the figures in Coathupe, (p.73).]

Mountain, writing in 1915, aged seventy-two, recalled that, "The pots were about 5 feet in height, 3-4 inches in thickness and about 70 inches across from brim to brim." It is not clear that this applied specifically to the Lilly cone furnace which he states held only four pots, or whether in fact the pot size changed after Coathupe's time.

J F Chance, 1919, writing about Nailsea, states that, "Furnaces at the works were three in number, two for sheet glass, with eight 65-inch pots, and one for rolled plate, with four." It seems that pot sizes varied with time, and in general it does sound as if pots got bigger.[22] Parkin, p.36, comments on the increase in pot sizes.

Figure 3.9: Changing a pot at the Red House Cone
© Broadfield House Glass Museum, Kingswinford

Once set in the furnace and the wall rebuilt, the pot would be glazed by ladling molten glass, it has been suggested, from an adjacent pot in order to coat the whole of the inside with a layer of glass (Coathupe, p.63). An alternative would seem to be by introducing a charge of cullet to the pot and using that. (Coathupe, p.40.) This would have the effect of sealing the clay surface before introducing the raw materials and commencing a melt. Vose, p.161, however, categorically states, "It should also be remembered that crucibles and the furnace interior are never purposely glazed, but become so owing to the heat of the furnace, which causes an exudation within the refractory." The writer is grateful to Mr Mike Tuffey of the English Antique Glass Co. for confirmation that the pots are indeed glazed internally once they are in the furnace, before batch is introduced. He also confirmed that because of the siliceous nature of the refractory there is an exudation from the furnace interior.

Associated with the pots were 'rings'. Some fragments of these rings, believed to be made of the same Stourbridge clay, which floated on top of the molten glass, were found. Of various cross-sectional areas and radii of curvature, [therefore possibly relating to different sized pots and different periods], they were more like a fine sandstone in texture, the clay being so dense and having been so highly fired. The function of the ring in the open pot was to keep a clear area on the surface of the melt from which the blower could gather the glass, having been skimmed clear of any impurities. As has already been mentioned, these are a drawback to using open pots when coal is the fuel. [Dr David Wardle of Pilkingtons, (*pers comm.*),

[22] Chance, J F, p.106

mentioned that the "Sodium Sulphate" mixture itself gives rise to a considerable amount of scum, that needs to be removed.] The reference to "skimmings" as waste, by Coathupe, implies that the ring would form a controlled area at the surface of the glass that would be skimmed periodically with some sort of ladle to ensure it was kept clear, rather than functioning automatically, as has been implied elsewhere.

A glassworks at Smethwick, Birmingham, was taken over by Robert Lucas Chance, nephew of John Robert Lucas, in 1824, and, according to J F Chance, rings were introduced by German workers there sometime before they left early in 1834 (due to a disagreement about working practices). By the end of that year, after trials, they "were in partial use in all the houses."[23] A footnote to that sentence states, "The dates are interesting, since Bontemps[24] in the *Guide du Verrier*, p.118 says that the rings, owed to Germany, had only lately – that is not long before 1868 – been adopted in England." This is of interest, because, as mentioned above, Coathupe quite clearly makes reference to rings in his notebook (1836-7).

Furnaces

From the archaeological evidence we have some idea of the layout within the two major cones at Nailsea, but due to the clearance of the site the exact configuration of the furnaces would have escaped us, were it not for Coathupe's notebook, again. It is important to remember that the dimensions are not 'cone specific', and he only gives us a snapshot about half-way through the life of the works, but the base of the last New House Cone furnace was clearly rectangular, and the Old House Cone remains gave no indication of anything other than a rectangular furnace. From the excavated evidence, the approximate final overall dimensions for the two principal furnaces were New House Cone, 7.5 x 5.0 m, and for the Old House Cone 10 x 5m. Mountain [see Appendix 8] states that both the New and Old House Cones had eight-pot furnaces, and this would have been round about 1860 onwards.

While it appears that there was no great difference in the overall dimensions of the two main cones, there are some observations to be made.

It is not entirely clear what the 'as-excavated' levels were at the New Hose Cone, but it would appear from a larger scale version of Figure 2.4 (1983) that there was in the order of 1.25 m of side wall surviving above the main airway floor. This had itself been raised slightly at some time. There appeared to be a maximum of a little over 1.4m of the side walls surviving above the airway floor of the Old House Cone. In neither case was there any observation that there had been bearing bars for the grate bars. Three feet equals 91 cms., so it is suggested that there should have been some evidence. Additionally, it does not leave very much headroom for a teazer to clear clinker or rake out ash. [The illustration in *The Red House Glass Cone* booklet, showing teazers working at the Walsh, Walsh factory in Birmingham shows them with clear headroom in the corbelled area beneath the furnace.] The width of the airway floor corresponds closely with the archaeology, but the diagram does not show, because no dimensions are given by Coathupe, how the walls of the airway under the furnace are actually corbelled in on each side. [They may not have been so in his time, of course.] This, plus the narrowing of the airway from cone circumference to furnace entry would have accentuated the force of the draught achieved, so what at first sight appears to be a rather deep-set grate probably needed to be that depth to generate the amount of heat required by burning a considerable volume of fuel. None of the interventions seem to record furnace bars being found.

[23] Chance, J F, p.8

[24] G Bontemps was a noted French glassmaker, who worked closely with the Chance Brothers.

The drawing used as the basis of Figure 3.10, below, has been amended on the left-hand side to show, notionally, the dimensions given by Coathupe, taking into account the corbelling of the airway. [However, bearing in mind that Coathupe, p.56, gives the length of the siege of a six-pot furnace as only 13 feet, and this has been checked against the original, there may be a problem with the above interpretation, because he gives the maximum pot diameter as 52¼ inches after annealing. Three times this dimension is just over thirteen feet.] Other illustrations of 19th century cone interiors may be used as analogies (e.g. that of the Richardson Glass Cone at Wordsley, Stourbridge, circa 1830, part of which is reproduced on the cover of the Shire publication *Glass and Glassmaking* by Roger Dodsworth). It is therefore suggested that there would have been arched areas of the furnace side-walls that would have been thinner than the rest in order to facilitate breaking them down to change pots.

These arches would have incorporated the working hole, which the original draughtsman has combined with the punty hole. The latter would in fact probably be separate. As originally drawn it would have been extremely difficult to get much more than halfway down the pot to make a gather. The punty hole has been shown as angled, because of "Inclination of Restings, 3 in." (Coathupe, p.57). It has been assumed that the function of the punty holes was to keep the ends of the punty rods hot, and the term "Restings" has been translated to mean where these rods rested. They are angled down and out so that the punty rods would not slide in to the furnace. It is possible, looking at the 'Richardson Cone' picture mentioned above, that the punty holes were in fact horizontal, placed lower than the working holes, and that there was an iron bar across the front of the arch on which the rods might rest, which might be three inches lower than the bottom of the punty hole. An alternative, suggested by an illustration in *The Window Glass Makers of St Helens*,[25] is that the 'restings' were where the pots sat on the sieges, because the drawing showed that there was a slope on them. In the illustration it showed this as outwards, but Mr Mike Tuffey considered that they should slope inwards, if at all, to make any flow of glass from a damaged pot run towards the eye of the furnace, rather than out the foot-holes towards the glassworkers. [This same illustration shows a double crown with the flue exit in the inner one directly over the pot, and the whole furnace heavily reinforced by an iron/steel frame and tie-rods.] No archaeological evidence remains at Nailsea for either case.

Also, by analogy with other illustrations, the flues might well have come up the outside of the furnace, rather than as shown speculatively. This would still have drawn the heat past the bottom of the pots, possibly thus reducing the particles in the furnace atmosphere, and the flues themselves would then have acted as buttresses to counter the outward thrust of the furnace roof arch. The latter would have reflected heat down on to the pots. Certainly, by 1847, Chance Bros. were building furnaces with "flues between every two pots as well as at the corners. James Chance took out a patent [English patent No. 11749, of June 15, 1847] on this principle: "the fire is placed below the pots, and the heat and flame rise up on either side of each."[26]

Having concluded that deeper grate rooms were desirable, only a year later it was, "the decided opinion of the board that shallow grate rooms are preferable to deep grate rooms for furnaces such as ours which are enclosed with doors; the former causing much less wear and tear both of the sieges and the pots."[27] Why this should be is not explained; presumably bitter practical experience was the driver?

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25 Parkin, R A, Figure 15, p.20
26 Chance, J F, p.46
27 *Ibid.*, p.47

The function of the foot-holes is not clear. It is wondered if it might have been an aperture through which a crowbar might be inserted to rotate the pot on the siege, to even out wear on the pot. It might have also been necessary to allow a check to be made on the integrity of the pot and to give early warning of leaks from the pot, which would damage the sieges, apart from anything else. It has also been suggested that they might serve some function in local draught, and therefore possibly pot temperature, control.

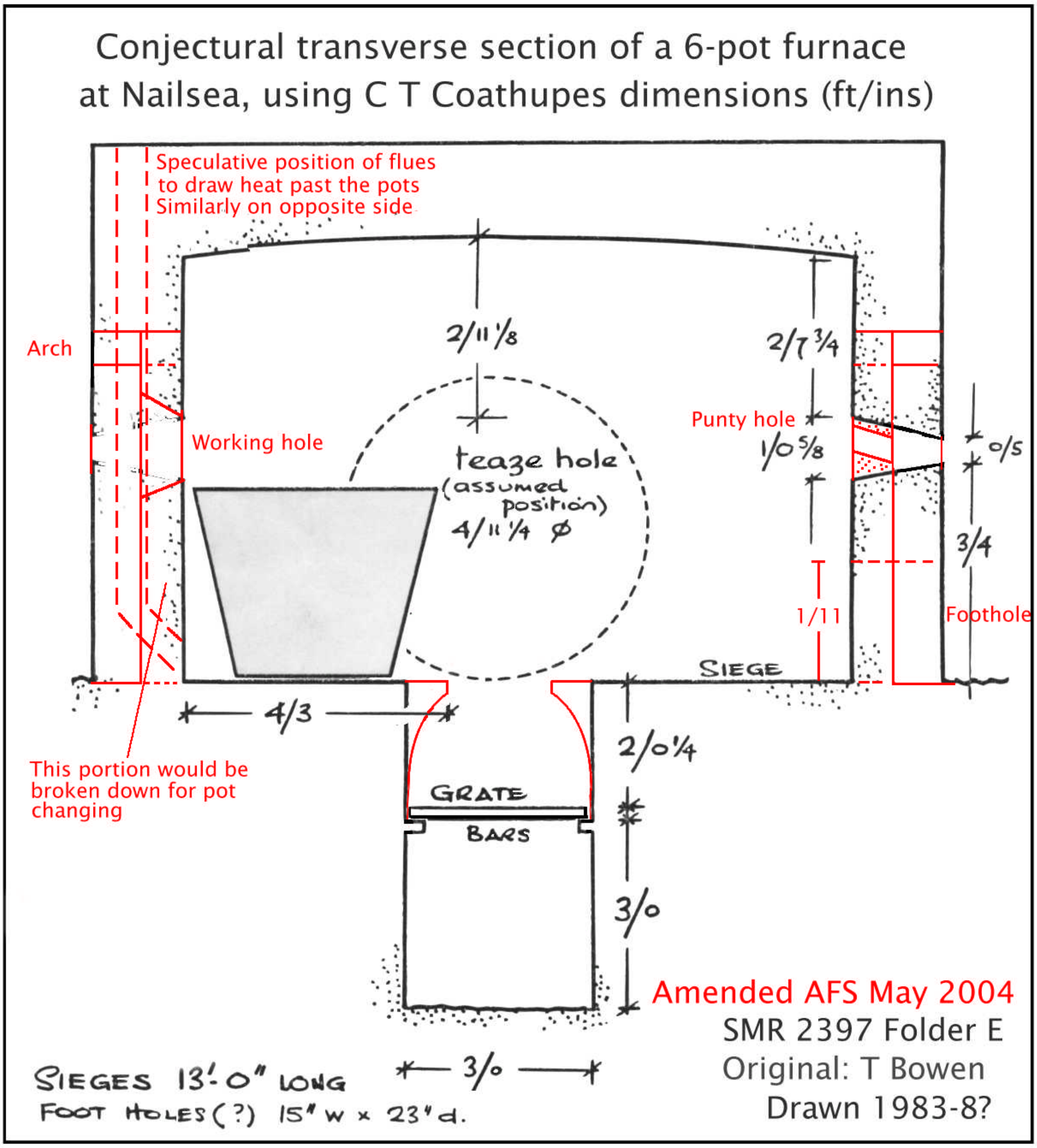

Figure 3.10: Furnace cross-section, derived from C T Coathupes dimensions

How the furnaces were fired, apart from the supposed position of the 'teaze holes' at each end, as shown in Figure 3.10, is not known, and the various illustrations seen have not made it any clearer. Likewise flues often seem to be omitted. Presumably the fuel was shovelled in at each end as required, and the openings closed between times. Clinker and ash were presumably raked out from below. Some clue may be gained as to later practice, as Mountain (Appendix 8) says, “The furnaces were worked underground.” This is where not knowing the actual working floor/siege finished levels is tantalising, especially as the floor of the main airway appears to have been raised slightly in the New House Cone at some time.

The presence of the two vertical chambers in the furnace base in the Old House Cone, already referred to in Part 2, 1995 and 2002, is also enigmatic. Some discussion has been included in Part 2, but for completeness an illustration and description of the Frisbie furnace feeder from the *Scientific American* of December 2nd 1876 is reproduced here, as Appendix 9. The feeder was patented in the UK by Frisbie in 1868; Patent No, 27. It is not certain that these chambers represent some sort of housing for the feeder, as neither the *Scientific American* article or the drawings accompanying the patent show clearly how it might be built in to a furnace, but they might represent a local attempt at something similar, as it was round about this period that there was a rebuild. Neither Chance nor Barker mentions this feeder in their histories, although Ashurst does twice, reporting its use on both occasions as unsuccessful.[28] It may be that the version shown might be more suited to a circular furnace

There may be two alternative explanations. One is that by drawing hot gas from the furnace the incoming air could be pre-heated and thus improve combustion. This might be an early attempt at a regenerative furnace, but on the available structural evidence and drawings of more advanced types this is discounted. The second is that they were chambers to produce ‘producer gas’, and/or ‘water gas’ to aid the combustion process and produce a cleaner flame. This would correspond with the schematic diagram, Fig. 20.9, on p.417 of Hicks’ *Comprehensive Chemistry*, but no scale is given. This will be discussed further under ‘Fuel’.

As well as the main furnaces, there would have been subsidiary furnaces. Mountain states that, “The number of kilns in use in the factory was about thirteen, with about five pot arches. There were about ten other furnaces used for heating before the metal was made in to Sheet or Crown glass.” This would probably have been around the 1860s. The dictionary definition of ‘metal’ in this instance is, “material used for making glass, in molten state”.

This leads on to the issue of furnace management, because the materials going in to the pot, even allowing for the cullet which has the effect of helping to lower the fusing temperature[29], require a higher temperature to fuse completely. At this temperature the (what is now) glass has a consistency, somewhere between a light machine oil and glycerine at room temperature[30], and the temperature has to be allowed to fall, even by something in the order of 10%, until the glass has a much more syrupy consistency for working. The actual temperatures involved obviously depend on the exact composition of the glass being made. It will be apparent that in a multi-pot furnace all the pots would require to be emptied and filled together, unless there was some way of regulating the individual pot temperatures, but no mention has been found of this being done.

On a visit to the English Antique Glass Company at Bordesley Hall the similarity between the shape of the flattening kiln there and the outlines (a tall ‘L’ shape with a bulky foot) shown on the alternative 1870 plan (Appendix 5) for the French Kilns in {10} was noted. In the present-day version the cylinders, having previously been cut and opened out slightly after annealing, travel down through the length of the flattening kiln. Each then comes in turn to a chamber at the end where they come on to a moveable table. Each cylinder in turn is completely opened out using a steel rod, and then flattened using a large block of wood. (Figure 3.11 below.) The

[28] Ashurst, pps. 79, 85
[29] Bell, J in Krupa and Heawood, p.5. also points out that cullet in larger sizes can “aid the entry of furnace radiation into the batch pile.”
[30] Frank, S, p.3