

A 16th Century Glasshouse at Knightons, Alfold, Surrey

by ERIC S WOOD

CONTENTS

In Text	<i>page</i>
List of Illustrations (for both Text and Microfiche)	3
Plates	
Text figures	
Glossary	5
Summary	5
The Site	8
discovery, ownership	
location, geology	
excavation, dating	
The Excavated features	8
furnaces	8
other features	11
The Finds	19
glass	19
crucibles and other finds	38
Conclusions	44
Deposit of finds	44
Acknowledgements	45
Bibliography	46
On Microfiche	<i>Microfiche</i>
The Background of the Wealden glass industry	2
The Site	
details of location	5
topography	5
geology	5
petrology	6
The Owners of Sidney Wood	
Henry Smyth	9

	<i>Microfiche</i>
The Excavation	12
direction, dates, workforce, visitors	12
methods	
The Excavated features (details)	
Furnace 1 and 2	14
sand store	15
Furnace 3	17
Furnace 4	17
space between F3 and F4	19
cullet store	20
possible shed	20
“floors”	21
claypits	22
waste tip	24
Extent of the glasshouse	25
Reliability of the attributions	25
The Finds	
Glass (see Text pp 19–38)	
crucibles	26
iron	29
pottery	31
coin	32
miscellaneous objects	
associated with the glasshouse	33
not associated with the glasshouse	35
Discussion	
The Functions of the furnaces	35
the annealing furnace (F4)	38
Phases of Wealden glass	42
The Composition of the glass	43
materials	46
Coloured glass	48
oak v beech	48
The Distilling apparatus	50
alchemy: Thomas Charnock	51
The Cullet problem: the local products	54
The Crucibles	55
The Pottery	60
daily life	61
Archaeomagnetic dating	62
Published references	64

FIGURES

	<i>page</i>
1 Outline map of England and Wales, showing position of Knightons	6
2 Detailed map of part of Sidney Wood (Dunsfold and Alfold parishes Surrey), showing location of the Knightons (A) and Sidney Wood (B) glasshouse sites.	7
3 Knightons glasshouse, Generalised plan	9
4 Furnaces 1 and 2, plan	10
5 Furnace 3, plan	11
6 Furnace 4, plan of west chamber	12
7 Painted glass	20
8 Masked-out piece	23
9 Triangles and roundels	23
10 Beaker rim and base	24
11 Handle	24
12 Moulded decoration	25
13 Necks	26
14 Globular vessels	28
15 Rim of plate or small dish and foot of bowl	28
16 (?) Stopper of albarello-type jar	29
17 Knop of pedestal stem	29
18 Bases	30
19 Urinal rims and base	31
20 Distilling apparatus: generalised section showing the components and their uses	32
21 Alembic collecting channels, spouts and tubes	33
22 Cucurbit and receiver necks	35
23 Bottle necks	36
24 Bottle bases	37
25 Reconstruction of bottle neck and base	38
26 Crucible rims	39
27 Crucible rims, anomalous forms	40
28 Iron objects	40
29 Lead and bronze objects	41
30 Double furnace at Jamestown, Virginia (1608)	41
31 Two-chambered horizontal furnace, Trestenshult, Sweden	42
32 Crown annealing furnace, French type	43

PLATES

1	West end of Furnace 1	13
2	Furnace 4, Overall view	13
3	Furnace 4, South west of west chamber	14
4	Furnace 4, West chamber partially excavated	14
5	Furnace 4, West chamber, as fully excavated	15
6	Furnace 4, Layers of crown on the floor	15
7	Stones between furnaces 3 and 4	16
8	Large posthole SE of furnace 1	16
9	the Waste tip under excavation	17
10	Massive base of crucible	18

GLOSSARY

- Albarello* A majolica jar, usually tall and waisted, used especially as a container for drugs.
- Blowing-iron* Blow-pipe.
- Came* A channelled piece of metal (usually lead) to hold and divide the panes or pieces of a composite window.
- Chair* A chair with special arms for manipulating and shaping vessels etc, used by the 'gaffer', or leader of the glassmaking team.
- Crown* Window glass made by blowing a bulb or balloon, transferring this from blowing-iron to pontil, cutting it off the former; the opened bulb was then rapidly rotated on the end of the pontil, and eventually opened out into a flat circular sheet, with 'bull's-eye' at the centre where it was attached to the pontil.
- Cullet* Broken pieces of glass added to frit to reduce the melting temperature of the glass, and improve its hardness and clarity.
- Flash* A thin layer of glass of another colour, eg red on white.
- Forest industry* The manufacture of glass in the forests of Europe north of the Alps, using forest products – bracken, tree ash etc – to produce potash as flux (Waldglas).
- Frit* The result of the first process of glassmaking – mixing sand and potash (or soda) and heating these moderately (to some 700-800°C). The materials partially fused, and threw up a 'scum' which had to be removed. The cake of frit left was then broken into a pot (crucible), and cullet, and other ingredients if required, added, to be heated to say 1100-1200°C, producing usable glass.
- Glory-hole* Access holes of furnace, opposite each crucible.
- Grozed* Edge cut with grozing iron – a sort of shears – leaving a nibbled effect.
- Kick* The re-entrant base of a bottle etc.
- Leer* or *lebr* Annealing furnace.
- Marver* A flat surface on which a gather (gob or lump) of glass could be rolled to prepare it for working up (on the end of the blowing-iron or pontil), or applied decoration could be smoothed into the surface of a vessel etc.
- Muff* Window glass made by blowing a cylinder, slitting it along its length, and opening it out to form a rectangular pane.
- Pontil* A long iron or iron-tipped rod for handling glass in the making, eg a vessel, or the early stages of muff or crown.
- Potarching* Preheating a pot (crucible) before it went into the furnace for melting ('working') glass, to prevent its cracking or bursting under the great heat.
- Quarrel* A cut piece of glass, usually diamond-shaped, forming part of a window.
- Trail* A thin strip of glass applied to the surface of a vessel etc, as decoration.
- Welting-off* Knocking off waste glass from the end of blowing-iron or pontil.
- Wrythen decoration* Diagonal ribbing made by twisting vertical moulded ribs, or by moulding.

SUMMARY

This paper describes the results of the excavation by the Surrey Archaeological Society, from 1965 to 1973, of a hitherto unknown and unrecorded glasshouse, and discusses their implications. The glasshouse was completely excavated, and all its structures and features were investigated. It dates from the 1550s, and represents the final stage of the "Early" phase of Wealden (Forest) glass in England. The glasshouse consisted of two working (melting) furnaces of standard rectangular northern European (Forest) type, one of which had been rebuilt; a horizontal two-chamber furnace designed for annealing crown sheets (so far unique in England); a cullet store; a tip of furnace waste; a working floor; and two claypits. The site is of



Fig 1 Outline map of England & Wales, showing position of Knightons.

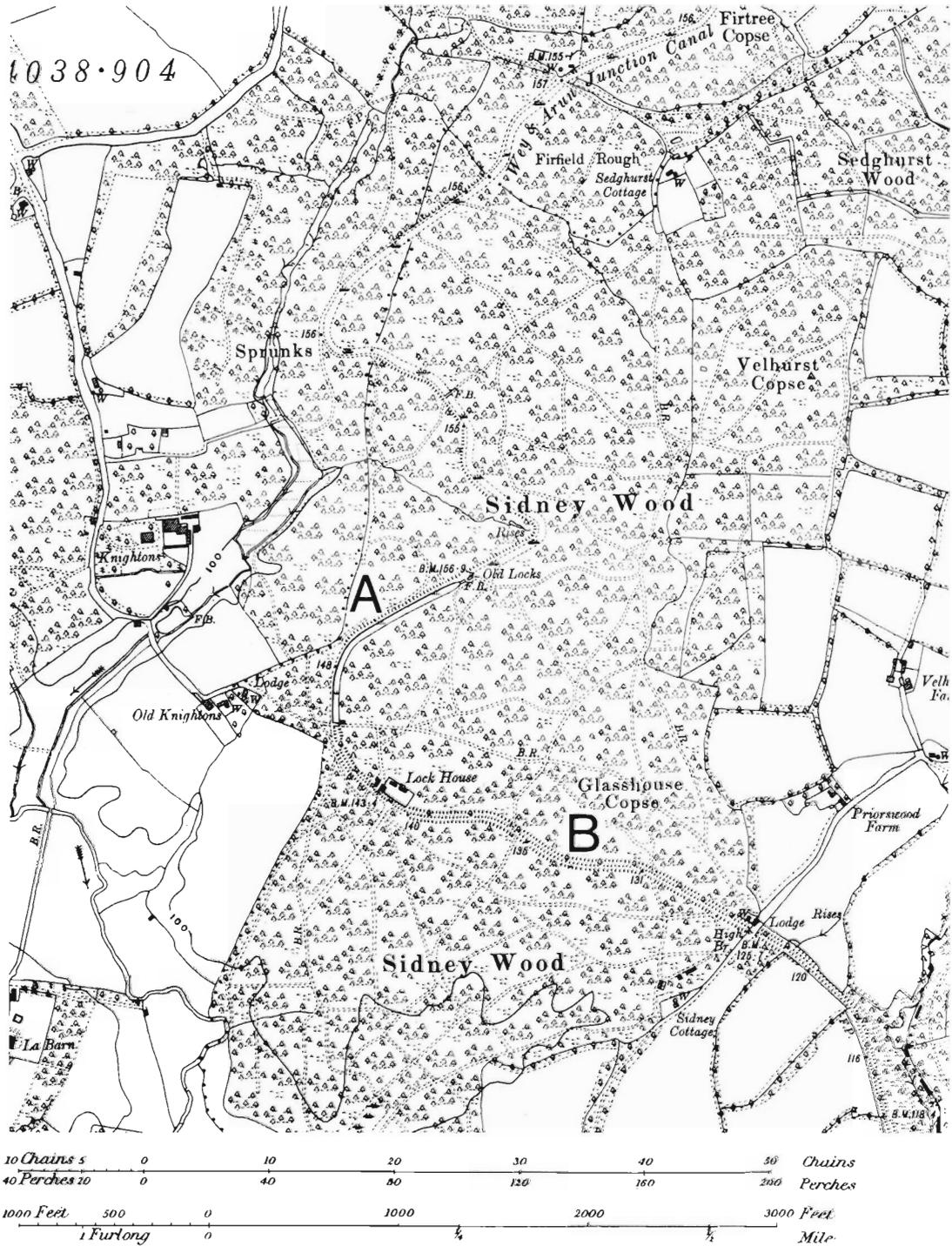


Fig 2 Detailed map of part of Sidney Wood (Dunsfold and Alfold parishes Surrey), showing location of the Knightons (A) and Sidney Wood (B) glasshouse sites. (Reproduced from the 6 inch Ordnance Survey Map, 1920 edition, with acknowledgments.)

national importance, at the least. This derives from the annealing furnace, from the rare possibility of being able to distinguish, with reasonable confidence, local manufacture from cullet brought in from elsewhere, and from the unusually comprehensive range of glass produced in the middle years of the 16th century.

THE SITE

(For fuller details see Microfiche 5)

Discovery. The site of the mid-16th century glasshouse at Knightons, Alfold, Surrey, was found in May 1965 by F W Holling, then Curator of the Guildford Museum, when walking in Sidney Wood. It appeared to be unrecorded and untouched. By permission of the site owners, the Forestry Commission, its excavation was undertaken by volunteers under the auspices of the Surrey Archaeological Society, directed by E S Wood (with Mr Holling's collaboration for the first two seasons), from October 1965 to May 1973.

Location, geology etc. The glasshouse stands some ¼ mile (400m) north of the 17th century house of Old Knightons, along a forest track, close to the parish boundary of Alfold and Dunsfold (see map, fig 2). It lies on the edge of a bank some 6m above, and just south of a stream; a smaller stream bounds the site on the west. The subsoil is stiff Wealden clay. The furnaces were built with blocks of sandstone from the Hythe beds of the Lower Greensand, set in local clay (TQ 017 314).

Dating. The glasshouse is closely dated to the 1550s by a coin of 1550, by archaeomagnetic dating, and by the nature and spread of the glass assemblage. The glass itself is predominantly of Kenyon's Early type (Kenyon 1967).

THE EXCAVATED FEATURES

(For fuller details see Microfiche 14–24)

An overall plan is given at fig 3.

The glasshouse consisted of the following structures and other features:

Furnaces

Furnace 1 (fig 4) occupied a central position, and may well have been the original main working furnace. It was of the traditional medieval Wealden (forest, or Northern European) type – rectangular single-chamber, with central fire-trench with a siege or clay and stone bank on each side, on which three crucibles stood. It measured 4.46 by 3.23m outside, and 3.36 by 2.3m inside. It had been heavily robbed, and one side was marked by a robber-trench only; but the west wall was intact for two courses (Plate 1), and was continuous, indicating that the fire was fed from the east end only – the hearth indeed was found. The fire-trench was 76 cm wide; the sieges were the same width, but had been reduced in height to only some 10 cm. A patch of solid waste glass occurred at the NE end of the fire-trench, no doubt the result of a burst or overturned crucible. The same area also contained a 1.5cm thick layer of unburnt sand, some 1.5 by 2.45 m, which appears to represent a sand-store.

Furnace 2 (fig 4) At an undetermined point in its life, Furnace 1 was dismantled and replaced by another of similar form (F2), built so close alongside that it overlapped the remains of the former F1. It was well-built, of good stones; the only surviving corner consisted of one large square stone. F2 was slightly narrower than F1, its dimensions were 4.3 by 2.76 m outside, and 3.38 by 1.84 m inside; the sieges and fire-trench were 60cm wide. These dimensions may have

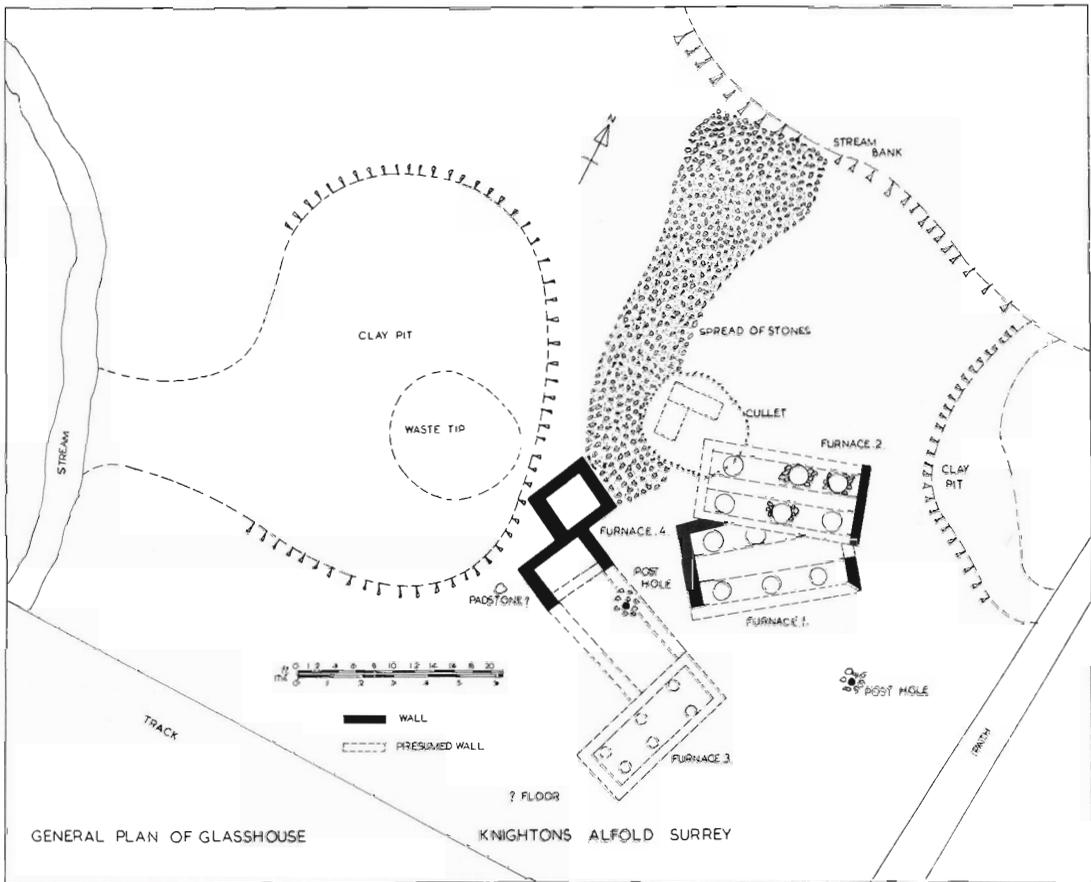


Fig 3 Knightons glasshouse. Generalised plan of site, based on excavations.

been thought the optimum for this type of furnace.

Furnace 3 (fig 5) of the same type as F1 and F2, lay with its NW corner only one metre from the SE corner of F1, but ran almost due N-S. It was almost entirely robbed out, but its layout was fairly reliably recovered. It was liberally scattered with lump glass, frit and scum from fritting; the latter was presumably its main function, although crucibles could also have been made in it. (These furnaces are discussed on Microfiche 35–8).

Furnace 4 lay some 3.5m west of F3. This was something entirely different. It consisted of two squarish chambers set diagonally to each other, and sharing a common wall for one metre, within which was a gap of 60cm, representing a passage for hot gases to pass from one chamber to the other (Plate 2). The lowest two courses of the walls survived (except for the east wall of the east chamber), and were made of roughly squared stones, giving a neat effect almost like that of well-laid masonry. Some of the stones were burnt through, and could have come from the dismantled F1 (Plate 3). The west chamber was 1.92 by 1.17 m internally, the east 2.15 by 1.53 m; the stones of the walls were some 22cm square, laid in two rows side by side, with clay and not mortar (fig 6). The floors of both chambers were clear, and both were reddened by

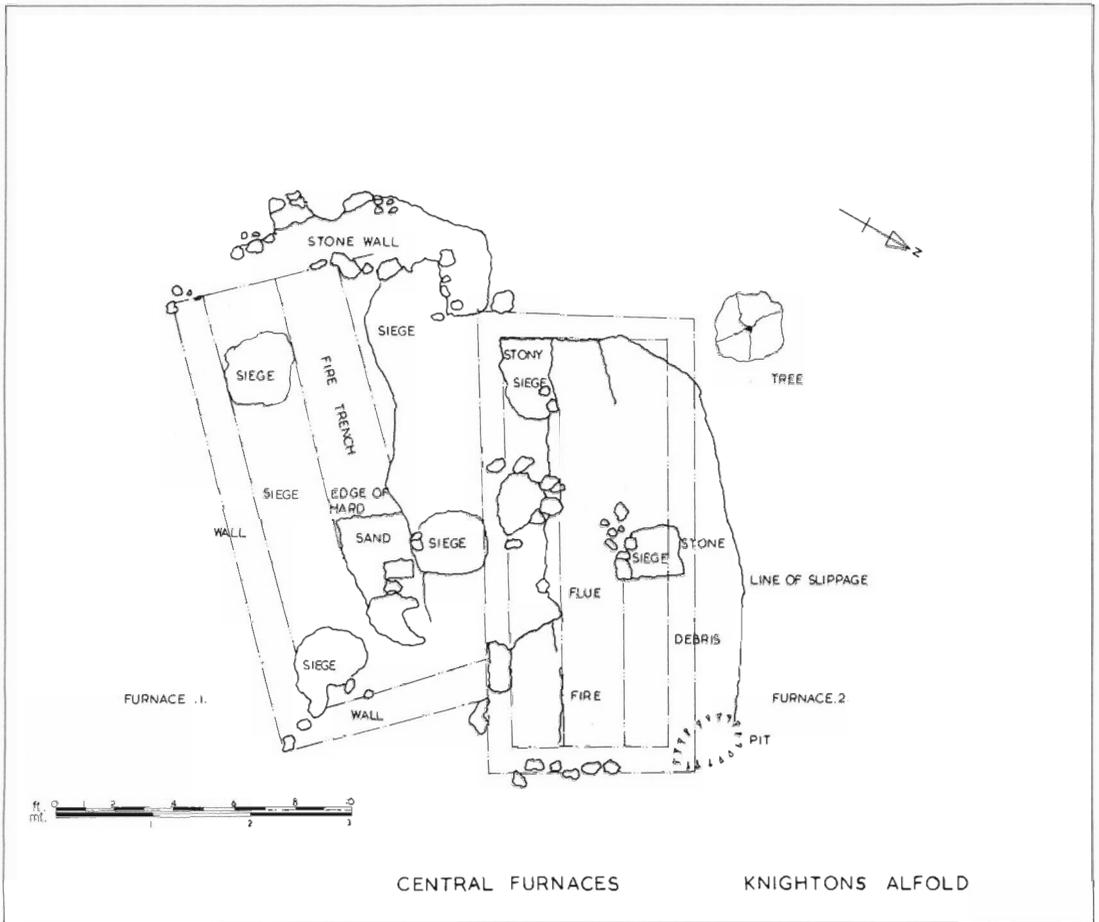


Fig 4 Furnaces 1 and 2, excavation plan, showing F2 replacing F1.

burning. The natural clay round F4 was unburnt, implying only moderate temperature inside the furnace.

Both chambers had lying on their floors pieces of crucible (Plate 4), bottle necks and bases (Plate 5), and pieces of crown glass, some piled in layers (Plate 6). The east chamber also yielded a base silver shilling of Edward VI, 1550 (see Microfiche 32). Pieces of iron strap could imply racks for supporting the ware to be annealed.

For this exceptional furnace, so far unique in Britain, was clearly used for annealing, and designed moreover for taking crown sheets. The chambers must have had long horizontal slit openings to take these sheets, on the lines of that illustrated in the French *Encyclopédie* of 1765 (fig 32). The type may be of ultimately Syrian origin, brought to Europe with the making of crown during the Crusades. The presence of similar products, and the equal burning of the floors, in both chambers, implies that, as at Jamestown (1608) (fig 30), the furnace was meant for continuous production, each chamber being fired and used alternately. Tiles found over the chambers suggest that this furnace stood under the roof of a shed. (The important implications of this furnace are fully discussed on Microfiche 38–42).

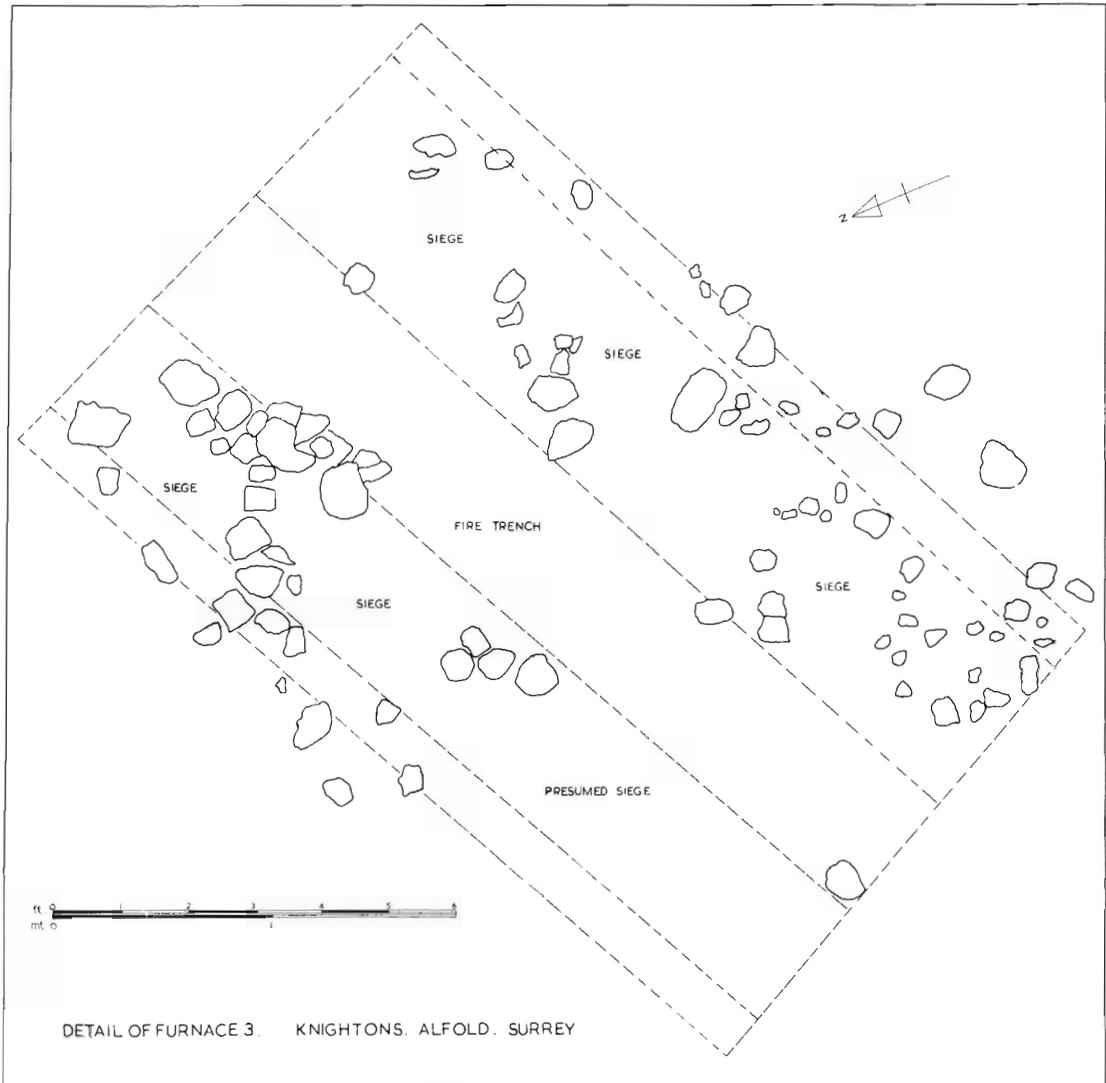


Fig 5 Furnace 3, excavation plan.

Other features (these are all described on Microfiche 19–24)

The space between F₃ and F₄ may have been floored with pieces of stone. But if so, all that remained were two irregular lines of stones joining the corners of the east chamber of F₄ with the west wall of F₃. In one of these was a cavity which might have been a posthole (Plate 7).

Cullet Store This occupied a central position just west of F₂. It appeared to have two phases, represented by two adjoining rectangular heaps at right angles to each other, presumably once contained in wooden cases – the earlier, running E-W, approximately 2.5 by 1.25m; the later, N-S, 1.25 by 1.25 m. As found, the cullet was closely packed, in a layer 15cm thick. It



Fig 6 Furnace 4, excavation plan of west chamber.



Plate 1 West end of Furnace 1, showing end wall, and part of the two siege-banks, with fire-trench between.



Plate 2 Furnace 4. Overall view from the north. The west chamber in foreground; the further ranging-pole lies in the (fragmentary) east chamber.



Plate 3 Furnace 4. South wall of west chamber, showing roughly squared stones, some burnt.



Plate 4 Furnace 4. West chamber partially excavated, showing pieces of crucible and crown glass.

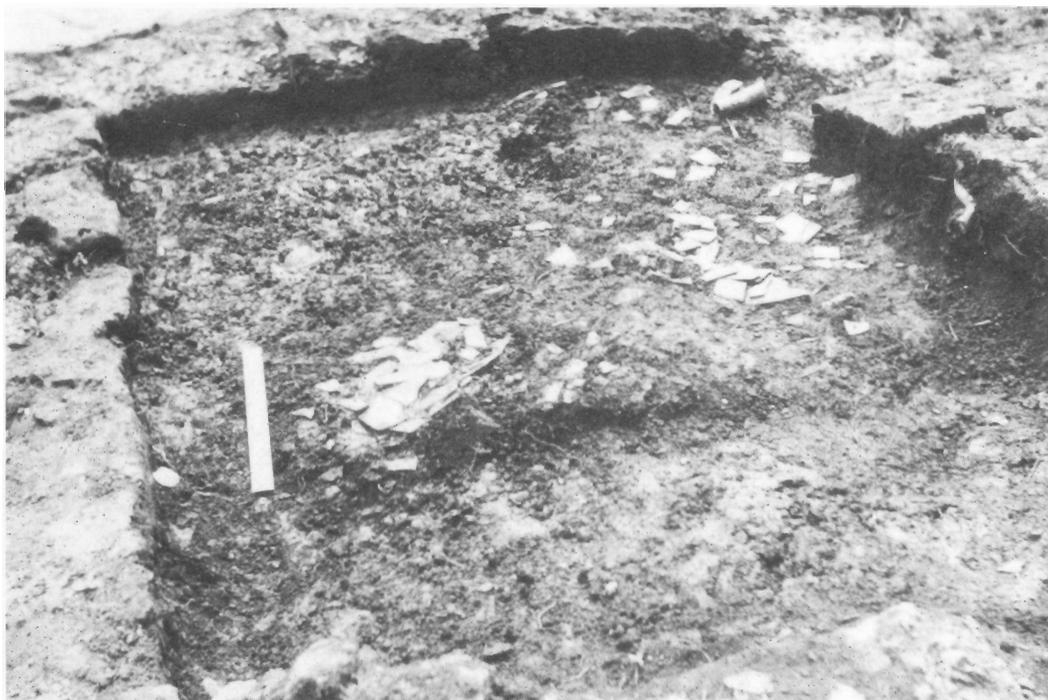


Plate 5 Furnace 4. West chamber as excavated, showing crown and bottle neck and base on burnt floor.



Plate 6 Furnace 4. Layers of crown on the floor.



Plate 7 Stones between furnaces 3 and 4. The foot rule lies over a small post hole or tree-root.



Plate 8 Large posthole SE of Furnace 1.



Plate 9 The Waste Tip under excavation, showing the dense concentration of broken material.

contained some 12000 pieces, nearly all weathered and Early, representing most of the products of the glasshouse, and some brought in from elsewhere (see Microfiche 54).

Shed

Enough evidence was found to suggest strongly the presence of a shed covering the main working area of the glasshouse. Tiles were found in the area of the furnaces; a large posthole occurred 1.5m south-east of F1 (Plate 8); and a flat stone which could have been a padstone lay south of F4. But the probable outline of such a shed could not be established.

Working floor

Much of the area north of F4 and the Cullet Store and up to the edge of the stream-bank was covered with a spread of stones, which probably represents a working floor. It contained some patches of burnt stones. Another floor may have linked F3 and F4; and south of F3 stones may represent the entrance to the glasshouse from the forest track.

Claypits

At both west and east ends of the site were claypits. Just west of the working area was an irregular pit cut into the clay bank, 12.92m from north to south, and 7.69m from east to west. Its purpose appeared to be to provide clay for building and repairing the furnaces, and for closing the glory-holes during firing. At the point on the edge of the pit nearest F4, waste material from clearing the furnaces had been tipped (Plate 9), and this tip – an unusual and valuable find – contained, besides crucible (eg that in Plate 10), a selection of the glass products of the furnaces. This, with the cullet, yielded a comprehensive view of the local products, which indeed constituted a wide range of the glassware current in the mid-16th century.



Plate 10 Massive base of crucible, containing fused waste.

The claypit on the east of the site, close to F2, was a roughly rectangular trench 6.15 by 2.46m, and 60-90cm deep. At each end of this was a short channel leading to the edge of the stream-bank, which could act as overflows into the stream. This pit could have been used for washing materials, vessels and tools; for mixing water with ash from the fuel wood, and lime, to make potash suitable for glassmaking; or for preparing clay for potmaking.

The area surrounding the structures and features just described was sounded in all directions until all traces of glassmaking activities ceased. It is reasonably certain that the entire glasshouse, with all its components, has been uncovered.

THE FINDS

Glass

The glass is widely representative of its period, consisting of window, vessel, drinking glasses, bottles, domestic ware (eg hour-glasses, smoothers), medical ware (eg urinals), and distilling apparatus. A few pieces of cullet are coloured, and a few decorated.

The glass phases represented are discussed on Microfiche 42; the analyses and their implications on Microfiche 43-6; the particular problem of the coloured glass on Microfiche 48; the distilling apparatus, and the possible special connection of Knightons with the world of alchemy, is discussed on Microfiche 50-4; and the cullet problem on Microfiche 54-5. The glass itself is described and commented on below.

A considerable quantity of glass was recovered, weighing 61.5kg (137 lbs), and estimated to number about 12000 pieces. The waste tip was only sampled. Most of this mass of bits was of course amorphous flat or curved. But some 320 pieces were diagnostic or significant, and are listed below. This figure is about 2.6% of the total, and even when allowance is made for crown rims not counted, cutoffs and unexcavated waste, the percentage of diagnostic pieces to the total is unlikely to exceed 3-4%. Of the cullet most is clearly of local manufacture, and only 46 diagnostic pieces (0.38%, say 0.4% to allow for cutoffs, or 15% of the pieces listed) were unquestionably brought from elsewhere. Almost all the glass is weathered, and of Early type. Of the listed items some 40 pieces are of the hard, clear, bluish-green Late type - 0.33% of the total, and 12.5% of the listed pieces.

(The items below are all from the Cullet Store unless otherwise stated; and many of those not so found may also be regarded as cullet, not furnace waste).

Coloured Glass

(Not painted; all the coloured glass, both painted and not painted, is window glass)

Blue, dark

Two pieces thin, thickness 1.5mm

One piece thick, thickness 3mm

One broken diamond or triangle, 4cm by 1.5cm by 2mm, with scratched lines parallel to the long edges

Blue, mid pale

Six pieces, 1.5mm thick

Purple

One piece, 2mm thick, Late quality

One piece, 1.5mm thick, one side straight, with scratch parallel to it

Mauve

One piece, 2mm, Late quality (from F4 area)

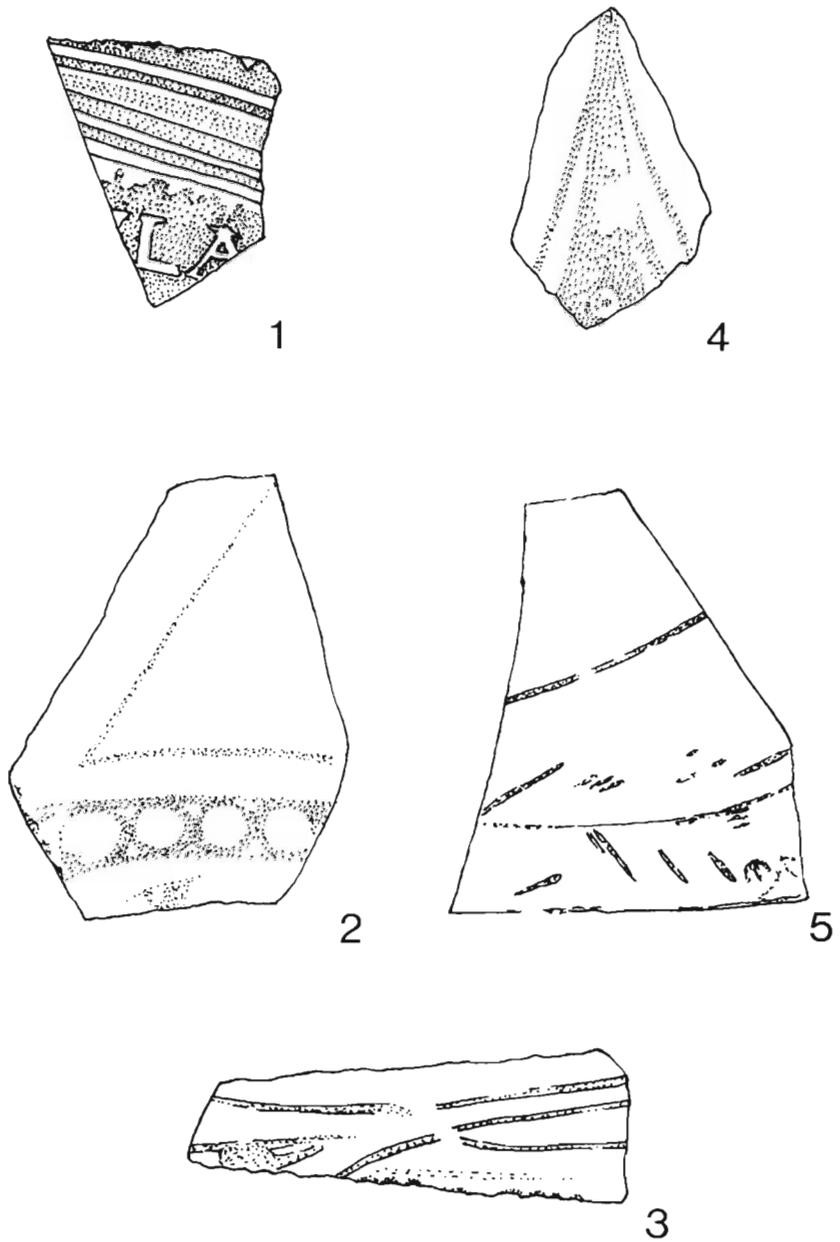


Fig 7 Painted glass: 1. manganese, showing lettering; 2. red on pale blue; 3. broken narrow triangle, clear with red linear pattern, one side grozed; 4. broken diamond, clear, with red pattern; 5. clear, with pale red (or yellow?) pattern of lines and strokes. (Scale 1:1).

Red flash on white

One piece, 2mm

Two pieces, 1.5mm

One piece, 1mm

One small cut-off, crescentic, 1.5mm

Red, dark solid

One piece, 1.5mm, Late quality

Red, pale solid

One piece, 1.5mm thick

Red, deep

Flash on muff (?), edge piece marked with single line on one side and three, which are not parallel on the other (see page 37).

Painted Glass**Purple (manganese)**

One irregular quadrilateral piece, 2.5mm thick. The lower part of this has letters, apparently stencilled, or more probably wax-resist, in a roughly painted white band. The letters visible are:- Upper right-hand tip of a serif; an L, complete, 7mm high, upright arm nearly 2mm wide; nearly-complete A. Above the letters are painted parallel white bands:- 2mm, 1mm gap. 2mm, 3mm gap. 1mm, 2mm gap. Then white 3mm to edge of piece. The piece is 32mm long across this sequence, 30mm wide at the furthest painted band, but only 20mm at the lettering. The lettering and decoration appear to be on a very slight curve, but the piece is too small to be certain on this. (fig 7:1)

Blue

One broken diamond, sides 6cm, width 4.5cm, with a band of red circles between two red lines – two on each side of it – all on a curve as of a circle; a thin red line, 1.5mm wide, parallel to upper left edge (fig 7:2)

Green ('white')

Two pieces painted red all over, 1mm thick, one has a scratched line (see p 37)

One broken long narrow triangle, now 5.5cm by 2cm at widest, by 2mm thick, long edges grozed; a red linear design on one side (fig 7:3)

One broken diamond, 3.5cm side by 2.5cm wide by 2mm thick, grozed; a red linear design on one side (fig 7:4)

One clear, Late, 1mm thick, with red line and dot on one side (not illustrated)

One clear, Late, 1.5mm thick, with thin red lines and short detached strokes on one side (fig 7:5)

White (?) soda

One piece, 1.5mm thick, with white marvered trail pattern:- plain band, crowned lines, and wavy band. The marvered band is impressed 0.5mm (not illustrated)

One piece, 1mm, with white marvered bands 2mm wide, with cable pattern between (not illustrated)

One piece with thin parallel trails, not marvered (not illustrated)

These are vessel pieces.

Marked-out

One piece whitish thin, 1mm, marked in parallel lines 1.5cm apart (fig. 8:6)

Shapes

One triangle on crown edge, 5 by 4 by 6 cm, one side straight, the long side snapped or grozed

in short lengths to form a curved edge, 2mm (fig 9:8)

One triangle, grozed, 2mm thick, sides 4cm, 4cm, and 5cm (fig 9:7)

One diamond, side 3cm by 2.5cm wide, 1mm thick, broken (not illustrated).

Cut-offs

A considerable number of crescents on crown edges with grozed or snapped straight edge, and of various sizes (not illustrated).

Small Roundels or Discs

Six were found all of different sizes:-

2.2cm diam by 1mm thick (not illustrated)

2.8cm by 3mm (not illustrated)

3cm oval by 2.3cm by 7mm (fig 9:10)

3.3cm by 1mm (not illustrated)

3.7cm by 1mm (fig 9:9)

4cm by 7mm (not illustrated)

These are all green, ie uncoloured, two rather Late in quality. They are flat on both faces, except one which has one face slightly convex. The largest one has a pontil mark taking up most of one face, and looks like a crown bull's-eye. The three thickest seem to have been shaped by clipping in short mostly straight cuts. Roundels occurred at Blunden's Wood also (Wood 1965, 65-7). Their origin and purpose is not readily apparent. The thin ones could have been used in windows; the clipped ones may be waste after quarrels were cut out of larger sheets.

Muff

Much must be included among the thousands of unidentifiable pieces of flat glass, but five pieces show an edge:-

One is Late, bluish green, 1.5mm thick

One is Late, yellowish green, 2mm

One is Early, and as though squared off, 2.5mm

Two, 1mm thick, Late, one bluish, one yellowish (this is presumably cullet from elsewhere (not illustrated).

Beaker Bases

With applied milled bands.

One is complete, 4.3mm diam, with remains of the walls; milling 4mm deep and flattish ridges 4mm apart (fig 10:12)

One is broken, but two-thirds present, 4.7cm diam, bold milling 4mm deep, 4mm apart (not illustrated)

The milling on these pieces is rather crude; it is on the outside edge of applied strips or trails from 5mm to 8mm thick, wrapped round the base, and the complete piece shows the overlapping ends of the trail. There seems no reason to doubt local manufacture. This type has been studied by Tait (1967), and shown to be a feature of a tall beaker, commonly decorated with a broken spiral trail of squarish flat 'islands' in relief. The spiral normally continues right to the apex of the kick, as in the example from Culross (Tait 1967, 95, fig 3) but this seems to be absent in the Knightons examples whose decorative scheme, if any, cannot be determined. They may well have been plain. Tait shows that the type appears to centre in the Antwerp area of the Netherlands, but was made in Germany and England also; it dates from the later 16th and early 17th century. The Knightons examples are of clear whitish glass, and Late. The Knightons pieces are useful additions to the short list of English parallels, all Late in Wealden terms;

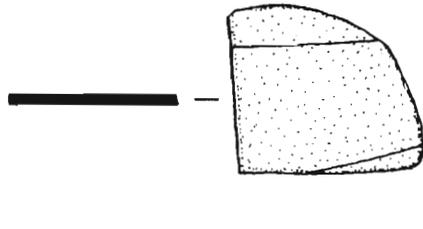


Fig 8 Marked-out piece. (Scale 1:1).

- (1) one in the Haslemere Museum, attributed in a note by Kenyon to Ellens Green (No 36)
- (2) in Guildford Museum (Box 7, ref 854, a base-fragment in thick dark green glass), diam 6.87 cm
- (3) Sidney Wood (No 38) several (Kenyon 1967, 204)
- (4) Buckholt, diam 5.6cm and 7.5cm
- (5) St. Weonards (Bridgewater 1963)
- (6) Bickerstaffe
- (7) Woodchester (Daniels 1950, pls I, II, IX, and see Kenyon 1967 pl XVIII)
- (8) Rosedale, showing a form of the chequered spiral decoration (Crossley & Aberg 1972, fig 60, 19)
- (9) Hutton (Crossley & Aberg 1972, fig 67, 111-12, 124)
- (10) Newent (Vince 1977)

These beaker bases are unusually small, in contrast to the late 16th century ones, eg from Rosedale and Hutton, which are 6cm in diameter and rim 9-11cm. A closer comparison is the examples from Dion-le-Val, Belgium, cited by Chambon (1961, 41, figs 5 and 6). These have bases of 4.5cm and 5.5cm and height of 5-11cm. These dimensions then may be a sign of early date. The beakers are either tall and straight, or shorter and flared. Some of the rims at Knightons could come from this kind of beaker (fig 10:11).

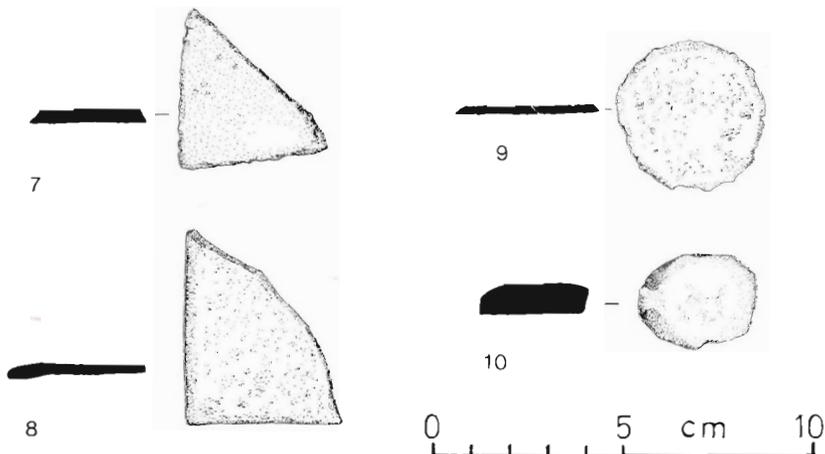


Fig 9 Triangles and roundels.

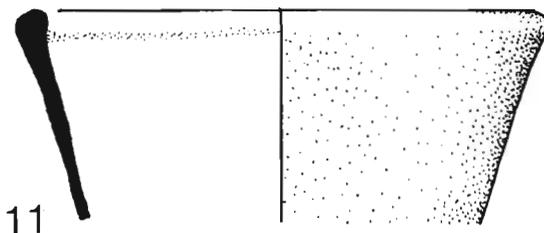


Fig 10 11. Beaker rim and 12. base with applied milled band. (Scale 1:1).

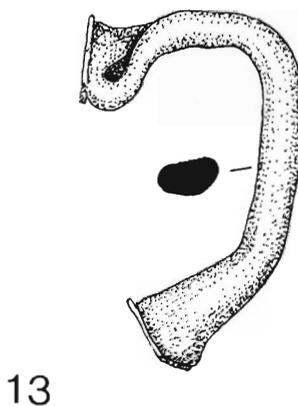


Fig 11 Handle. (Scale 1:1).

Handles

These are made of flattened rod and one end is folded over. Two of the three found are complete:-

One, weathered, 47mm between outside of attachment areas, which are 12mm across, 27mm apart inside; stem 8mm by 4mm (fig 11:13)

One, Late glass, 41mm overall, 22mm inside gap, attachment areas 10mm diam, stem 6mm by 4mm (not illustrated)

The third, heavily weathered, is a broken fragment (not illustrated).

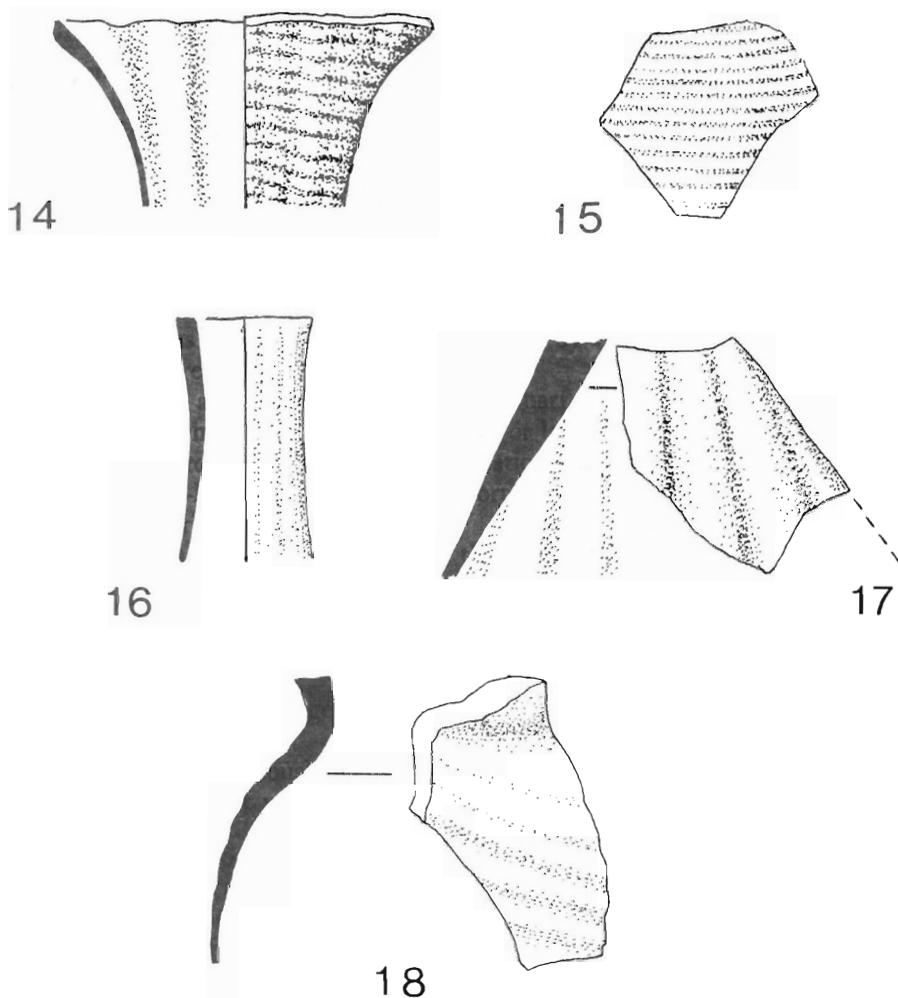


Fig 12 Moulded decoration: 14, wrythen on vertical ribbing; 15, horizontal; 16 and 17, vertical; 18, neck of bulbous bottle, wrythen. (Scale 1:1).

Moulding

One piece appeared at first sight to be the corner of a square bottle, eg a small unguent bottle, like that found at Brookland Farm, Wisborough Green (Kenyon 1967, 183 and pl XVI, 3). A similar bottle has since then been found at Rovehurst. But it may be only a twisted piece of waste (not illustrated).

The commonest forms of moulded decoration at Knightons are ribbing and wrythen. The ribs are rounded and 'fluid', and not sharply defined, unless so noted. This ribbing or fluting is generally vertical. Commoner still is wrythen, and there are a few examples where wrythen overlies vertical fluting.

Vertical

Three pieces, 4mm thick, of the neck and upper part of a thick heavy flask, ribs 7mm between centres (fig 12:17)

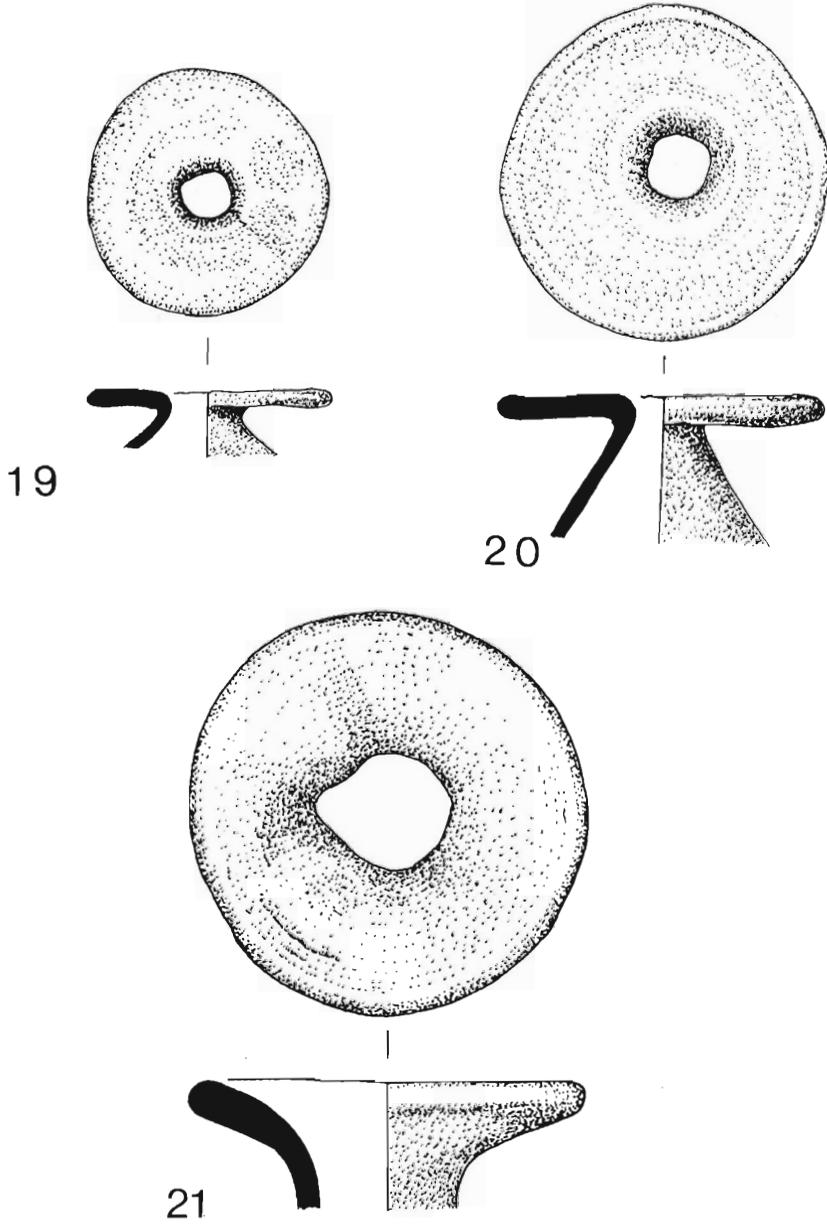


Fig 13 19 and 20. Hourglass necks; 21. neck of (?) cupping-glass. (Scale 1:1).

One piece narrow neck, 1.8cm diam, ribs 3mm apart (fig 12:16)

Wrythen

This may be right-hand or left-hand. The pieces are mostly bottle-necks, three with parts of rims. The ribbing runs up to the projecting rim, except in one case where at least 2cm and one where 1cm is left plain:—

Three pieces left-hand, ribs 3mm, 4mm and 5mm apart (cf fig 12:15)

Thirteen pieces right-hand (not illustrated)

Thirteen pieces of thin, 1mm, flask, have ribbing 2mm, 3mm, or 4mm apart, wrythen, but appearing almost horizontal (not illustrated)

One small piece with wrythen ribbing from the upper part of a bottle of bulbous shape, with part of the neck (fig 12:18)

Anomalous

One piece with wide fluting, 1cm between ridges, slightly diagonal, left-hand, with narrow, 2.5mm, horizontal ribbing crossing it (fig 12:14)

One piece curved, with thick tubular trail. This could be a failed (distorted) part of an alembic (not illustrated)

One piece of neck, 7cm long by 2.2cm diam, 2mm thick, slightly curving, with point of attachment for handle 5cm from break; vertical ribbing 4mm apart, ceasing 2.5cm below break. From F3 area (not illustrated).

Smoother

About a third of the 'bun' part, and beginning of the handle. Late quality. From the Waste Tip. This is a Late type in the Weald (Kenyon 1967, 90) (not illustrated).

Hour-glasses

Two rims:—

One, 3cm diam, hole 7mm diam, 2mm thick (fig 13:19)

One, 4.2cm diam, hole 8mm diam, 3mm thick (fig 13:20). These, which appear to be of local make, should be set against Kenyon's statement (1967, 90), that no evidence has been found in the Weald for the making of hour-glasses.

Cupping-glass

A small rim of bottle type, wide and nearly flat with narrow hole, 5cm externally, 1.4cm internally, 2mm thick, is not impossibly from a blood-letting cup. Renaud (1962, 4.5 and col 110) shows a small vessel from the Delft Charterhouse AD 1470-1571, with a very similar neck, 4cm diam but with opening 1.5cm across (fig 13:21).

Globular Vessels

Two pieces are parts of the rims of the openings of vessels, the sides of which slope gently away from the opening at a low angle without any neck, suggesting a bulbous or globular form. The rims are thicker than the body of the vessels. These may be 'scientific' glassware, but as one of the pieces has wrythen decoration, they are more likely to be domestic. The openings may be designed for bungs or stoppers. No parallel can be traced. The opening of one piece is 1.7cm diam, the other 1.3cm (fig 14:22, 23).

Plate

A piece with thickened rim, 3mm deep, has sharp thin trails 1mm wide parallel to it on the underside, and certainly comes from a plate or small dish. These were popular in the late 16th century (Barrington Haynes 1959, 149; Thorpe 1961, 113) (fig 15:24).

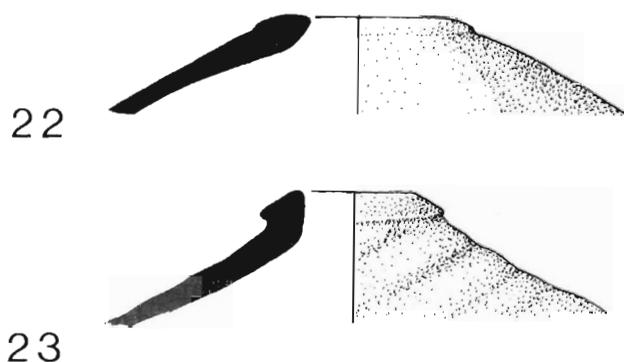


Fig 14 Globular vessels. (Scale 1:1).

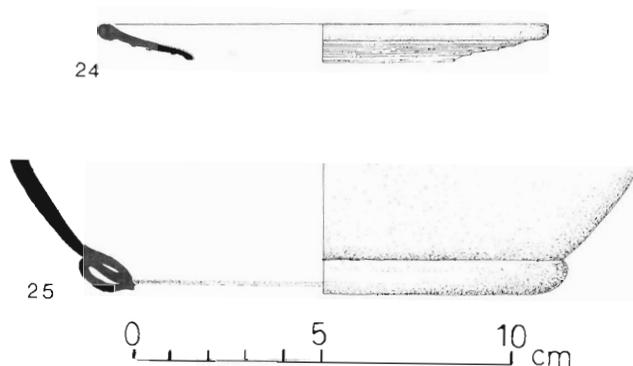


Fig 15 24. Rim of plate or small dish, with trail decoration; 25. foot of bowl.

Bowl

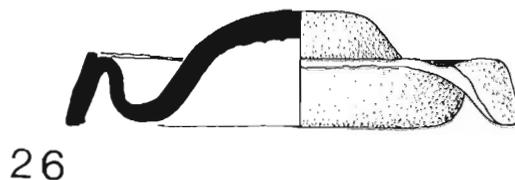
Rim of a foot, made from a double fold, forming a roll 1.5cm deep, with part of the body, which thickens to 4mm as it rises. The shape of the upper part cannot be determined, but the foot is c 22 cm diam (cf illustrations in Barrington Haynes 1959, pl 39a and 51c) (fig 15:25).

Albarello

Two pieces (only one illustrated) which look like failed bases at first sight, in fact, instead of rising to form the sides of a flask, are folded back, and there joined by a straight outer skin. These may be stoppers or caps for albarello-type jars (fig 16:26).

Drinking Glasses etc

Two pieces (only one illustrated), having a thick plain rim, 6mm thick, 3.5cm diam, not everted, from which rises an inner skin of thinner glass, are almost certainly knobs from the pedestal stems of drinking-glasses; the thin inner skin being the lower part of the bowl of the



26

Fig 16 (?) Stopper of albarello-type jar. (Scale 1:1).



27

Fig 17 Knob of pedestal stem. (Scale 1:1).

vessel itself (cf Kenyon 1967, pl XIV top left; or, more closely comparable, Barrington Haynes 1959, pl 63a) (fig 17:27).

Feet

Plain rims

(Edges not folded or bent over) Three pieces:—

One is doubled by a ridge just inside it, 7.6cm diam – is this a clumsy urinal rim?

Two are 10cm diam (not illustrated)

Rims folded over

Four pieces:—

One, 1mm thick, rim folded underneath 4mm thick, 1cm diam (fig 18:28)

Two, very thin, 0.5mm, rim folded under for 4mm, rises unusually steeply from edge (72°); diam 7.4cm, (?) goblet stem (not illustrated)

One, 1mm thick rim folded under for 9mm, diam 9.8cm, rises at 45° (fig 18:29)

Pushed-in bases

With hollow rims, eight pieces, mostly very thin, 1mm when doubled

One, nearly 2mm thick, shows top of foot with pontil mark 1.3cm diam (fig 18:30)

One, a failed piece, thick towards kick, upper fold very thin, rim distorted (not illustrated)

Another pushed-in beaker base, distorted, has parallel white lines on one surface which are probably due to weathering (not illustrated)

The pushed-in base is the result of a method of making a vessel, usually either beaker or spherical shape, in one piece instead of, as in most vessels, joining the foot onto the body. The

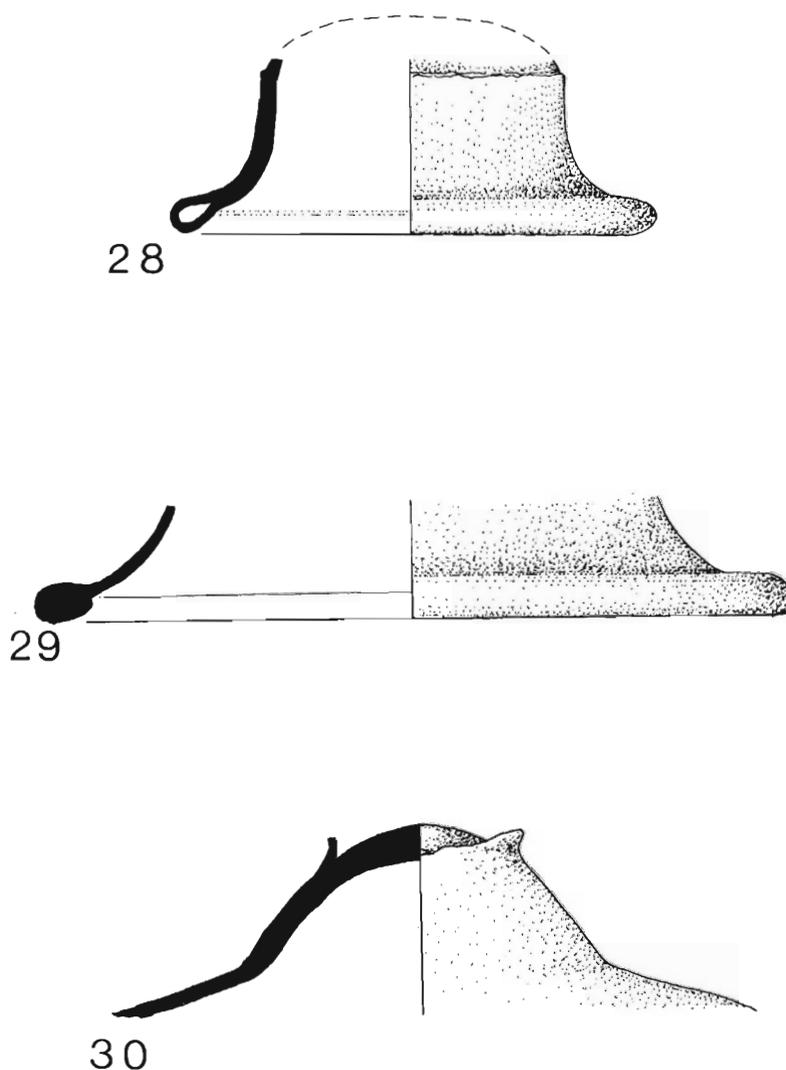


Fig 18 28. and 29. folded bases, 30. pushed-in base. (Scale 1:1).

pontil-mark is inside the kick on the outer surface of the vessel and the upper part is continuous with the outer skin of the base. Charleston (1979, 290) describes this method as 'the classic way of forming the foot in the forest glasshouses of England'. The method has a long history, and Barrington Haynes (1948, 147, and pl 31a) illustrates a late 4th century Gallic example. Barrelet (1953) shows several 15th and 16th century vessels with high base (eg pl XXI bottom right, and those carried by the pedlars in pls XXXII and XXXIII, cf Kenyon (1967, pl XI)) which probably reflect this technique. A somewhat clumsy example, but not unlike ours, is a drinking-glass where the high kick forms the floor of the cavity of the vessel, illustrated in Renaud (1962, fig 4.1). This comes from the site of the Charterhouse in Delft, AD 1470-1571, but may be of French origin. Parallels have been found at Oxford, Southampton and London

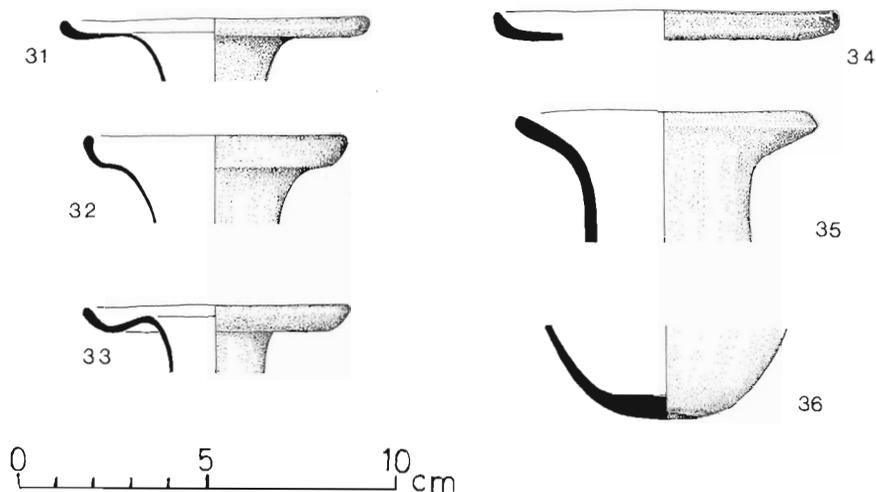


Fig 19 Urinal rims and base.

(Charleston in Crossley & Aberg 1972). Excavated examples from glasshouses are not common. One came from Bagot's Park, c 1535 (Crossley 1967, 68), one from Rosedale, c 1590s (Crossley & Aberg 1972, 135 and fig 60, 16 and 17), and one from Woodchester (loc cit). A probably roughly contemporary example in late glass was found by D L Williams in 1977 on the Reigate Vicarage site, but not stratified (pers comm).

Urinals

were prominent among the products of Knightons. They fall into two types:—

Type 1

With wide and heavy flaring rim and elongated round-based body of oval profile; examples from London are recorded in Hume (1957, 105 fig 2). A rim from Knightons is of this type; 3.8cm internal diam, ie the neck, 7.5cm external diameter, 3mm thick – unless this is just a very large bottle (fig 19:35)

Another, in Late quality clear bluish glass, 3mm thick, with slightly thickened edge, 10cm external diam, is not large enough to diagnose with certainty, but may well come from a urinal also (not illustrated)

Also seven rims, plain, but three with right-hand wrythen decoration on neck after a gap. Diameters range from 6cm, 6.4cm to 6.6cm (not illustrated).

Type 2

The other type has a flat brim with edge turned up vertically, the body is globular with a straight neck. Examples from Winchester are illustrated in Charleston (1964, 148 and fig 16).

Rims

The rims are mostly thin, 1mm; diameters range from 7.2cm to 11cm. One piece, 10cm diam, has a vertical turn-up 4mm high. Twenty-three found, four illustrated (fig 19:31–4)

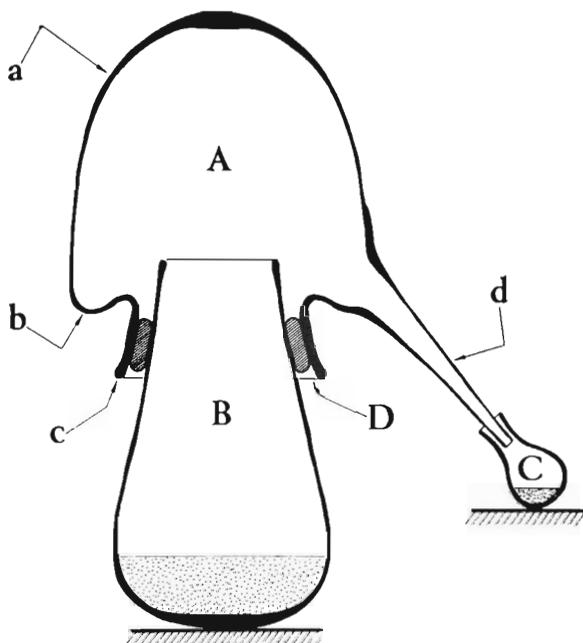
Bases

With pontil marks or low wads on the convex side (the bottom of the vessels) and no kicks; most of these marks are c 4cm across. These bases are not easy to distinguish from recipient

bases, but are here assigned to urinals on grounds of probability, in view of the large number of rims. Nine found, one illustrated (fig 19:36).

Distilling Apparatus

Parts of all the components of these apparatus were found (many in the F3 area), and there is no doubt that they are locally made; some are distorted (fig 20).



COMPLETE UNIT

The complete apparatus is known as either a *still*, *alembic* or *limbeck*, with variations in the spelling.

- | | |
|--------------|---|
| A. ALEMBIC: | <i>alembic, still-head, head and helm</i> |
| B. CUCURBIT | <i>cucurbit, body, matrass, flask and gourd</i> |
| C. RECEIVER: | <i>receiver and bolt-head</i> |
| D. LUTE: | <i>lute</i> |

DETAILS OF THE ALEMBIC

- | | |
|----|--------------------|
| a. | DOME |
| b. | COLLECTING-CHANNEL |
| c. | RIM |
| d. | SPOUT: <i>pipe</i> |

Fig 20 Distilling apparatus: generalised section, showing the components and their uses. (From C.C. Moore's note in Moorhouse 1972, with acknowledgments).

Alembics

Rims, with collecting-channels.

Four found, only two illustrated.

One, 2.9cm deep, 2mm thick, channel 1.5cm deep, diam 10cm (fig 21:38)

One in clear Late glass, 2cm deep, channel very shallow (fig 21:37)

Spouts

One is complete, with small piece of gallery adhering, 3cm at mouth, pipe 1.2cm diam at 5.5cm from mouth (fig 21:39)

Fourteen fragments of pipe, some tapering, some straight tube, 7mm diam, and one 4mm (not illustrated).

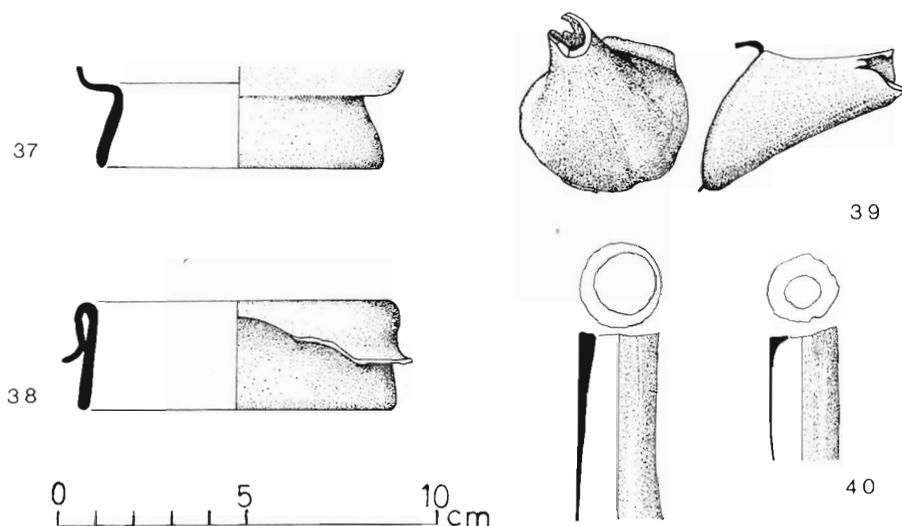


Fig 21 Alembic collecting channels, spouts and tubes.

Cucurbits*Rims*

6 plain, of which one is distorted, 2mm thick, diam 7cm, 9cm

Two are thickened with flat lip outside, 7mm wide, c 9cm diam

The smaller ones could be urinal rims, or even beaker bases (fig 22:41-5).

Bases also occur, see page 31.

Receivers

Six large fragments (from F3 area), in clear Late glass. This has rim complete or broken off close to it, 6mm thick, 4.3cm diam (fig 22:46)

All except two of the remaining pieces can be reassembled to form a considerable part of the whole vessel, 16cm high by 8cm diam – and this is not the full width (fig 22:47)

Ten miscellaneous pieces, one of these is ribbed and may be a thick beaker (not all illustrated, fig 22:48-9)

For bases, see page 31. This apparatus is discussed on Microfiche 50

Tubes

Seven pieces of straight tube, 1mm, 2mm, and 3mm thick; 1.5-2cm diam. These are difficult to identify, they could come from chemical glassware or from long-necked flasks, as from Bagot's Park (see Moorhouse, 1972, 103) Only one illustrated (fig 21:40).

Crown Window

Probably the bulk of the glass, and most of the flat. Most is of Early type, except some from F4. Rim and centre (bull's-eye) was found in quantity. The thickness is normally 1.5-2mm (1.3cm at centre), and the diameters of the sheets range from 88cm (34½ inches), (four samples), to 90cm (35½ inches), (two samples). This implies great accuracy in estimating the size of each gob, and high operative skill (not illustrated).

Bottles, Flasks etc

A wide variety was found of what was the second most important product of the glasshouse, after crown. Harrington (1952, 27 and 31), illustrates possible types of bottles and vessel made at Jamestown. (These are more comprehensive and useful than the corresponding figures in his revised edition of 1972, p.34). The similarity with the finds at Knights is very evident.

Necks and rims

These fall into two categories; those with straight or nearly straight rims, and those with flaring rims.

Straight rims

Eleven:—

Six range from 2.1cm diam to 2.4cm; 2.8cm diam to 3.1cm: 2mm to 4mm thick

One, very thick, 8mm, and large, 3.6cm diam

One, 2.5mm thick, 3.2cm rim diam, is 10cm long, and shows the gently swelling profile (6cm diam at 10cm from rim)

Three are Late; one 1.6cm diam, 2.5mm thick; one 2.2cm diam; one (from F1/2) 2.4cm diam, 4mm thick.

All these appear to be recipients (see fig 22).

Flaring rims

Thirty-six:—

These range from narrow necks 1.5cm diam and 1.5mm thick (eleven), through an intermediate size – eg 3cm diam externally, 1.6cm diam internally, 1mm thick (six), to larger, heavier sizes – eg 4.5cm externally, 2cm internally; 4.5cm externally, 2.7cm internally; 5.1cm externally, 3cm internally; 4.5cm externally, 2.6cm internally (thirteen)

Five are Late clear (one from F1 area) – 3.2cm externally, 1.5cm internally; 3.4cm externally, 1.6cm internally; 3.5cm externally, 2cm internally; 4cm externally, 2-2.5cm internally (distorted). Seven illustrated (fig 23:50-6).

Bases

If from flasks, these have the pontil mark on the concave underside, ie inside the kick. The kicks can be either rounded (fig 24:57, 59-61) or 'pointed' (fig 24:58). They can be shallow or deep. They fall, like the necks, into three size ranges:—

Small

Twenty found:—

Examples: 2.5cm diam by 6mm high; 3.6cm diam by 1.1cm high; 3.5cm diam by 1.3cm high; 3cm diam by 8mm high.

Medium

Thirty-two found:—

Examples: 4cm diam by 1.2cm high; 4.5-5cm diam by 1.4cm high (distorted); 5.2cm diam by

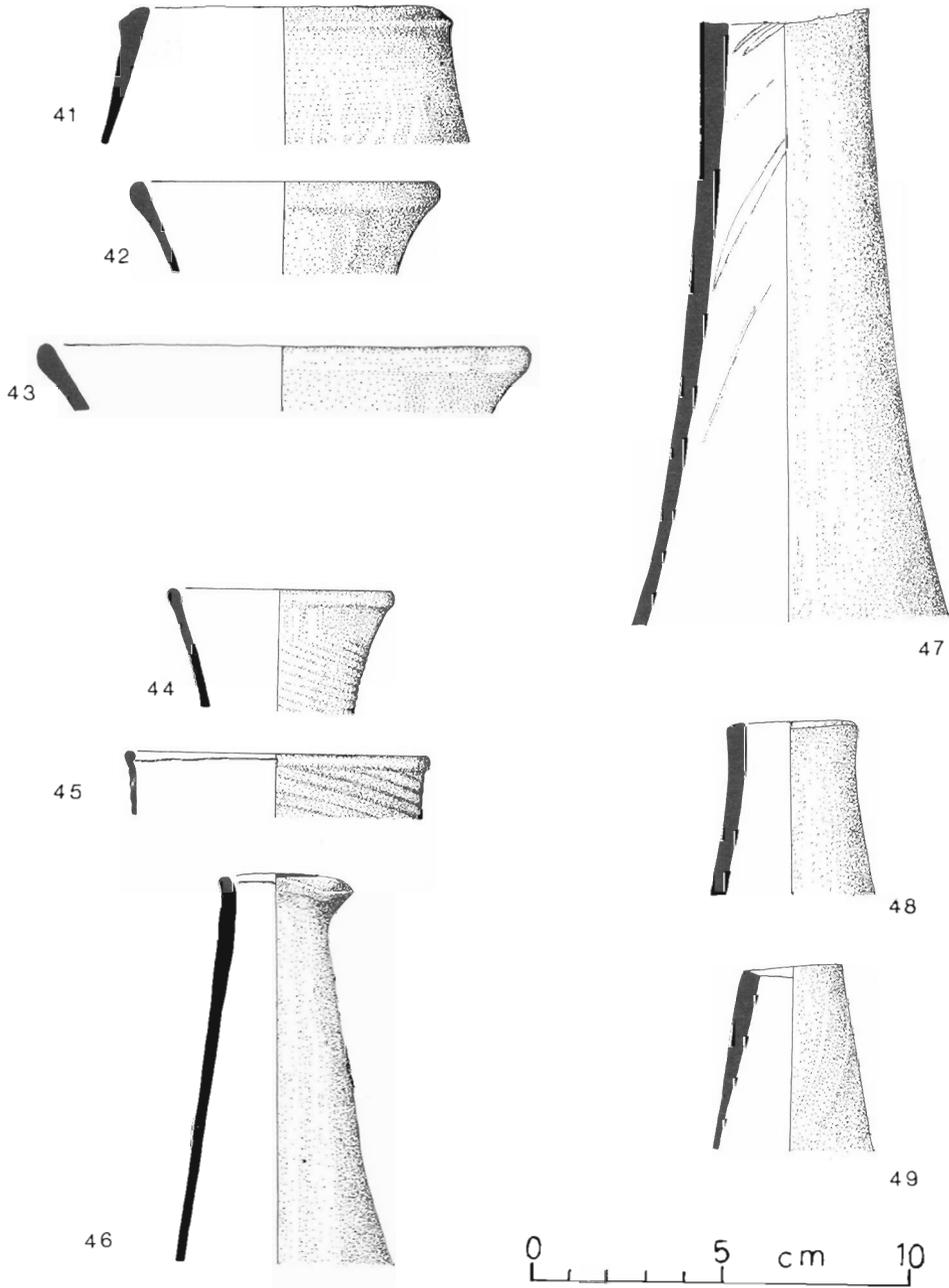


Fig 22 Cucurbit and receiver necks..

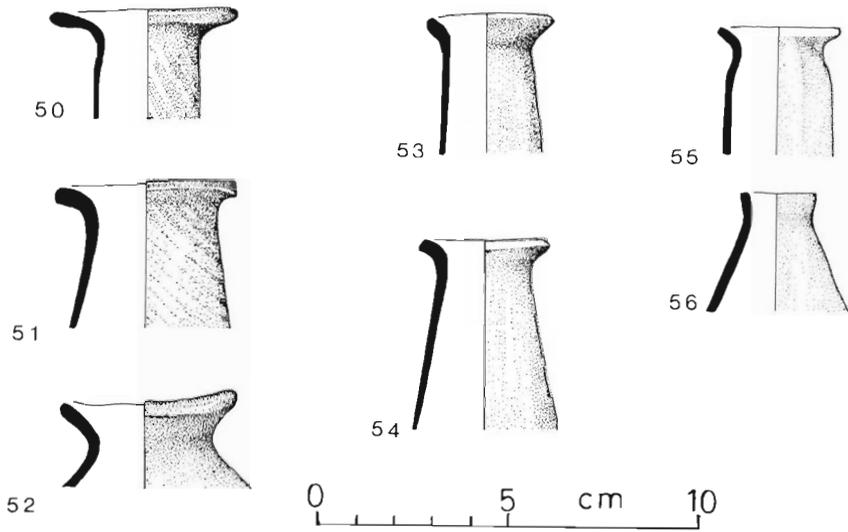


Fig 23 Bottle necks.

1.7cm high.

Large

Eight found:-

Examples: 7cm diam by 1.8cm high; 7.5cm diam by 1.7cm high; 9cm diam by 2.4cm high. One medium base has walls rising vertically, instead of, as is normal, at a low angle, which indicates a straight-sided bottle, not a bellied flask. Some of the bases are more oval than round. A long straight neck, 2.7cm externally, 1.8cm internally, was found in the north chamber of F4. This is nearly 10cm long and 4.5cm diameter at that point. Near it was a wide base, 7cm diam to middle of the 'trough' and kick 2cm high. It is very probable that these come from the same flask, and the figure suggests a possible outline of the vessel (fig 25:62)

The Waste Tip

This contained a fairly representative sample of the products of the glasshouse, but it was not fully excavated and not every piece was collected. A random sample consisted of:-

- One crown centre trimmed to roundel
- One possible handle or drip
- Six kick (flask) bases
- Three urinal or recipient bases
- Two pieces of recipient or cucurbit
- Three large tubes or narrow necks
- One wide foot with turned-down edge, 8.5cm diam
- One foot with turned-down edge and steep rise (goblet). These are all types occurring in the list above (none illustrated).

Miscellaneous Unidentified Pieces

Possible waste included seven pieces, mostly thick, in contorted shapes, which could not be ascribed to recognisable types, but
 One is a solid plug 2.2cm long and 1.3cm diam, perhaps from a blowpipe

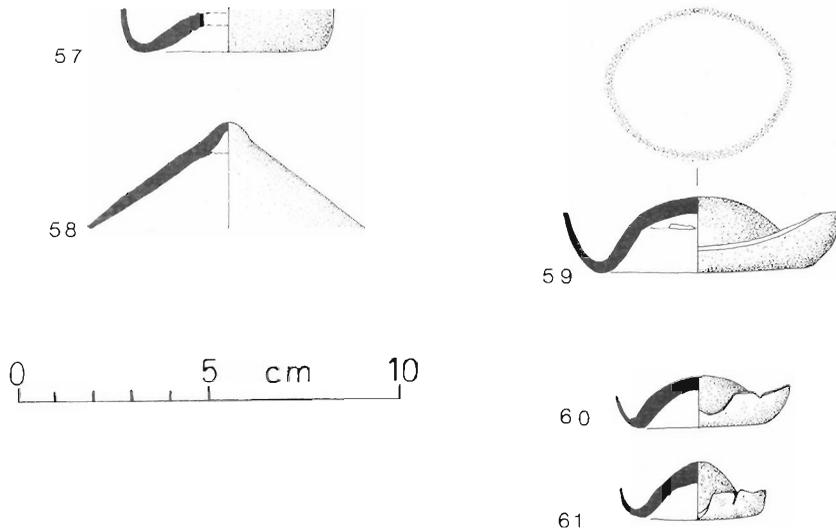


Fig 24 Bottle bases.

One piece of thickened plain rim, from an object 10cm diam, 3mm thick, Late quality clear bluish-green (none illustrated).

Drips and Rods

Of various shapes and sizes. A random selection of fifteen Early and seven Late was made. Drips and threads of glass may arise merely by dripping off the pontil as the gob is gathered, but they can also occur as a result of deliberate testing of the melt to ensure the right viscosity for using (Harrington 1972, 46). A similar suggestion has been made by Six (1976, 133) – ‘vermutlich waren sie (die Glastropfen) ebenfalls ein Fertigerzeugnis’ – ‘presumably the drips of glass also indicated readiness for use’.

Strike-offs

(Knock-offs, welting-off rings or wads). A large number was found, from which a random selection was kept. They reflect pontils of 1.8cm and 1.6cm. diameter.

The Late glass ranges from yellowish through mid-green to bluish-green, and sixteen pieces were selected to illustrate this. It is also harder and sharper than the Early. All the Early glass is more or less weathered or opaque, iridised or encrusted; much of it is dark greenish-brown on the surface. Where clear it is pale green, or deeper green if in lumps. Three pieces were selected to represent an advanced stage of weathering decay, with porous or layered interior (a sandwich of dark-light-dark). Weathering sometimes takes the form of thin, white, apparently scratched lines, which can seem deceptively like intentional marking-out. Examples are:–

A flat piece with grozed straight edge, with lines in squares of 2.5cm sides (not illustrated)
 A clear Late piece snapped off on three sides of a square 4cm, but the fourth side failed – this side has a line.

A crown edge with three rough parallel lines (none illustrated).

There was also a considerable quantity of lump glass, both Early and Late, this came from crucible residues; several pieces of crucible base had thick deposits of glass adhering. Much frit and scum (formerly known as ‘slag’) came particularly from F3. Cindery material probably

represents clay impregnated with glass or sand and burnt hard. Burnt stones and lumps of clay, from furnace walls, etc were common; some of the clay had glass spill on one side.

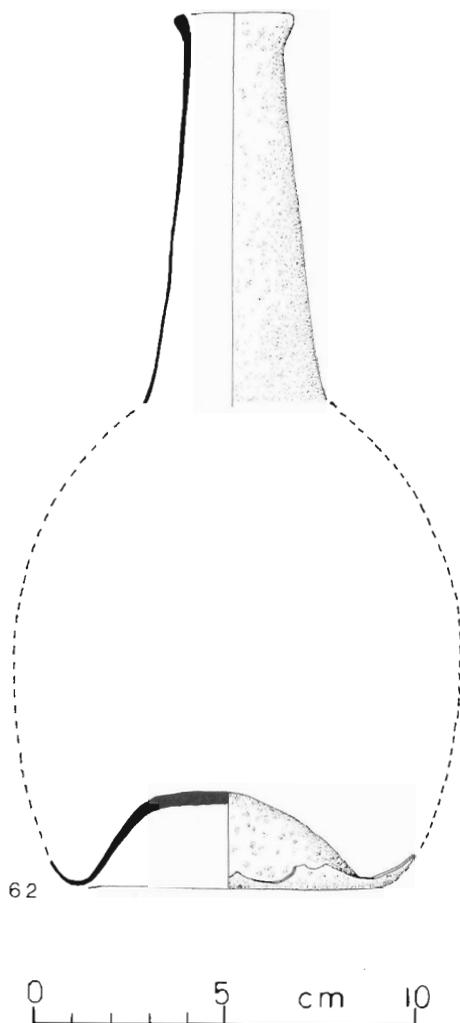


Fig 25 Reconstruction of bottle from neck and base in F4.

Other Finds

Crucibles (For description see Microfiche 26-9; for discussion see Microfiche 55-60).

A large number of fragments was scattered all over the site. The pots with thicker walls (2cm and over) were bucket-shaped; those with thinner walls (1.1-1.8cm) had straight sides incurving for the top few centimetres. The rims were of a form distinctive to Knightons – a ‘signature’ of the maker – being pinched-in to a sharp edge on the inside of the pot, leaving a flat or slightly rounded rim (fig 26:63-6). Only three pots were found with different rim-forms, these were

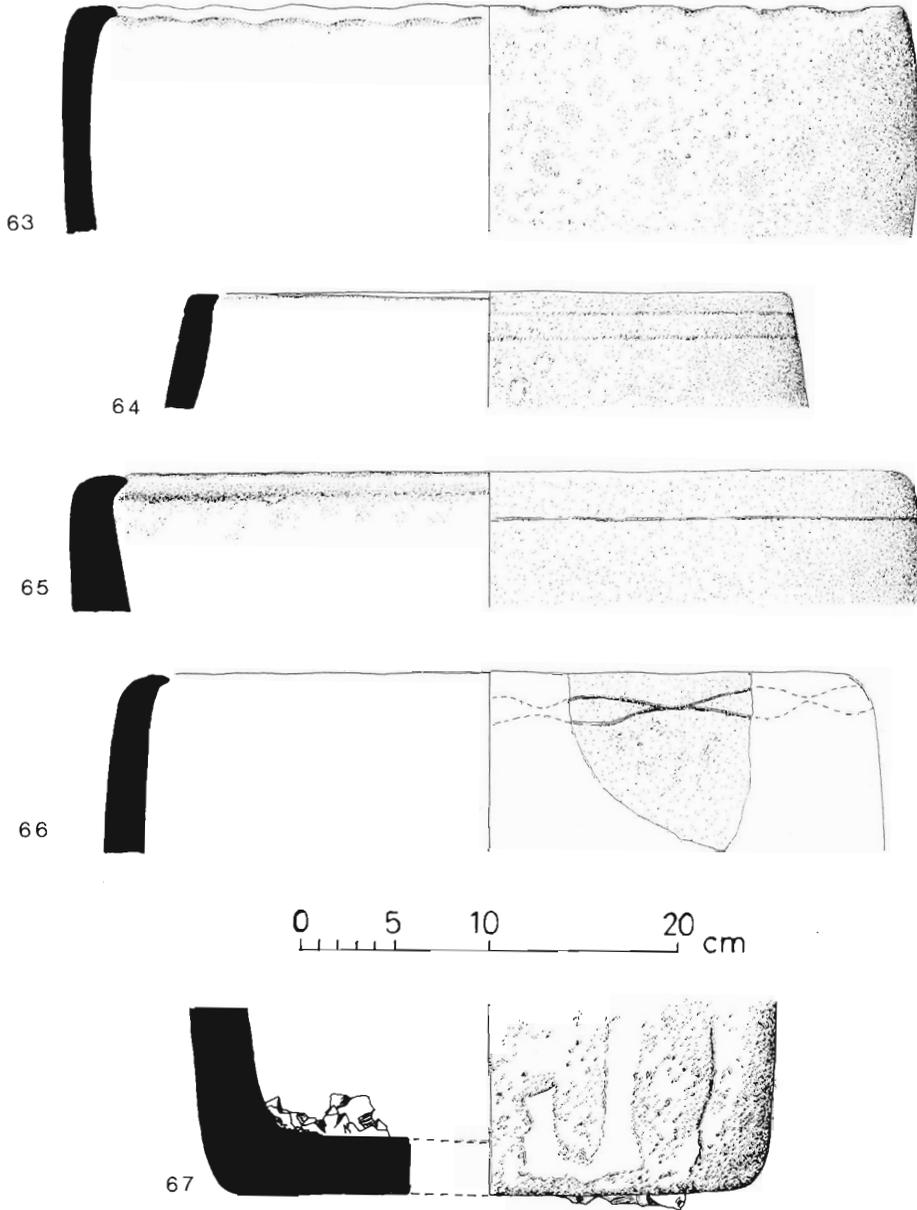


Fig 26 Crucible rims 61-66 (standard Knightons type), decorated; 67. crucible base.

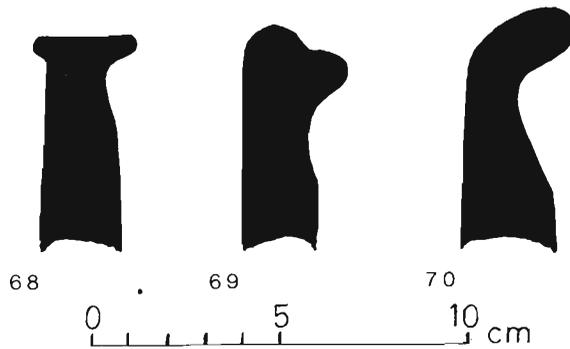


Fig 27 Crucible rims, anomalous forms.

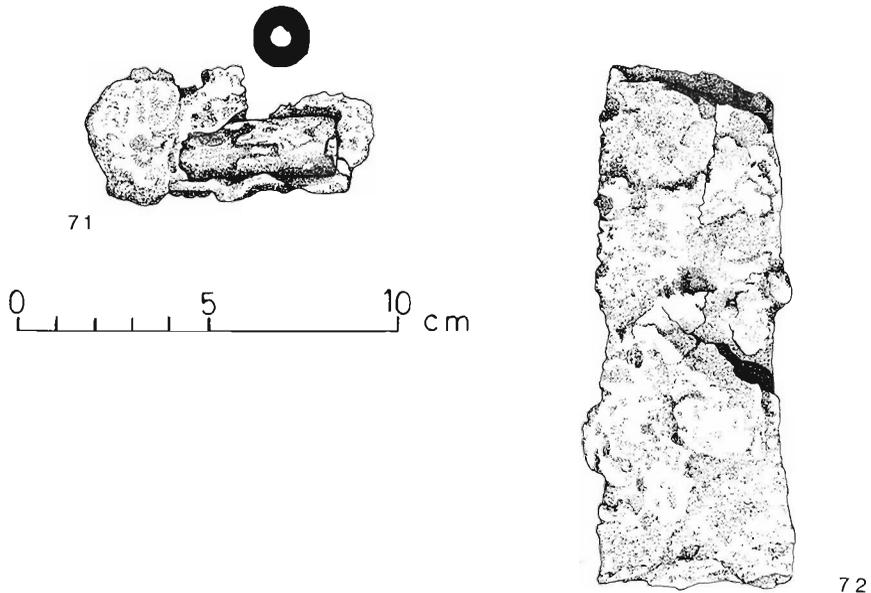


Fig 28 71. Fragment of blowing iron; 72. Iron strap.

heavy and squashy, rolled over to project either inside the pot or on both sides. These were clearly the work of another maker (fig 27:68-70).

Some of the pieces had glass adhering to them, and, in the case of bases (fig 26:67), sometimes quite thick masses. One very large complete base was found in the Waste Tip, filled with fused cindery frit (Plate 10). A few pieces from the rim parts of pots were ornamented with incised lines; one has an interlacing pattern (fig 26:66). The crucibles were not made from the local clay, but none the less appeared to have been made at the glasshouse.

Iron. Several pieces were found, representing pontils, blowing-iron, strap and nails (fig 28:71-2). (See Microfiche 29-31)



Fig 29 73. Lead came; 74. bronze ring.

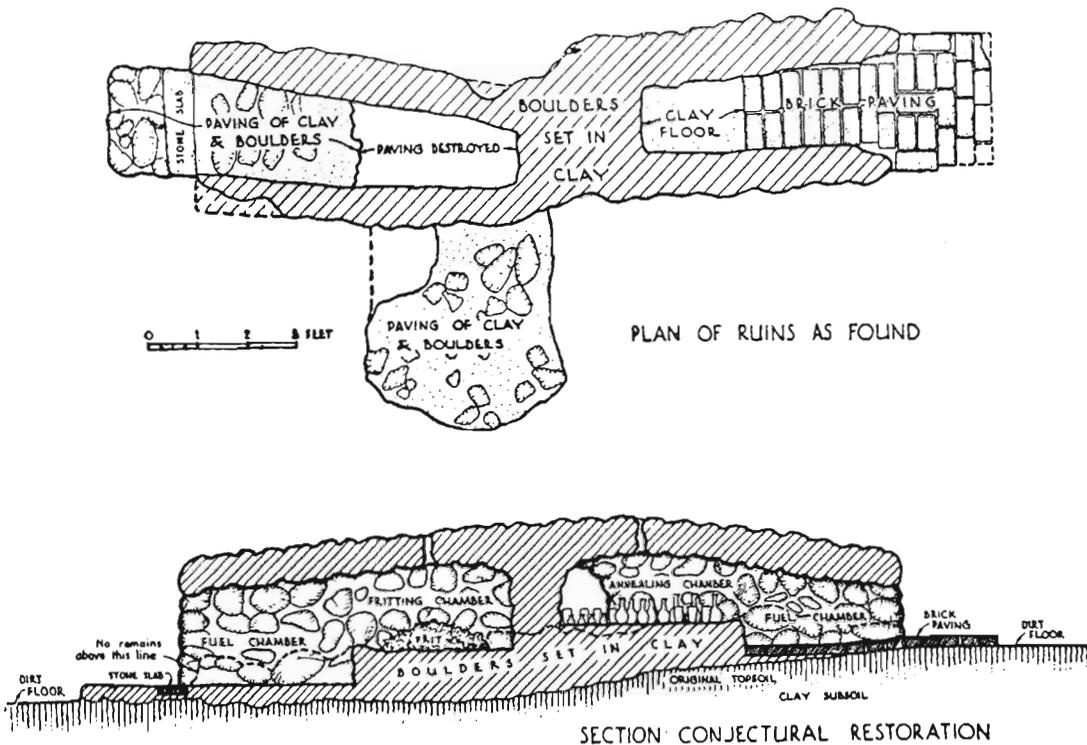


Fig 30 Double furnace at Jamestown, Virginia (1608), possibly used for continuous annealing (from Harrington 1972, with acknowledgments).

Pottery. Fragments of seven vessels, including saltglaze stone-ware (brown speckled on grey): plain gritty buff, unglazed, with flat rim; a shallow bowl, pale redware, black or grey inside; a storage jar, pinky-buff gritty, blackish outside, unglazed; and green-glaze ware. These are all 16th century types. In addition, yellow-glaze bowl, 18-19th century; and blue and white earthen-ware, after c 1790. These may be related to the canal. For descriptions see Microfiche 31-2; for discussion of the significance of the pottery for life at the glasshouse, see Microfiche 60-2 (none illustrated).

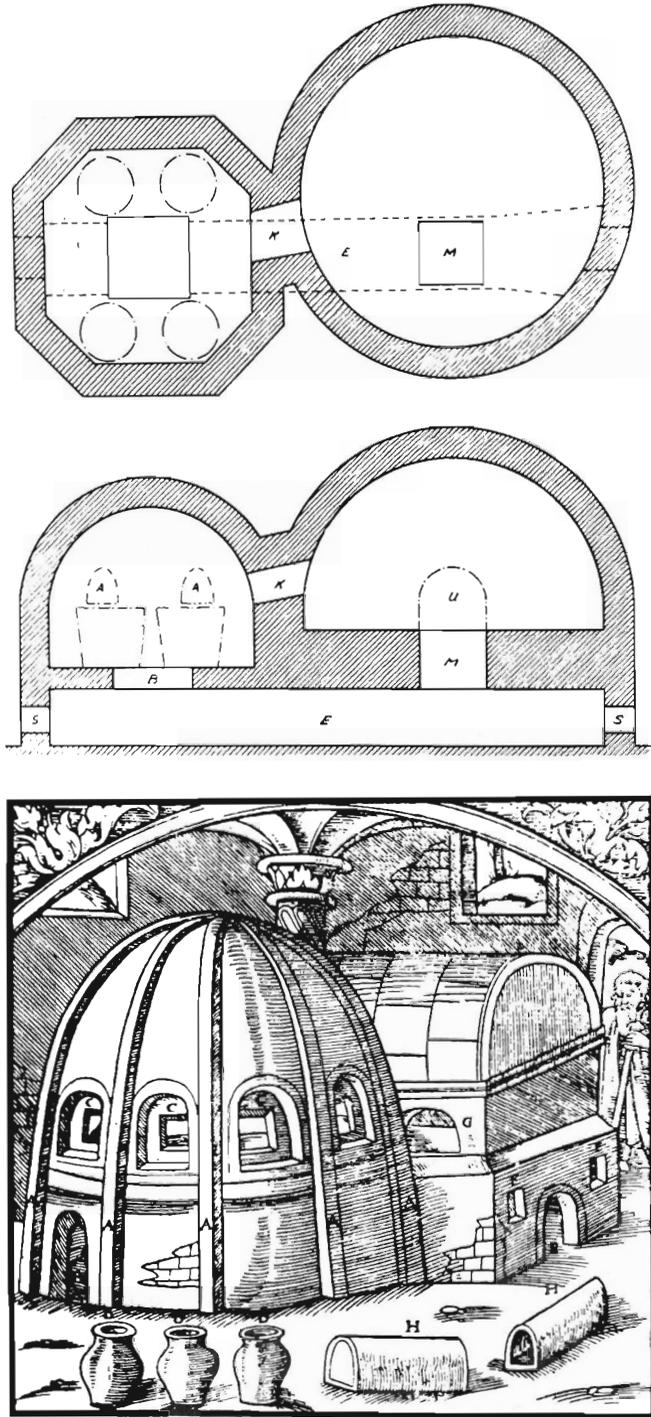


Fig 31 Two-chambered horizontal furnace, Trestenshult, Sweden (from Stromberg 1932, with acknowledgments).

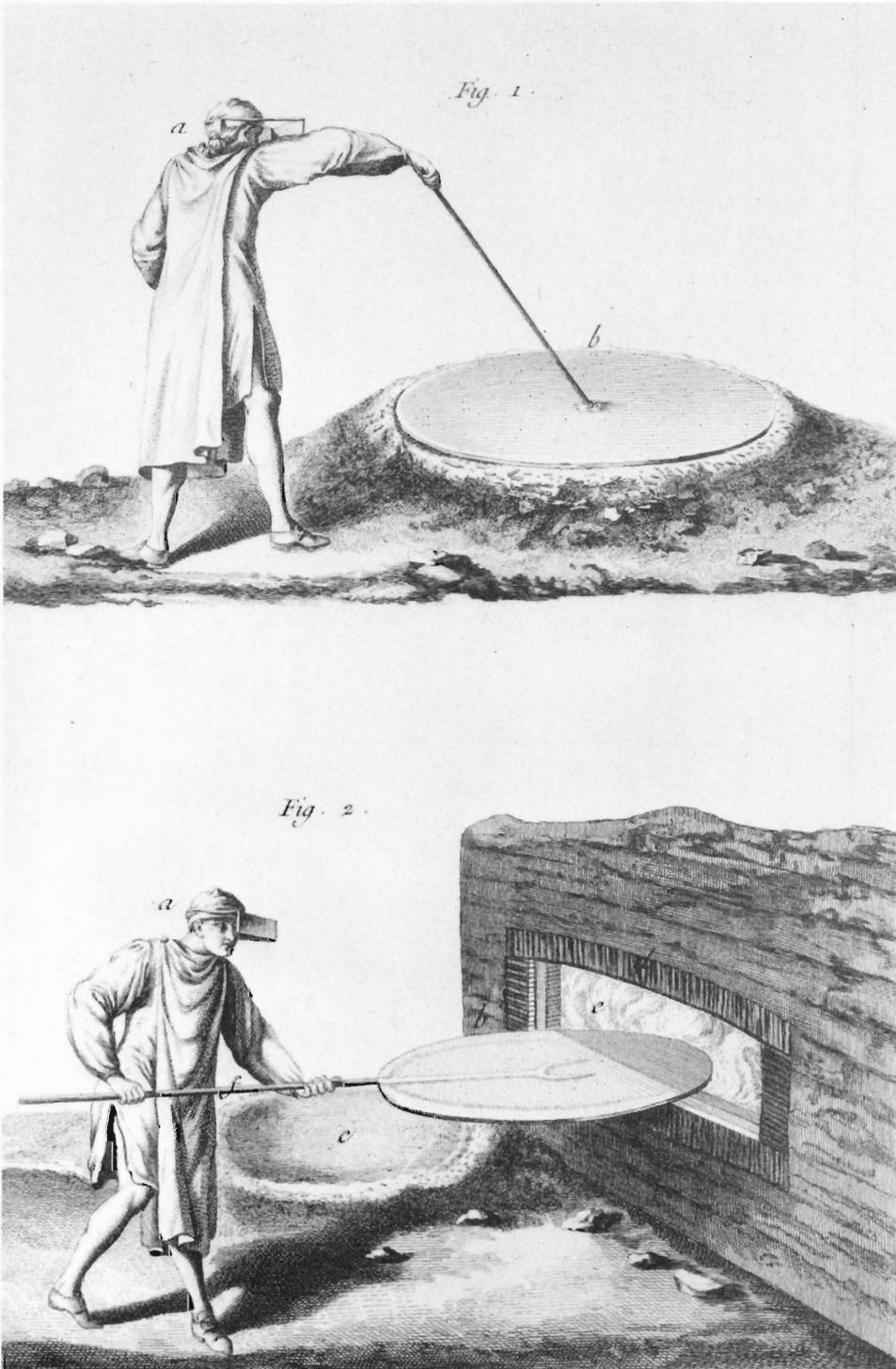


Fig 32 Crown annealing furnace, French type (from *Encyclopedie* 1765).

Coin. A base silver shilling of Edward VI, 1550, came from the east chamber of F4. It was in "very good" condition, and is crucial for the dating of the glasshouse. (See Microfiche 32) (not illustrated).

Lead comes from windows (fig 29:73).

A bronze (?) thin wire penannular ring (fig 29:74).

Oyster shells perhaps for lime.

A (?) padstone (not illustrated).

Bricks, unregulated sizes, no frogs (see Microfiche 34) (not illustrated).

Tiles, flat, with nail-holes.

Objects not associated with the glasshouse included *flint flakes*; *sheep* (?) *bones*; *clay pipe* bowl, of Oswald's type 4 (1650-80) or 6 (1680-1710); 18th century *wine-bottle* fragments; *modern bottle* (none illustrated).

CONCLUSIONS

The products of Knightons were mainly of Early type Forest glass. The small proportion of glass of Late type presents a problem. Much of it may be brought-in cullet, originating from other Wealden glasshouses not yet located; but some was found in the furnaces, and if of home manufacture, may be freak or genuinely experimental. The evidence, such as it is, points to Knightons being active in the 1550s, although it could begin in the 1540s and continue into the 1560s. This implies that Late glass begins, if only in a small way and in one glasshouse, at least by the early 1560s, which brings the currently accepted date forward by a few years. Knightons seems to be one of the last glasshouses to use furnaces of the old medieval type, of rectangular plan with rows of sieges on each side of a long, straight, central fire-trench. The Late furnaces are either precision-built in brick or stone or both, to geometric designs (eg Fernfold), or are of the winged type (Buckholt, Vann, Rosedale, Hutton) which is associated with immigrants from Lorraine. The lower-temperature processes at Knightons were carried out in separate furnaces.

The innovation at, and the importance of, this site, is the special two-chambered horizontal annealing furnace designed for crown sheets, so far unique in England. This makes it reasonably certain that Knightons was operated by glassmakers who had come direct from Normandy for this purpose. But the mixture of furnace-types remains puzzling, unless this too is a direct French influence. In the English context Knightons may be regarded as the last of the medieval glasshouses, with one foot in the past, but on the watershed, looking forward into the new age of wider demand, and of new production methods and industrial organisation to meet it.

Deposit of Finds The site owners, the Forestry Commission, have kindly consented to the finds being lodged in Guildford Museum, Castle Arch. The museum reference is RB 1577. A small representative selection of glass and crucible will also, with permission, be offered to the Pilkington Glass Museum, St Helen's, and to the Corning Museum of Glass, New York, USA. It is hoped to mount a small display at the Forestry Commission's Information Centre in Alice Holt Forest, and to include the site in a projected Sidney Wood Trail. The excavation notes and working papers have been given to the library of the Surrey Archaeological Society, Castle Arch, Guildford.

ACKNOWLEDGEMENTS

The excavation of Knightons could not have been carried out, nor the investigation and research done, without the help, so willingly given, of a large number of people, often under difficult conditions. I cannot adequately express my debt to them. (54 people worked on the site, on 48 working days, representing 212 man-days). F W Holling, who discovered the site, shared the direction of the excavation with me for the first two seasons, and his advice was available throughout; he advised on the pottery, and on the sources of white clays (as did Mr Dent, Ewell Library, on the latter). The Forestry Commission not only gave permission for the excavation, but their staff visited the site and kept a discreet and effective eye on it over the years. G H Kenyon was a major inspiration, showing unfailing support and interest, sharing his specialised knowledge of the Wealden industry, and being always ready to discuss. R J Charleston has always been ready to advise on difficult aspects, and to provide references which I should certainly have missed; he has examined the glass on several occasions, and reported on it; he has also kindly read the typescript of this paper, and made many suggestions for its improvement. To him I owe more than I can say. Dr D B Harden, and Hugh Tait, gave useful material and ideas. The Pilkington Museum and Research Laboratory staffs (Dan Hogan, Dr W J R Merren, F Hartley) continued their earlier interest in Blunden's Wood, and carried out analyses. Ruth Hurst Vose gave information on her Lancashire sites. Dr A G Crocker initiated a project at the Physics Department of the University of Surrey, which included the analysis of glass etc using the electron micro-probe technique. Dr M J Aitken and N Hawley, of the Oxford University Institute for Archaeology carried out remanent magnetism tests; Dr G P Moss (Queen Mary College), and Dr D R Cousins (University Chemistry Laboratory, Cambridge) kindly analysed crucible by Mössbauer spectroscopy. The Forest Products Research Laboratory kindly identified a sample of wood.

Miss G M A Beck, Archivist at Guildford Muniment Room, and her staff, provided information on Henry Smyth and Old Knightons; J Pettitt did research into John Aubrey's MSS, and J L Nevinson, into Thomas Charnock. Mrs M Youle discussed alchemy with me. David Crossley shared his knowledge of the Bagot's Park, Rosedale and Hutton sites, and Raymond Hayes arranged a visit to Rosedale. Dorothy Charlesworth (DoE) commented helpfully; W E S Norris (Sussex Arch Soc) provided notes on the Bramber alembics, Martin Biddle (then at Winchester) on Moor Park, and Stephen Moorhouse on distilling apparatus generally. Professor R G Newton (York) initiated a most valuable enquiry into the use of beech and oak in the Weald. A large number of people, societies and libraries replied to specific enquiries, and I should mention here Miss E M Pyatt (Inst of Geological Sciences), B Butterworth (Building Research Station), and R T Laird (Redland Bricks Limited). Mrs Eleanor Godfrey was kind enough to discuss several points arising out of her research into late 16th century glassmaking; Baron Carl Hermelin (Växjö) initiated me into the history of glassmaking in Sweden; Hr Mogens Schlüter (Holmegaard), was most helpful on furnace problems. R N B Hubbard (University London Inst Arch) provided analyses of the glass buried in the Wareham experiment (Evans & Limbrey 1974, 194); Miss Joan Sheldon was helpful on pollen. Norris Thompson has kindly read much of this paper in draft, and suggested many improvements. John Baker kindly investigated the architectural history of Old Knightons. The overall plan was initially drawn by C M Blatchford. The glass was drawn by Mrs Jenny Stringer, whose help and advice went far beyond the mere drawing; and the maps and plans by W Goddard. The Surrey Archaeological Society made a generous grant in support of these drawings. Miss J A Cowie helped greatly, not only in the final stages of the excavation, but in preparing the drawings for publication.

BIBLIOGRAPHY

(sources mentioned in Text or Microfiche)

- Agricola 1556 *De Re Metallica* (English ed, 1950)
- Aitken, M J, 1970a Dating by archaeomagnetic and thermoluminescent methods *Phil Trans Roy Soc London*, **A269**, 1193
- , 1970b Physics applied to archaeology, I, Dating, *Rep Progress Physics*, **33**, 941-1000
- , 1975 *Physics and archaeology*,
- , & Hawley, HN 1971, Archaeomagnetism: evidence for magnetic refraction in kiln structures, *Archaeometry*, **13** (1), 83-85
- Anderbjölk, Jan Erik, 1966 *Glas och glasbygd* (Stockholm)
- Ashmole, Elias, 1652 *Theatrum Chemicum Britannicum*
- Barrelet, James, 1953 *La verrerie en France de l'époque gallo-romaine à nos jours* (Paris)
- Barrington Haynes, E, 1959 *Glass through the ages*
- Biek, Leo & Bayley, Justine, 1979 Glass and other vitreous materials, *World Archaeol*, **11**, 1, 1-25
- Bridgewater N P, 1963 Glasshouse Farm, St Weonards: A small glassworking site, *Trans Woolhope Natur Fld Club*, **37**
- Chambon, Raymond, 1959 Esquisse de l'évolution morphologique des creusets de verrerie de l'Antiquité à la Renaissance, *Annales du 1er Congrès des Journées Internationales du Verre*, Liège
- , 1961 : La Verrerie dans le Brabant Wallon au début de la Renaissance, *J Glass Stud*, **III**, 38-49
- Charleston, R J 1961 Ancient glass-making methods, *Circle of Glass Collectors*, typescript *Bulletin*, **124**, March 1961
- , 1964 in Cunliffe B, *Winchester Excavations, 1949-60*, Vol I
- , 1978 Glass furnaces through the ages, *J Glass Stud*, **20**, 9-33
- , 1979 Some aspects of 17th century glass found in England, *Annales du 7^e Congrès de l'Association Internationale pour l'Histoire du Verre*, Liège, 283-297
- , 1980 Our Forefathers in glass, *Glass Technol*, **21** i, 27-36
- Charlesworth, Dorothy, 1967 A primitive glass furnace in Cairo, *J Glass Stud*, **9**, 129-132
- Cowen, Painton, 1979 *Rose Windows*
- Crossley, D W, 1967 Glassmaking in Bagot's Park, Staffordshire, in the 16th Century, *Post-Medieval Archaeol*, **1** 44-83
- , 1972 The performance of the glass industry in 16th Century England, *Econ Hist Rev*, ser 2, **25**
- , 1980 *Kimberidge Excavations 1980*
- , & Aberg F A, (1972) 16th Century glass-making in Yorkshire: excavations at Furnaces at Hutton and Rosedale, North Riding, 1968-1971, *Post-Medieval Archaeol*, **6**, 107-159
- Daniels, J S, 1950 *The Woodchester glass house*
- Dansk Glas* 1970 Jexlev Thelma, Riismøller Peter & Schlüter Mogens : *Dansk Glas i Renaessancetid 1550-1650* (Copenhagen).
- Davey, Norman, 1961 *A History of building materials*
- Encyclopedie*: Diderot, Denis, d'Alembert J-B et al *Dictionnaire Raisonné des Sciences, des Arts et des Metiers* (Paris, 1751-57 and 1765; plates 1765 and 1772)
- Engle, Anita, (ed) 1973 *Readings in glass history*, **2** (Jerusalem)
- , (ed) 1977 *Readings in glass history*, **8** (Jerusalem)
- Evans, J G & Limbrey, S 1974 Experimental earthwork at Wareham, *Proc Prehist Soc*, **40**, 170-202
- Flavell, Ray, & Smale, Claude, 1974 *Studio glassmaking* (New York)
- Geological Survey 1920 Mem Geol Survey*: Summary of Progress for 1920
- Godfrey, Eleanor S, 1975 *The development of English glassmaking 1560-1640*
- Harden, D B, 1961 Domestic window glass, Roman, Saxon and Medieval, in *Studies in Building History* (ed E M Jope)
- , 1978 Anglo-Saxon and Later Medieval glass in Britain: some recent developments, *Medieval Archaeol*, **22**, 1-24
- Harrington, J C, 1952 *Glassmaking at Jamestown*: America's first industry (Richmond, Va). This was reissued with revisions as *A Tryal of Glasse: The Story of Glassmaking at Jamestown* (1972)
- Higgs, J, 1964 *The Land*
- Holling, F W, 1969 Seventeenth-century pottery from Ash, Surrey, *Post-Medieval Archaeol*, **3**
- Hume, I Noel, 1957 Medieval bottles from London, *Connoisseur*, March 1957
- Hurst, Joseph, 1970 *The Rosedale glass furnace and the Elizabethan glassworkers* (Ryedale Folk Museum, Hutton-le-Hole)
- Kenyon, G H, 1967 *The glass industry of the Weald*
- Knowles, J A, 1926 The Source of the coloured glass used in Medieval stained glass windows, *Glass*, **3**, 157-9, 201-3, 295-6
- Kunckel, J, 1679 *Ars Vitriaria Experimentalis* (Frankfurt; 4th ed, Nuremberg, 1756)
- Lafond, Jean, 1969 Was crown glass discovered in Normandy in 1330? *J Glass Stud*, **11**
- Le Vaillant de la Fieffe, O, 1873 *Les Verreries de la Normandie* (Rouen)
- Logan, John C, 1972 The operation of a glassworks in the Industrial Revolution, *Industrial Archaeol*, **9**, 2, 177-187
- Manning, O, and Bray, W, 1809 *The History and Antiquities of the County of Surrey*
- Merret, Christopher, 1662 *The Art of Glass*. This is a translation of and commentary on Neri 1612
- Milet, A, 1871 *Histoire d'un four à verre de l'ancienne Normandie*
- Moorhouse, Stephen (1972) Medieval distilling-apparatus of glass and pottery, *Medieval Archaeol*, **16**, 79-120
- Neri, Antonio, 1612 *L'Arte vetraria* (Florence); see Merret 1662
- Newton, R G, 1978 Colouring agents used by medieval glassmakers, *Glass Technol* **19**, no 3, 59-60
- , 1980 Recent views on ancient glasses, *Glass Technol*, **21**, 4

- Nicholls, Robert V V, 1979 The Society of Arts and the production of potash in America, *J Roy Soc Arts*, December 1979
- Polak, Ada, 1975 *Glass – its tradition and its makers* (New York, and English edition)
- Oswald, Adrian, 1967 English clay tobacco pipes, *J Brit Archaeol Ass*, **23**,
- Renaud, J G N, 1962 Glas uit het Einde der Middeleeuwen, *Bull Van de Kong Ned Oudb Bodemond* 6 ser, Jrg **15**, 2, Apr 1962, cols 101-114
- Schubert, H R, 1957 *History of the British iron and steel industry*
- Seaby, P, 1980 *Coins of England* Vol 1, 17th ed
- Six, Herbert, 1976 Spätmittelalterliche Glashütten im Hils bei Grünenplan mit Farbglasproduktion *Festschrift für Waldemar Haberey* (ed Thea Haevernick & A von Saldern) (Mainz), 129-144
- Strömberg, Edvard, 1933 Glasugnen vid Trestenshult (*Jorden Runt*, 4) (in Seitz, H Mäster Påvels Hytta vid Trestenshult)
- Sutherland, C H V, 1973 *English Coinage 600-1900*
- Tait, Hugh, 1967 Glass with chequered spiral-trail decoration, *J Glass Stud*, **9**, 94-112
- Theophilus: *De Diversibus Artibus* c1110-40, (trans and ed C R Dodwell, 1961)
- Thorpe, W A, 1961 *English Glass*
- Thurrell et al, 1968 Thurrell R G, Worssam B C & Edmonds E A, *Geology of the country around Haslemere* (HMSO)
- Vince, Alan G, 1977 *Newent Glasshouse* Com Rescue Archaeol Avon Gloucester Somerset *Occasional Papers*, **2**
- Vose, Ruth Hurst, 1980 *Glass*
- Winbolt, S E, 1933 *Wealden Glass*
- Wood, Eric S, 1965 A medieval glasshouse at Blunden's Wood, Hambledon, Surrey, *SyAC*, **62**, 54-79
- Wooldridge, S E, & Goldring, F, 1953 *The Weald*