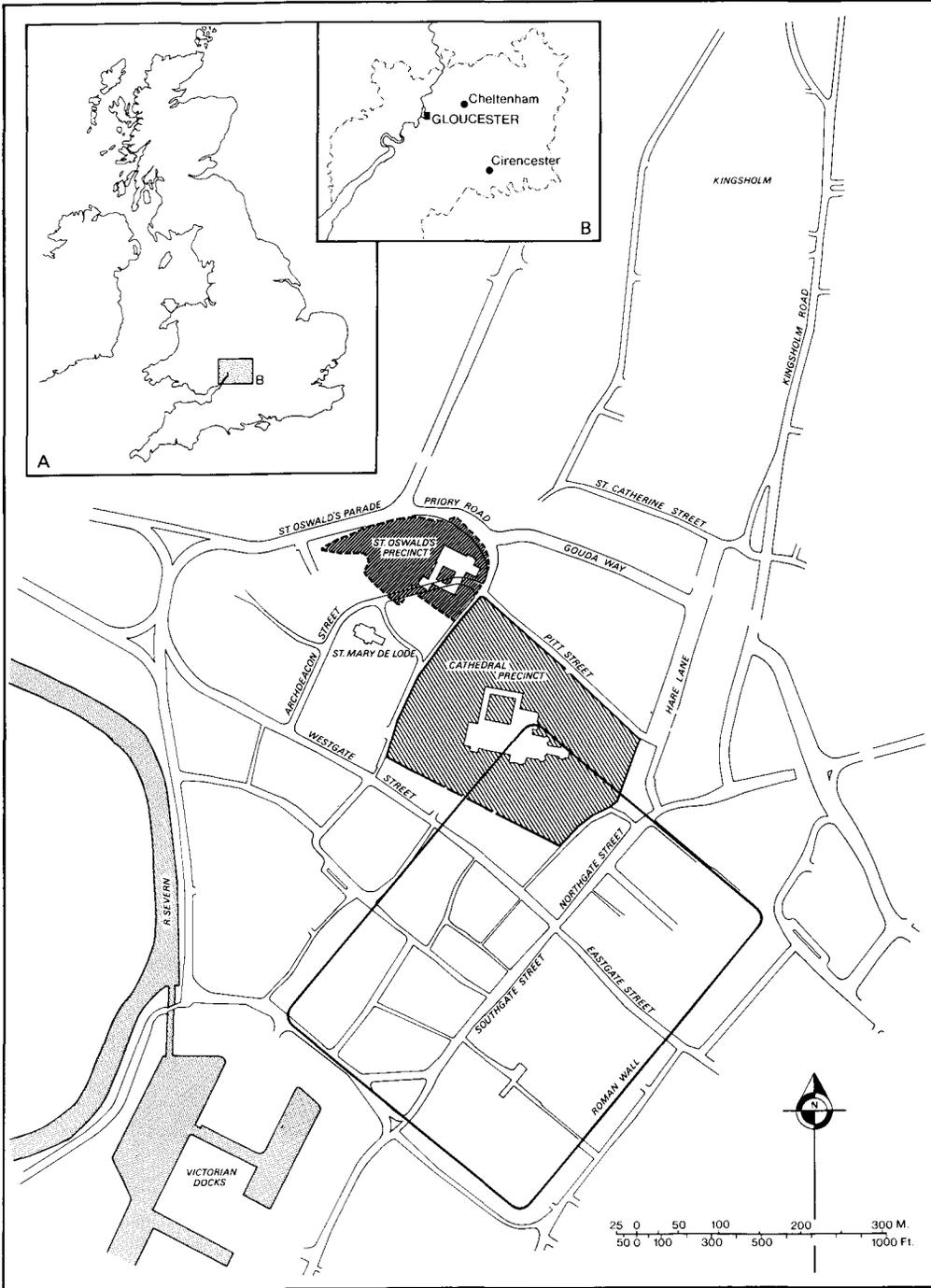


FIG. 3  
St Oswald's Priory, Gloucester: location plan

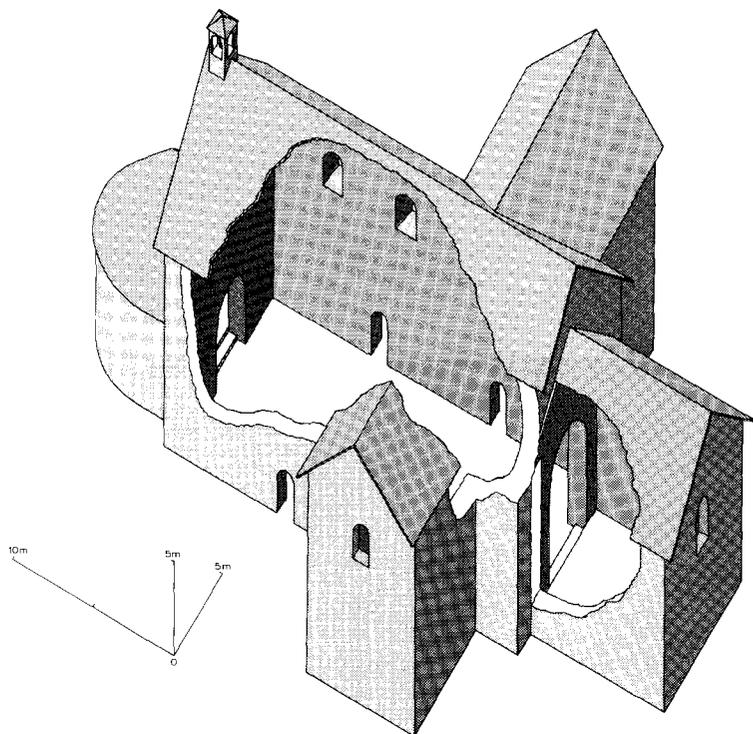


FIG. 4

Reconstruction of the first church on the site of  
St Oswald's Priory, Gloucester

activity (Period 1B; see Fig. 5). At the W. end of the nave was a small bell-pit, described below; there was also a layer of hammer-scale and smithing slag (330) with some fragments of hearth-lining. Layer 330 also included lenses of burnt clay similar to the bell-mould; the early 11th-century floors above 330 contained residual fragments of melted copper alloy which analysis showed to be similar in composition to bell-metal found in the mouth of the bell-pit. The bell-pit was set in an 'island' of stratigraphy, but the sequence of layers in the 'island' suggests that the bell-pit was likewise sealed by the earliest surviving church floors and therefore probably formed part of the industrial activity. The activity probably derives from the construction period of the church *c.* 900; it seems unlikely that the nave would be turned over to such a variety of industrial use later in the 10th century when the church was at the height of its fame.

#### *The bell-pit*

The round bell-pit had a central channel lined with oolitic limestone blocks, all worked, one with a bevelled edge, and probably reused Roman (Fig. 9, Pl. v). The pit had only one stoke-hole and flue, unlike the late 10th-century pit with two stoke-holes found at Winchester.<sup>2</sup> Most of the stoke-hole had been cut away by a later grave, but a layer of charcoal remained to indicate its position. Signs of burning and a layer of charcoal indicated that there had been a fire outside the mould as well as beneath it. The flue was obstructed by an oolite block placed to support one side of the bell-mould — this must have been inserted after firing. Around the surviving mould of the bell-mouth were scattered bell-mould fragments made of

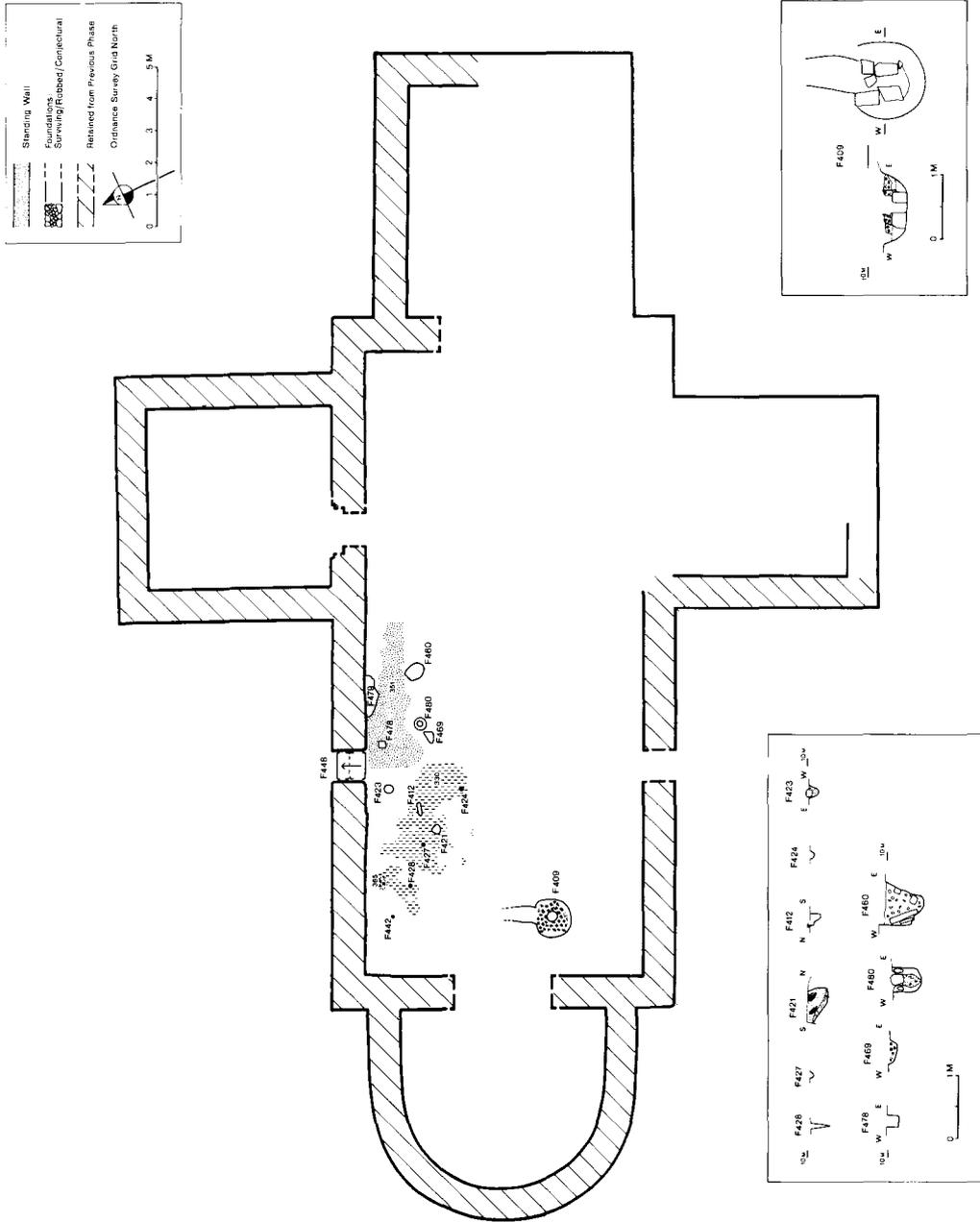


FIG. 5  
 Plan of Period Ib features, including bell pit

very sandy clay, poorly fired and very friable; some of these were inscribed (see below). A plaster cast was made of the bell-mould mouth before it was removed.

#### *Copper alloy slag and waste*

There are *c.* 630 grammes of copper alloy waste droplets from the site. One droplet was from Roman levels; most of the rest came from the general area of the bell-pit. There are two fragments from the floors over the bell-pit, while seven fragments from other 11th-century floors could derive from bell-pit levels disturbed during floor-laying. There were also a number of fragments from the mouth of the bell-pit. A fragment (SF 444) of copper alloy dross came from the construction levels of the church. One broken curved fragment of copper alloy scrap (SF 846; Fig. 6) came from the debris of the early 12th-century rebuilding; this fragment appears to be part of a bell. All the copper alloy fragments including the curved fragment could have come from the same melt (see Tables 2 and 3 below). It would appear that the copper alloy derived from the manufacture of the bell and that the curved fragment was accidentally lost in the early 12th century when the bell was being broken up for remelting. The alloy is unusual for bell-metal, having a very low tin content.

#### *Reconstruction of the bell (Fig. 6)*

The bell-mouth has been reconstructed from the *in situ* mould (Fig. 7), which was removed at excavation but could be reconstructed around the plaster cast. Approximately one third of the base of the mould survived intact with the basal ring betraying the actual outer rim of the bell-mouth. A further third survived as the outer mould alone with a scar for the basal rim on the clay bedding laid on the stones of the flue. The final third had been disturbed and distorted during the removal of the bell. The dimensions of the bell-mouth and the shape of the rim were thus given by the surviving mould. The fragments with inscription were large enough to calculate their circumference and therefore the bell's diameter at this point, and it was clear that these could only be placed near the bell-mouth, rather than near the shoulder.

Fragments from the shoulder, with moulding-wire, and from the crown, were also large enough to provide angle and diameter, and one fragment gave the crucial junction between the canons and the argent. These established all the critical dimensions except for height. To calculate the overall height, comparison was made with early bells with similar rim diameters from Europe<sup>3</sup> and Harescombe, Gloucestershire.<sup>4</sup> All these bells were cast before the mid 13th-century introduction of 'modern' bell shapes with pronounced shoulder and flaring sound-bow.

The height of the St Oswald's bell has been calculated by taking the average height:diameter ratio of the other four bells and applying it to the St Oswald's rim diameter, which gives a height for the St Oswald's bell of 322 mm (Table 1). The moulding wire on the shoulder and the inscription are incised into the bell (raised on the mould). The curved metal fragment (SF 846) fits the reconstructed bell just below the moulding wire on the shoulder, and it has therefore been used to suggest the thickness of the bell.

#### *Manufacture of the bell (Fig. 9)*

The bell was made according to the 'lost wax' method described in the 12th century by Theophilus.<sup>5</sup> First a tapered spindle was made of wood, and the core of clay built onto it in thin layers, each layer being smoothed flat as the spindle was turned, the clay being allowed to dry between each application. All the bellmould fragments at St Oswald's were built up in this way, forming laminations which, when the mould was broken, often broke into individual layers. The final stage of building the core would have been the addition of a thickening at the base of the bell, a 'collar' or base-ring to carry the bell lip. The St Oswald's bell mould includes a fragment with the impression of a square-section rod that passes down through the base ring and out at the bottom of the mould. This must have been the hole for

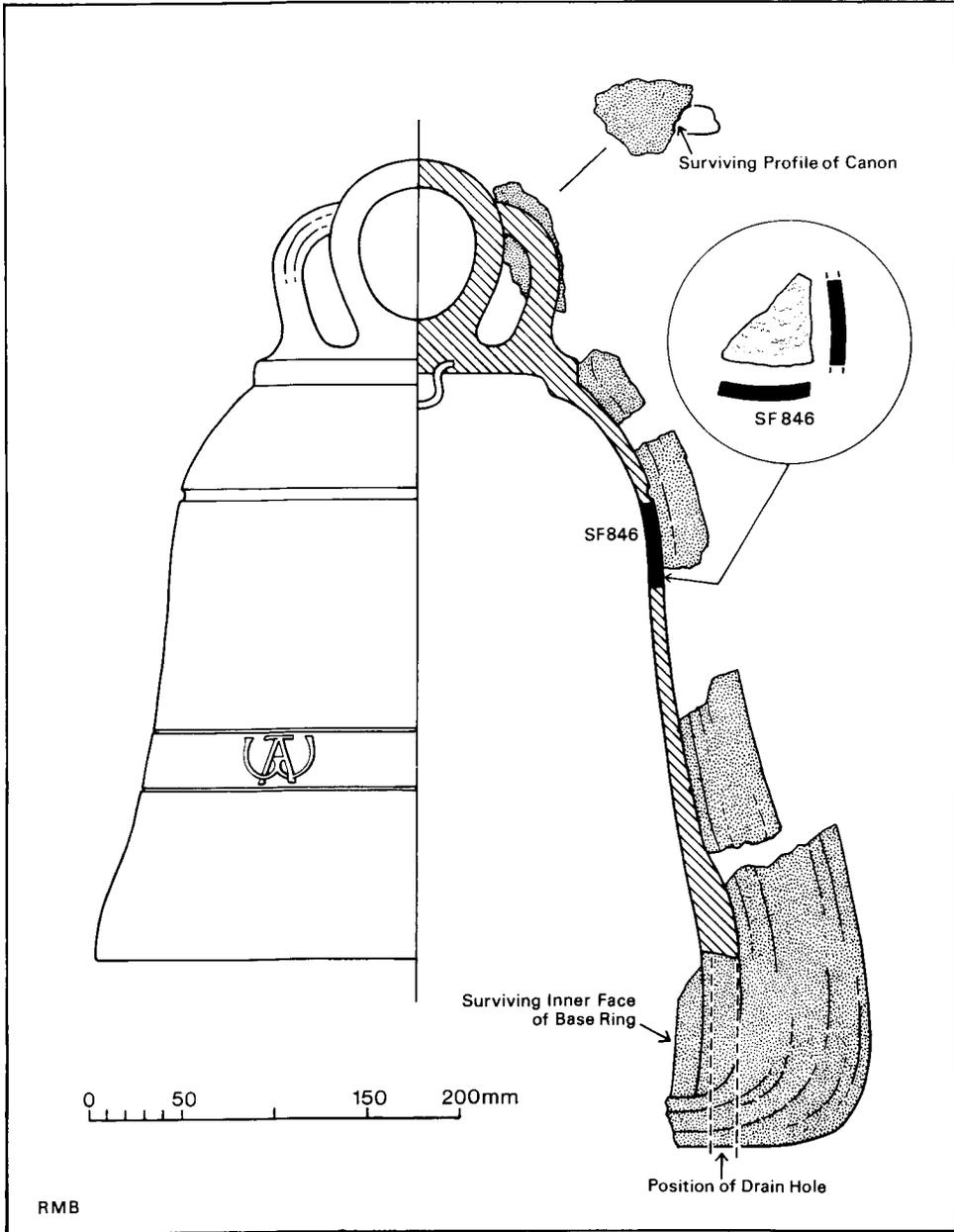


FIG. 6  
Reconstruction of the 10th-century bell

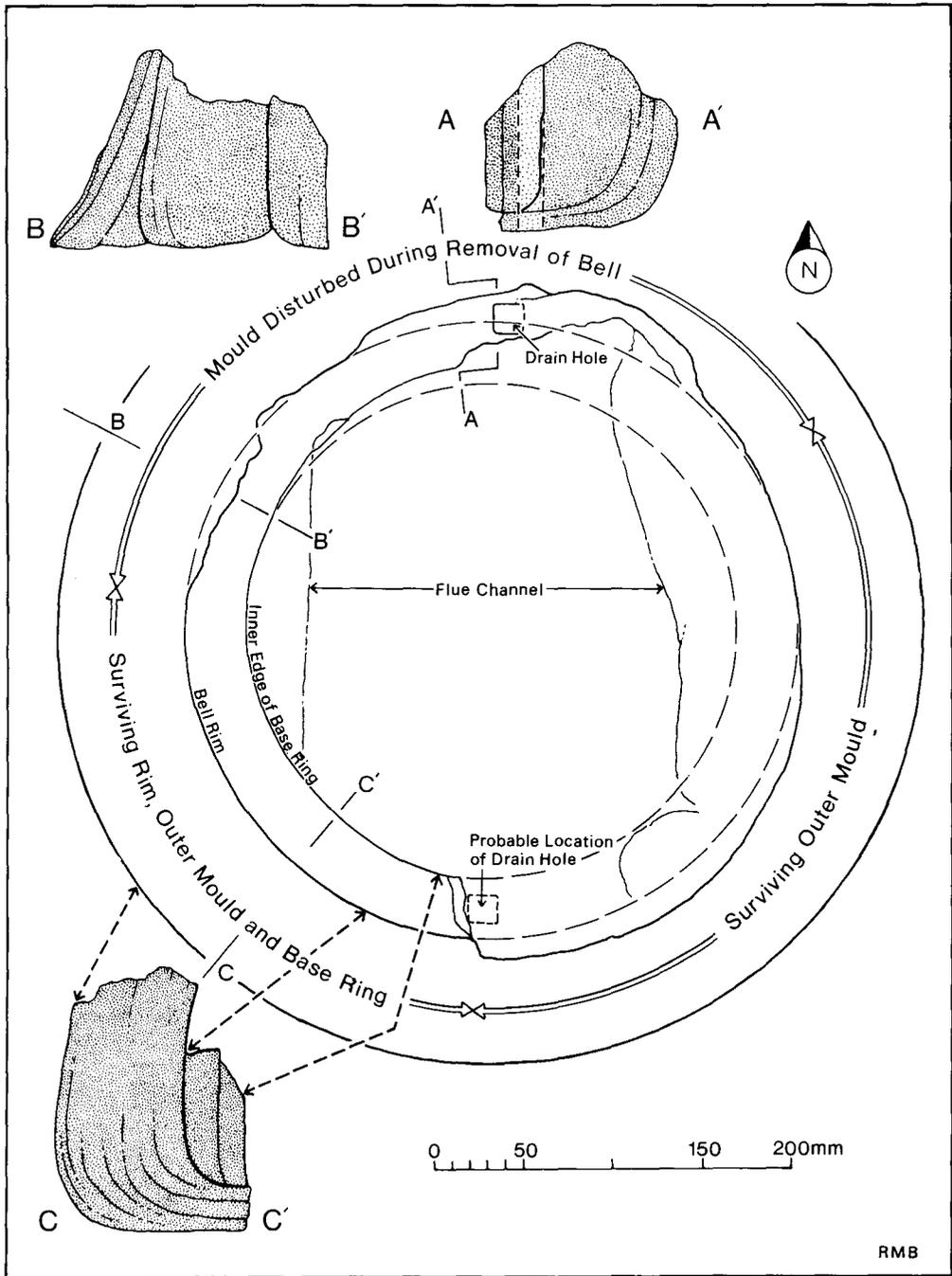


FIG. 7  
Plan of surviving bell mould

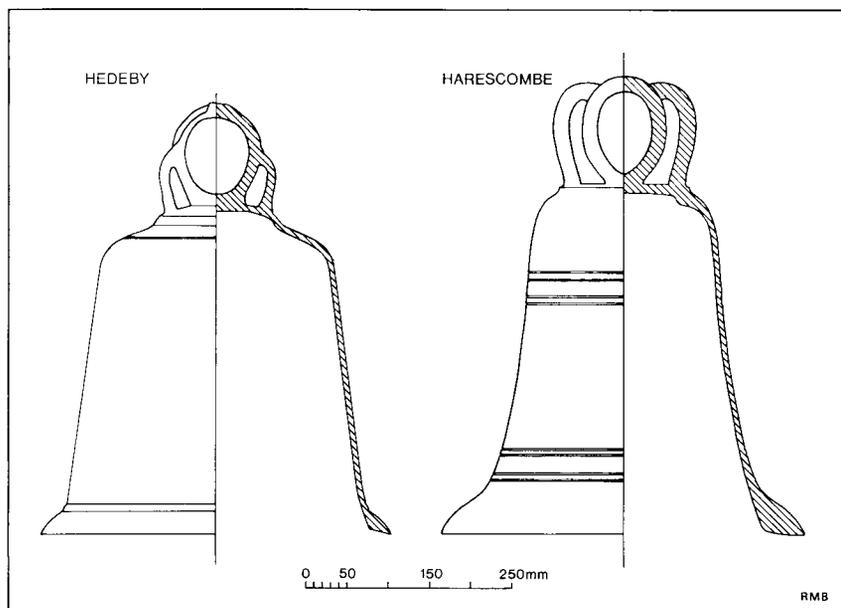


FIG. 8

Comparative sections of bells (Harescombe section by George Elphick)

extracting the tallow; the hole must have been made by leaving a square-section rod in the clay as the mould was built, for pushing the hole through from below the bell would have left drag marks in the clay and created a distortion in the mould. The final layer of the core may have been made with a wooden former, mounted on a spindle, though Theophilus only says 'using the appropriate tools'.

The bell shape would have been created by placing rolled tallow sheets on the core, and an inscription was then incised. Over this the first layers of the cope were laid; a layer of particularly fine clay (about 6 mm thick) was placed over the tallow<sup>6</sup> and one more outer layer of clay (another 10 mm). These first two outer layers must have stopped at the shoulder, in order to leave visible the top of the tallow model onto which the argent and canons could be fixed. The mould was then removed from the spindle. The core of the bell-mould was hollowed out, since the mould could not be moved or baked if it was too heavy. The St Oswald's core was surprisingly thin, about 15 mm, though only the base mould survived and it may have been thicker higher up. The spindle hole in the top of the bell would have been filled with a 'stopper' of clay smoothed flush with the top of the core. A U-shaped piece of iron, for the clapper to hang on, was pressed into the clay with its ends projecting into the tallow that was used to model the crown of the bell. After this, the argent and canons, with a vent and in-gate on top, were shaped out of tallow and fitted onto the crown. This whole assemblage was covered with several layers of clay to complete the first phase of the outer mould (Fig. 9).<sup>7</sup>

The bell would have been carried to the pit and placed over the stone flue channel. It is clear from the remaining fragments that the mould was placed on a bed of clay which was in places folded up around the cope, then more layers of clay were added to form the full thickness of the cope, a maximum of 68 mm. Where the two sides of the mould passed over the flue channel, several additional layers of clay were added under the collar to strengthen it (see sections A and C, Fig. 7). This was only done over the channel; elsewhere the outer layers of clay were smoothed out over the supporting stones. Theophilus says that before these outer

TABLE I  
COMPARATIVE SIZES OF EARLY BELLS

	Date (century)	Height (mm)	Rim Diameter	Height: diameter ratio as %
Bremen	12th	304	332	91.60
St Oswald's	10th	[322]	346	[93.61]
Canino	8th	370	390	94.87
Hedeby	8th-11th	393	425	92.47
Harescombe	12th	417	441	95.50

The height of the bells is measured from crown to rim.

layers were added, iron hoops were put round the mould<sup>8</sup>; these may not have been used at St Oswald's, since none of the mould fragments show any sign of them, but presumably the mould would have cracked along the hoop-lines, destroying any trace of them. (Theophilus says the final layers of clay and the iron hoops were put on *before* the mould was put in the pit, but that is clearly not the case here.) The mould would be positioned with the drain-holes over the channel. Some sort of stick could be left as a marker so as to position the holes correctly over the small pots which would be placed to receive the melting tallow, or perhaps the original sticks were left protruding and were now removed.

Theophilus notes that a furnace or kiln in which the mould was fired was then built round it. There is no room for this in the St Oswald's bell-pit, and no surviving trace of a structure. The pit in which the bell was cast was deep enough for most of the mould to stand within it, with only the argents and canon protruding above ground; it is probable that the pit itself acted as the kiln, with an additional wall built around its rim at ground level (this would not then have survived). The burning noticed on the inside of the earth pit shows that there was a fire round the bell, as well as underneath it in the channel. The firing at St Oswald's was also quite uneven; part of the bell-mould is oxidized, part reduced, as is often found with clay moulds.

The bell-pit was then fired sufficiently to melt the tallow into the pots, the pots were removed, the drain holes stopped up with clay, and the fire kept burning so that the clay mould was well baked. After 24 hours the fire was removed and the pit and the channel filled with earth which was packed well round the mould (at St Oswald's the underside of the bell-mould in the channel was supported by an inserted stone). A separate furnace would have been built close by (there were no structural remains of this) to melt the metal which would then be channelled or, with smaller bells, poured from crucibles into the in-gate on top of the mould.

As soon as the metal had hardened in the in-gate, Theophilus recommends carving out the inner core, since it would crack the bell if it were left in whilst the bell was cooling. In the case of the St Oswald's bell, this might not have been necessary, since the core appears to have been quite thin to start with. When the bell was quite cool, the mould was broken off; the gate was then filed off and the clapper and hanging gear added.

#### *The inscription* (Fig. 10)

The inscription has been described by Okasha.<sup>9</sup> However, examination of the bell-mould and reconstruction of the bell enables further deductions to be made. Some fragments can be orientated, and the reconstructed bell size indicates that we have about a quarter of the maximum possible length of the inscription band. One additional letter has been discovered.

Text (ii) includes parts of two letters, and could read *-[C.]*-. It could be the other way up. Text (iii) also has two letters, and reads *-[O.]*-. The reconstructed bell profile established that fragment (iii) is this way up. The large space preceding *[O]* suggests this may be the

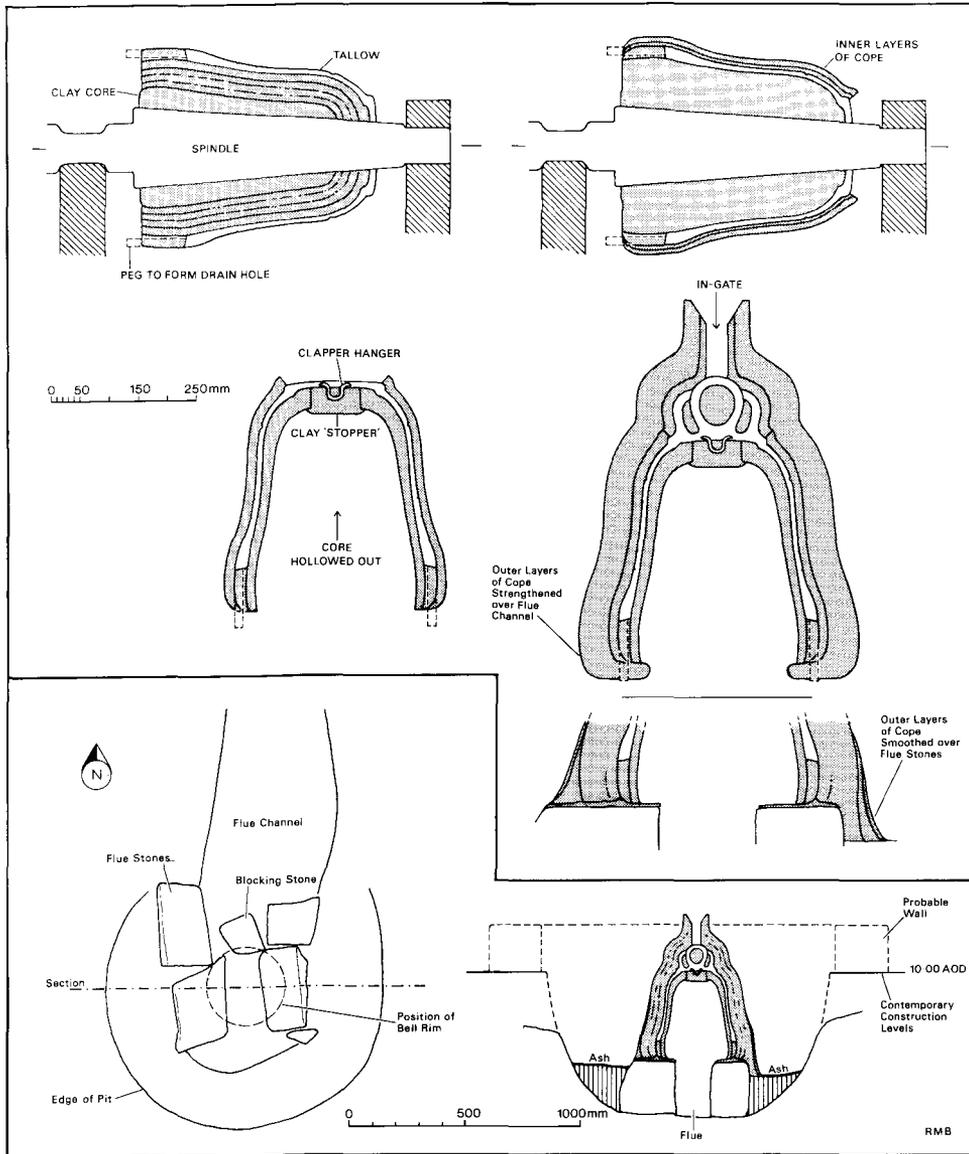


FIG. 9  
Construction technology for the 10th-century St Oswald's bell

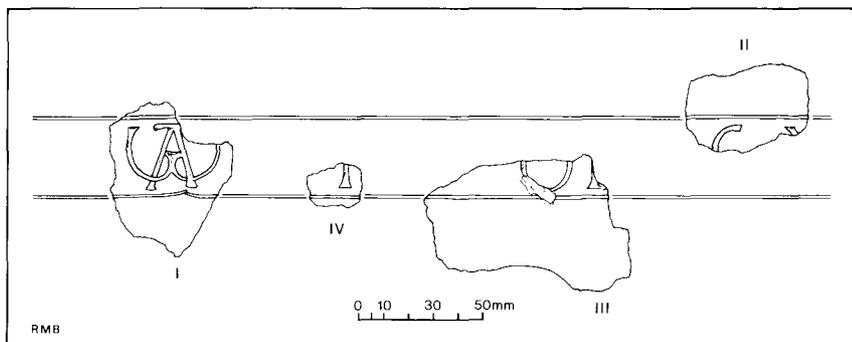


FIG. 10

The bell inscription (shown reversed as would appear on the bell)

beginning of a word. A further fragment (iv) has been found, containing a serif and part of an upright stroke.

*Analyses of possible bell metal from St Oswald's, Gloucester* by GERRY MCDONNELL

A fragment of possible bell-metal (SF 846) was analysed by X-ray fluorescence which indicated that it was not of the usual bell-metal composition (20–25% tin). A small section was removed, ground flat and polished to one micron finish for quantitative analysis using the Scanning Electron Microscope with an attached energy dispersive X-ray system. The analyses were obtained using 20 kv acceleration voltage, and full and reduced area raster scans. The results show (Table 2) that the metal is a bronze with minor amounts of lead, zinc and iron. The analyses also show that there was no severe segregation.

The corroded droplets, etc. were also analysed by X-ray fluorescence and were all of similar composition, copper with low levels of tin present, i.e. similar to the analysed piece. There were no examples with high tin contents, indicative of typical bell-metal.

The irregularly shaped lump of corroded dross or metal (probably a spillage) from which a sample had already been removed was further sampled (SF 444). The results are given in Table 3, and are comparable to those obtained from the first piece (Table 2). However there are slight differences. The dross is lower in copper, zinc, and iron, but they would have no marked effect on the properties of the metal. Given that the dross was discarded it is not surprising to see some differences in the composition from cast metal.

*Conclusions*

The analyses show that the presumed bell fragment, the lump of dross and the metal droplets could have derived from the same melt. Later medieval bells normally contained 20–25% tin (see Table 4) and this is in marked contrast to the Gloucester analyses. Their low tin content is more closely matched by the other early bells which suggests that it was not only the shape of bells but the composition of the alloy used to make them which underwent a change between the 10th and 13th centuries. Because the metal of this bell had such a low tin content, it would probably have sounded dead and unresonant.<sup>11</sup>

The 10th-century bell at St Oswald's, though small, is one of the earliest known from Anglo-Saxon England, and its shape and composition are of interest. Its manufacture was associated with smithing activity whose purpose is unknown, though the manufacture of items such as door furniture is a possibility. However the bell manufacture would have required a considerable amount of iron-work: a bell-clapper, or a frame for the bell, or possibly the reinforcing bands of the bell-mould. The bell manufacture would also have

TABLE 2  
MEAN COMPOSITION OF SAMPLE FROM SF 846  
AREA ANALYSES

	1	2	3	4	Mean	S.D.
Cu	80.7	87.3	85.0	85.2	84.5	2.8
Sn	12.5	12.8	15.0	15.2	13.9	1.4
Zn	1.9	1.9	0.7	0.3	1.0	0.6
Pb	1.3	1.3	3.3	1.8	1.9	0.9
Fe	0.6	1.7	1.9	0.5	1.2	0.7
Total	97.0	104.1	105.9	103.0		

TABLE 3  
COMPOSITION OF METAL DROSS (Weight %)

	1	Areas	2	Grain	Grain Boundary Eutectic	Pb Inclusion
Cu	82.2		82.7	86.2	72.4	22.8
Sn	14.8		13.6	11.4	26.5	2.6
Zn	n.d.		0.2	0.1	n.d.	0.4
Pb	1.5		1.6	0.2	n.d.	74.0
Fe	n.d.		n.d.	n.d.	n.d.	0.2
Total	98.5		98.1	97.9	98.9	100.0

TABLE 4  
BELL METAL ANALYSES<sup>10</sup>

Site	Date	Sn%	Pb%	Zn%
Hedeby	8-11th C.	17.37	6.56	0.09
Winchester	10th C.	18.75	4.35	<0.1
Gloucester				
(bell)	c. 900?	13.9	1.0	1.9
(dross)	c. 900?	14.2	1.6	0.1
Cheddar	12th C.	20	—	—
Thurgarton	12th C.	22-25.5	3.5-4.5	1-2
Winchester	13th C.	23	?	?
Chichester	14th C.	24.0	2.7	0.03
Norton Priory	medieval	20.0	—	—
Wharram Percy	A.D. 1617	23.0	<1.0	—

needed an iron pot or pots which Theophilus says should be made especially for the purpose.<sup>12</sup>

The position of the bell in the church cannot be certain, but since bells were usually made as close as possible to their intended hanging point, the bell has been reconstructed as occupying a small belfry on the west end of the ridge of the Anglo-Saxon nave (Fig. 4).

#### ACKNOWLEDGEMENTS

The drawings for this paper were done with the aid of a grant from the Leverhulme Trust in 1988-89, and the Trust's assistance is gratefully acknowledged. Figs. 3 and 6-10 were drawn by Richard Bryant, Figs. 4 and 5 by Jean Williamson. The authors wish to acknowledge the contribution of English Heritage's Ancient Monuments Laboratory, and to thank the following who have assisted with compilation of the text: Michael Hare, Elisabeth Okasha, Mary Bliss.

JUSTINE BAYLEY, RICHARD BRYANT and CAROLYN HEIGHWAY

## NOTES

<sup>1</sup> Interim reports on the first two seasons of excavation will be found in C. Heighway, 'Excavations at Gloucester: fourth interim report: St Oswald's Priory, Gloucester, 1975-76', *Antiquaries J.* 58 (1978), 103-32, which included an interim report on the bell-pit; and C. Heighway, 'Excavations at Gloucester 1977-78: fifth interim report: St Oswald's Priory', *Antiquaries J.* 60 (1980), 207-26. The method of reconstruction of the first church is described in C. Heighway and R. Bryant, 'A reconstruction of the 10th-century church of St Oswald's, Gloucester', in R. Morris (ed.), *The Anglo Saxon Church*, Festschrift in honour of H. Taylor (London, C.B.A. Research Report 60, 1986), 188-95. The documentary evidence is summarized more fully in M. Hare, *The Two Anglo-Saxon Minsters of Gloucester* (Ninth Annual Deerhurst Lecture, 1993). A final report on the site is in preparation.

<sup>2</sup> Russell M. Davies and Peter J. Ovenden, 'Bell founding in Winchester in the tenth to thirteenth centuries', in M. Biddle, *Object and Economy in Medieval Winchester*, part ii, Winchester Studies (Oxford, 1991), 104.

<sup>3</sup> H. Drescher, 'Glockenfunde aus Haithabu', *Berichte über die Ausgrabungen in Haithabu*: Bericht 19 (Neuminster, 1984), 9-62, at 29-35; *Das Reich der Salier 1024-1125*, Katalog sur Ausstellung des Landes Rheinland-Pfalz (Sigmaringen, 1992), 405-19.

<sup>4</sup> M. Bliss, *Church Bells of Gloucestershire* (Gloucester, 1986), 357-61 and pers. comm.

<sup>5</sup> J. Hawthorne and C. Smith (ed. and tr.), *Theophilus: on Diverse Arts* (New York, 1979); see also Davies and Ovenden, op. cit. in note 2.

<sup>6</sup> Hawthorne and Smith, op. cit. in note 5, 169-70.

<sup>7</sup> Ibid.

<sup>8</sup> Ibid.

<sup>9</sup> E. Okasha, 'A supplement to the handlist of Anglo-Saxon non runic inscriptions', *Anglo Saxon England* 11 (Cambridge, 1983), 92, no. 167 and Pl. VIc.

<sup>10</sup> Data for Winchester from Davies and Ovenden, op. cit. in note 2, 108 and 112; for Chichester from A. Down, *Chichester Excavations III* (Chichester, 1978), 164; for Hedeby from Drescher, op. cit. in note 3, Table 6 and for the rest from R. F. Tylecote, *The Prehistory of Metallurgy in the British Isles* (London, 1986), Table 23.

<sup>11</sup> Alan Hughes of Whitechapel foundry, *in litt.* He also commented, 'If the bell was cast to a particularly thin scale, and if additionally the cooling rate was rapid, the effects would have been partly offset'.

<sup>12</sup> Hawthorne and Smith, op. cit. in note 5, 171.

## THE OUTER GATE HOUSE AT DUNAMASE CASTLE, CO. LAOIS (Figs. 11, 12; Pl. VI, A)

Dunamase Castle has been described as 'perhaps the one convincing piece of Marshall castle masonry in Ireland'.<sup>1</sup> The Irish Pipe Roll of 1211-12 includes the entry 'And £6 [rendered by William Marshall] for the land on which the castle of Dunamase stands'.<sup>2</sup> Because the castle stands on a precipitous limestone hill, it has always been assumed that it was built of stone from the first, and so, by implication, that the remains now visible are in the main those of the first castle. H. G. Leask, whose book on Irish castles is still the only one in the field, describes the castle briefly, with a sketch of the outer gate tower, which he states is 'a round-faced gate tower which has the traces of a drawbridge'.<sup>3</sup>

If we combine Leask's description with the dating evidence outlined above, it is only reasonable to conclude that the outer gate of Dunamase Castle gives us an early 13th-century (probably before 1225) example of a drawbridge in the British Isles. Because this would be a notable occurrence it seemed worth a small amount of work to check the possibility in the field. Evidence for a drawbridge could exist in various ways. The standing masonry might preserve pivot stones at the base of the gate opening; there might be a recessed frame for the bridge to close into when raised; there might be holes in the front wall for the lifting chains to pass through, or traces of a pit behind the gate proper, into which a counter-balanced bridge could drop. Outside the gate, the outer end of the drawbridge when down would have to be supported, either on a revetment of the outer edge of the ditch, or on a pier built within it.

The castle crowns the hill with only one practicable approach, from the SE.; the gate tower stands at the apex of a triangular outer bailey covering the line of approach (Fig. 11). The walls of the outer bailey are structurally additions to the curtain walls of the main castle, but this need not be significant for the date of the building because, at the junctions, the main curtains are built on ledges of the limestone rock of the hill: to bond them to the walls of the outer bailey would have been difficult and unnecessary. The gate tower is unique in plan (Pl. VI, A, Fig. 12) but is effectively a round tower pierced by the gate passage. There are the