It must not be imagined that the change to coal as a fuel was painless. Coal, as mentioned above, needed more oxygen, therefore more air, for combustion and its smoke was heavier and dirtier, resulting for a while at least in more difficult working conditions. Not applicable at Nailsea, it is thought, but certainly for "lead crystal" glass this quickly led to virtually closed pots to exclude smoke and ash and ensure the clarity of the glass.[13] However, the problems were not insoluble, and while the process by which this came about does not seem to have been documented it obviously happened.

In consequence it meant that there would be economies to be gained from transferring glassmaking from the forested areas of the country to those with a good supply of suitable coal. During the seventeenth century this clearly happened. It also appears that sometimes the geology of the coal measures brought further benefits in terms of other raw materials, for example sands and clays, being readily to hand.

It also seems that in the longer term this enforced change to coal as a fuel gave British glassmakers an edge over those on the Continent, who persisted in using wood for a much longer period. Presumably with more heat available a faster melt and therefore increased production for a given number of workers was possible. A bigger cone would mean a greater draught and greater space for more workers around a larger furnace. The mathematics have not been investigated, but it is likely that something between a square and a cube increase in capacity with change in linear size would be not unreasonable.

That this was in fact the case is suggested indirectly in Buchanan and Cossons, p.146: "It is reported that there were fifteen glasshouses in the city in 1761, and 'about twelve' in 1794. Arrowsmith's *Dictionary* of 1884 states that all the Bristol bottle factories had merged into one house ... although: 'Their output equals very nearly that of the whole glass manufactories of the 18th century.'" Previously they pointed out that the competition from "larger-scale enterprises in the North and elsewhere during the nineteenth century" had led to the gradual demise of the industry in Bristol

How the cones were constructed, and especially in the case of Nailsea by whom, has not been determined, but presumably some kind of centring/formwork and working from an internal scaffold would have been employed. It is apparent from various illustrations of cones that the size and number of openings at the base circumference were not by any means standardised.

The two principal methods of flat glass making have already been described, but crown [glass] was the method of choice for manufacture of window glass as the industry went in to the eighteenth century, although plate glass had made a recent appearance in 1688[14]. This was made by pouring the molten glass on to an iron table and rolling it out in to a thick uniform plate, much like rolling pastry. See Appendix 8. This would result in two faces that had not been 'fire-finished', so were generally less clear than was desirable. After annealing the glass would therefore be ground and polished, often to about half its original thickness, so the result was a luxury product, used principally for mirrors and coach windows.

Crown glass in the late 1820s at least, was sold in five classifications: "Firsts, (an ideal ...), seconds, thirds, fourths and CC, the last being described as 'the worst glass ever made'. ...The inferior quality of glass that was disposed of in Ireland was sold much more cheaply. For that market there were only four categories: A, B, C and CC."[15] Prices for a given grade varied, depending on the part of the country for which it was destined.

[13] Ashurst, p.37, states, "This is usually attributed to Thomas Percival between 1611-1614...."
[14] Burgoyne and Scoble, p.10
[15] Barker, p.47

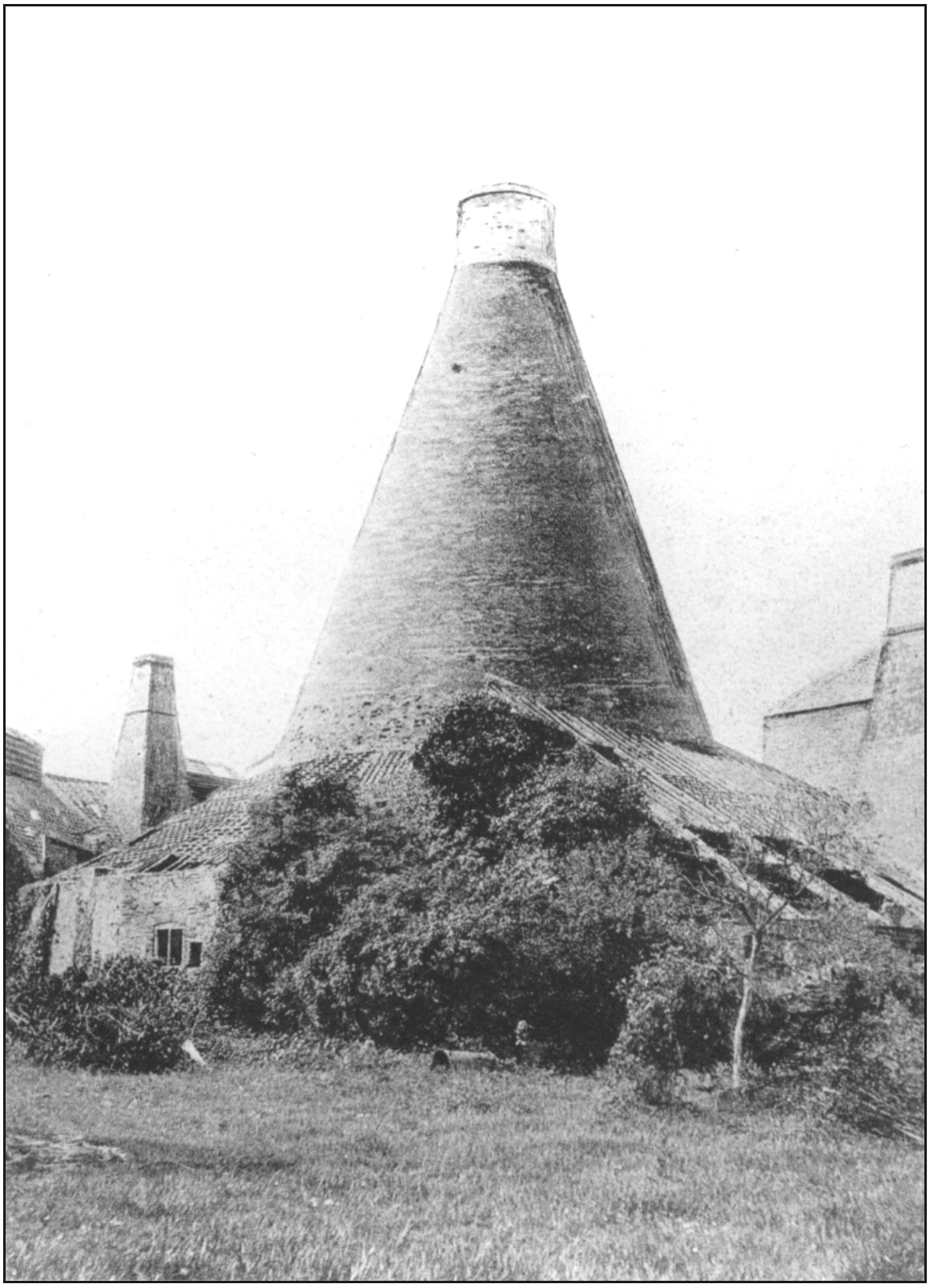

Figure 3.5: New House Cone Nailsea, showing ancillary buildings and onset of dereliction

(© M J Tozer collection)

However, although cylinder glass in its 'broad glass' form had gone out of fashion it was not exactly forgotten. It seems that the technique had been further developed in Germany, because the term 'German sheet glass' was applied to the 'improved' cylinder method (Burgoyne and

Scoble, p.5). This involved the gathering and blowing of a larger bubble than the broad glass method, and instead of merely swinging the cylinder to and fro a greater application of centrifugal force was achieved by swinging the cylinder right round overhead in a complete circle. This entailed the construction of 'swinging pits', over which the blower would stand on a platform giving sufficient clearance for the large cylinder to be swung. By careful re-heating, a thinner, more uniform product would result, in a larger sheet, in the order of twice the size of that from the crown method. It is at this point that, apart from the size and the swinging technique, the main change from the broad glass method now occurs. Instead of the cylinder end being opened out and the cylinder opened up longitudinally with shears while the glass was still malleable the 'improved' cylinder was allowed to cool (annealed) before further work was done. It was then cut with a diamond so that the rounded end and the end that had been attached to the blowing iron came away. The remaining open-ended cylinder would then be scored with a diamond to allow the glass to open up in to a flat sheet when it was reheated in a special kiln on a hard polished surface. This meant that there should be little or no damage to either face of the sheet. There is some debate about when the technique was introduced in Britain. See Part 1. Angerstein mentions swinging pits in 1755. Barker writes, "As early as 1758 the Excise commissioners were aware of the manufacture in England of an improved form of broad glass 'appearing to be of a quality and colour greatly superior to common Green Glass and of as good colour as some crown glass and being judged to be Crown Glass by several Glass-makers and glaziers'. In 1777 when the excise duty on glass was doubled, special provision was made for 'Glass now called German Sheet Glass' ..." [16] It seems unlikely that Lucas would have gone to the expense of devising a novel method and then taking out a patent on it in 1805 if there was not a good commercial reason for so doing. In fact, he actually states in the patent registration, the text of which is reproduced as an Appendix to Part 1, the Desktop Study, "this is the method I use."

The manufacture of fine glassware of many different forms does not come within the scope of this review, not being a significant commercial operation at Nailsea as far as is known. However, for the opposite reason, bottle manufacture should now be considered.

It is apparent from archaeology that bottle making has been practised for a long time. Indeed, bottles in one form or another were probably one of the first artefacts to be produced following the invention of the blowing technique.

Generally speaking it seems that the bottle would be blown either freehand or by blowing and rotating the gather into a half mould to produce a more consistent size. Marvering would have been used as necessary. Once the required size was reached a pontil would be attached to the base which may have been flattened, or alternatively pushed in to a greater or lesser extent, or even left as a 'bag-end'. The blowing–iron would then be broken off and the neck formed in a number of different ways, depending on the period in question and/or the expected use of the bottle. In the simplest case the neck would probably merely be smoothed by heating and manipulating.

According to Vose, p.129, multi-part moulds "were apparently used by Carré's Lorrainers in England in the 1590s, but the use of moulds in bottle-making appears to have died out in the mid—seventeenth century." On p.130, Vose notes that by 1696, Houghton, who analysed English glass manufacturing in that year, listed "around forty-two bottle houses, producing nearly three million bottles annually ...". It seems that from the mid-seventeenth century until 1821 there was "little change in the techniques of bottle making", (*Ibid.*, p.130), although Weeden (p.26) states that, " by the early part of the next century [18th], the straight sided bottle

[16] Barker, 1977, p.58

began to replace the bulbous shape, and to obtain regularity in shape moulds began to be used. These were simple in construction and formed only the body of the bottle." The neck and shoulder still had to be formed by hand, so there were still irregularities in the product.

To overcome this, Henry Ricketts, son of Jacob Wilcox Ricketts (the founder of the Portwall Lane glassworks in Bristol) took out Patent No. 4623, dated 5th December 1821. In effect this added a two-part mould for the shoulder and neck to the earlier type of mould, so that the complete bottle was made in one operation. In addition he also designed a false bottom to the mould so that the one mould could form bottles of different heights and therefore of different capacities. The 'push-up' of the bottle bottom could also be formed by a suitably shaped bottom to the mould, which could also carry the makers name and any other information required. This standardisation of sizes was of great help to traders and customers alike.

We have now reached the time when the glassworks at Nailsea were in production, and we should consider how the technologies for glass manufacture that have been considered were applied there, and indeed how they were developed. This will be the subject of the next section. As well as the primary function of glass production the technologies applying to ancillary processes will also be mentioned. In many cases it will necessarily be speculative at times because of lack of direct evidence.

2. NAILSEA GLASSWORKS - 1788 - 1873

Buildings

The date for the start of the glassworks is consistently given as 1788. The inference drawn from the various documents is that the move was carefully thought out and planned by J R Lucas. For example, it seems he was already involved in mining interests in Nailsea. However, production could not have started at once, as a finite time is required to build the works, hire staff etc. Trying to put oneself in the place of Lucas, the guess of the present writer is that the first construction would have been the bottle house. This is on three premises. The first is that it is the nearest cone to the mineshaft on the edge of the site. Secondly, while it is labelled 'Cone No. 2' on the 1830 plan, it is shown standing squarely, the building with 'Cone No. 3' (the Lilly Cone {55} in 1870) appears to wrap around its north-western corner. Its outline coincides with {49} on the 1870 plan – 'Open spaces where old bottle house stood'. Thirdly, it would probably have been a relatively simple building to construct, and he had staff available with the necessary skills from either or both Bristol and Stanton Wick. We are too early at this stage for any mechanised assistance with the bottle production, but this would start money flowing in to the business.

It is then thought that the Lilly Cone would have been the next to come in to production, on the basis that, as already mentioned, its associated building appears to have been built up against the bottle house. It has been noted that Lucas had advertised his Bristol interests for sale in *Felix Farley's Bristol Journal* of 2nd August 1788, stating that he wished to "confine himself solely to the Crown Glass and Bottle Manufacture"[17]. The assumption therefore is that this small, slender cone was the next to be brought in to use to produce a familiar product, namely window glass using the 'crown' method. Again this would bring money in to the business and help the cash-flow situation. The raw materials might not have been processed at the works at this stage, because of his existing business connections. It is imagined that the construction of the Old House Cone, a major undertaking, together with other ancillary buildings would have been progressing as quickly as possible in parallel with getting the earliest, simplest products out of the developing works.

[17] Thomas, 1987, p.2

It would appear that this stage might have been substantially completed by 1790. The *Bristol Gazette* of 6th May that year reported, "on Thursday last a fire broke out in the new glasshouse at Nailsea belonging to Mr. J. R. Lucas which burnt part of the roof; but by timely assistance the other parts of the buildings belonging to both Crown glass-houses were preserved."[18]

It must be emphasised that no direct documentary evidence has been found, either written or cartographic to support the above inferences. As can be seen in Part 2, the archaeological investigations came nowhere near elucidating the structures of the Lilly cone and what remained of the bottle house.

The initial rank of housing for the workers was built around the same time, because these were mentioned by Collinson, 1791, and certainly occupied when Hannah More visited in 1792 (See Part 4.) By 1822 the row on the opposite side of the High Street had also been built.

It appears that all this initial development took place on land that was available for lease, from an earlier enclosure from the Heath and any further extension was inhibited by the often quoted hostility of Nailsea parish vestry towards further enclosure of the Heath. Whether or not they eventually recognised the value of the works to Nailsea, gave way to *force majeure* from other local landlords, for some other reason, or a combination of them all, it seems that enclosure eventually took place in 1814. Lucas was thus able to start to develop the western portion of the site up to what became the present site of 'The Royal Oak', including building the New House Cone. It is clear that this took place probably from 1826. (See Part 1.)

Coincidentally, the St Helens Crown Glass Company [eventually to become Pilkington] was also building its first cone in 1826. This was 120 feet high and with an internal diameter of 66 feet. It has been stated that it was modelled on one of the cones at Dumbarton, and was built during the last nine months of 1826 for about £8,500.[19] It was therefore slightly larger than the New House Cone at Nailsea, the remains of which have an internal diameter of 60.6 feet, and an outside diameter of 68.63 feet. This is slightly smaller than the Old House Cone.

We now have the snapshot of the 1830s plan, (that might be as early as 1829 – see Part 1, para. 5.35) when a butcher's shop fronted on to the High Street. This had gone by 1870, and further buildings had been erected to the boundaries. From the limited cartographic evidence it would appear that this was probably a gradual process. The evidence from these two plans, as well as the archaeological evidence, supports this and also demonstrates changes in use. These will not be detailed here, but may be derived from the plans and the 1870 schedule.

The New House Cone has been shown earlier (Figure 3.5 above): in the view, looking approximately south-west, it is believed that the two tapering, rectangular-section structures to the left and right are the chimneys for the furnaces associated with the two larger sets of 'blowing holes', or 'swinging pits', {7}. In the right background is part of the six-storey building {6}.

The two illustrations below show buildings in both brick and/or stone, with slate or pan-tiles as roofing material. The buildings in the first (Figure 3.6), looking approximately east-north-east, are clearly identifiable, from left to right, as {3}(Smith's shop - totally overgrown), {2}(Two French kilns), {1}(Offices), {72}(3-storey building – cutting packing and assorting rooms – another, later, picture (not reproduced) shows that this is so more clearly. There is a ramp up to the first floor doorway, and there are wide arched openings to the ground floor. Then there is the brick kiln, {27}, partly behind {30}, the stone dressing room.

[18] *Ibid.*, p.12
[19] Barker , T C, p34