

62. *ibid*, p.173.
63. E.A. Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England*. (Cambridge, 1988), *passim*. Also, for economic data and their significance, Julian Hoppit, 'Counting the Industrial Revolution', *Economic History Review*, 2nd. series, Vol. XLIII, no.2, May 1990, pp.173-93.
64. Wrigley, *Continuity, Chance and Change*, pp.114-5.

## Window-Glass Making in Britain c.1660-c.1860 and its Architectural Impact

---

HENTIE LOUW

*'The use of glass in our windows, instead of the louvre-boards of our ancestors, has introduced comfort into the meanest dwelling which previously did not belong to the richest palace. By means of this contrivance the light is filtered from the wind, the rain, and the cold; we can enjoy the one without being inconvenienced by the others; and we can, in conjunction with our methods of warming, create an in-door climate adapted to our feelings and desires.'*

Charles Tomlinson, *Cyclopaedia of Useful Arts* (1854)

Three major factors led to the transformation of attitudes to fenestration in this country from the late-seventeenth century onwards: the coming of the Baroque age with its emphasis on light; the large scale switch from metal to wood as the constructional material in windows, and the ability to produce progressively larger sheets of flat clear glass relatively cheaply. It is the latter development which will be the subject of this paper.

### Late Seventeenth Century Foundations

When the sash-window was introduced into this country during the second half of the seventeenth century the foundations of a local glass industry were already in place. The significant gains made in the production of window glass earlier in the century<sup>1</sup> were consolidated after the restoration of Charles II in 1660. The French-inspired craze for ostentatious living amongst the wealthy in England created an unprecedented demand for better quality flat glass for a variety of fashionable purposes, especially mirrors, coaches and sash-windows. The local glass industry, which hitherto had not catered seriously for the luxury end of the market, or for such specialist needs as those of a burgeoning scientific movement, was put under pressure to expand in order to counter the drain on the national purse by the large-scale importation of such goods from the Continent.

Spurred on by the challenge of foreign competition English entrepreneurs and scientists, aided by the expertise of foreign glassmakers, in the space of three critical decades, c.1670 to c.1700, succeeded in establishing the technological base which was to sustain glassmaking in England throughout the next century. A manufacturing process unique to this country, the coal-fired reverberatory furnace, was perfected and by 1700 the cone shaped glass house, which became the outstanding feature of the local glass industry was in full operation.<sup>2</sup> The effects of this revolution were far-reaching. Even though, as John Aubrey observed in 1678,<sup>3</sup> there were still isolated parts of the country where the poor could not afford glass for windows, the use of the material had already by then progressed further

and more comprehensively down the social scale here than in any of the other glass producing regions in Europe.<sup>4</sup> By the end of the seventeenth century there was certainly no shortage of good window glass of all price ranges any more in England. Out of a total of about 90 glass houses operative in England and Wales in 1969, 24 concentrated almost exclusively on window and plate glass,<sup>5</sup> with an annual output worth something of the order of £31,000.<sup>6</sup> Add to this the considerable quantity of window glass still imported from abroad and it is obvious that the contemporary builder had an unusually wide selection at his disposal. According to Richard Neve's *The City and Country Purchaser*, there were no less than 12 different types of window glass regularly available in the market in 1703.<sup>7</sup>

The availability of relatively cheap window glass in England had thus led to an early and lasting commitment to the use of the material in fenestration. Of vital importance to the future development of the window was the introduction of efficient processes for the manufacturing of crown and plate glass.<sup>8</sup>

#### Crown Glass and Plate Glass

While the technique for making crown glass was brought to England by French glass-makers in the 1560s,<sup>9</sup> it never seems to have found favour with local glass-makers who instead adopted the cylinder method for window glass. However, Normandy glass continued to be imported from France and by the 1660s was regarded as the finest window glass on the market, albeit expensive.<sup>10</sup> It was therefore the logical choice for the new type of wooden sliding window which made its appearance in Royal palaces at the time.

As the sash-window gained in popularity towards the end of the century the demand for Normandy glass increased correspondingly causing local manufacturers to attempt its production. According to a petition of 1695 to the House of Commons a certain Henry Richards in 1679 'went to Normandy solely to learn the art (there used) of making the kind of glass as hath hitherto been transported thence for sash-windows, he being the first person that brought that invention (i.e. crown glass process) to England'.<sup>11</sup>

Richards, whose petition was successful, may have been an employee of John Bowles for it was at the latter's glasshouse at the Bear Garden, Bankside, Southwark that Crown glass was first produced commercially from c.1684.<sup>12</sup> Tradition has it that the name 'crown glass' derived from a small crown embossed on all glass produced at this factory which already in 1691 boasted of producing crown window glass, 'much exceeding French window glass in all its qualifications which may be squared into all sizes of sashes for windows and other uses and may be had at most Glaziers in London'.<sup>13</sup> In the meantime Bowles had opened another crown glasshouse at Cockhill, Radcliff. A third London factory was later established at Lambeth.

Despite an influx at Protestant glassmakers after the Edict of Nantes, and periodic embargoes imposed on the importation of crown glass, progress was very slow at first. This was mainly due to internal disputes. Once these were resolved production flourished and, as Richard Neve testifies, by the early eighteenth century the English crown glass manufacturers, especially the Radcliff factory, were producing a product which was superior to that of the French.

The manufacturing of plate glass for mirrors on the Venetian model was first introduced into England by Mansell who established a company of Venetian

craftsmen at the Vauxhall glass house c.1620. However, production virtually ceased during the Civil War and it was not until 1673, when the Duke of Buckingham reinstalled a Venetian workforce at the Vauxhall works, that a serious challenge could be offered to the import trade in French and Venetian plate glass.

Once established the industry expanded rapidly. In September 1676 John Evelyn, after a visit to the Vauxhall works, reported with satisfaction that he had seen there, 'looking glasses far larger and better than any that come from Venice'.<sup>14</sup> Buckingham left England in 1685, but the factory continued under new management who in the early 1690s switched to the French casting process. In 1701 cast looking-glass plates of 6 feet long were being sold there.<sup>15</sup> Its principal rival, the Bear Garden or Bankside glasshouse in Southwark, which continued to produce blown plate, in January 1703 advertised 'Looking Glass Plates blown from the smallest size upwards to 90 inches, with proportionable Breadths, of lively colour, free from Bladders, Veins and Foulness, incident to the large plates hitherto sold'.<sup>16</sup>

The English glassmakers thus not only succeeded where the Venetians had failed, namely, in the production of large sheet of plate glass by the cylinder process, they also mastered the French casting technique. It is therefore with some justification that Ephraim Chambers, in the first edition of his *Cyclopaedia* (1728), could claim a role for the English equal to that of the French in the development of this particular branch of the trade.<sup>17</sup>

It was a view which contemporaries would have shared. The confidence of the English glassmakers, who in 1706 claimed that their product was held in 'great

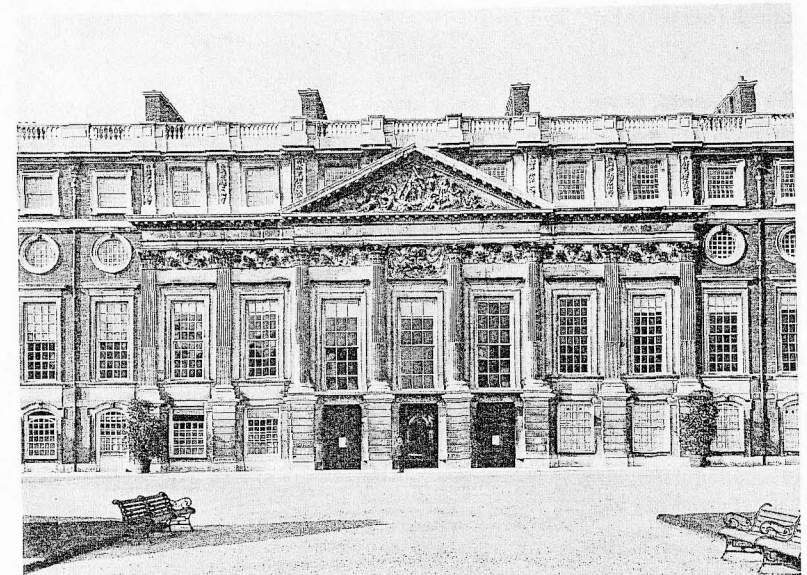


Fig.1 Hampton Court Palace Garden or East Front (1689-94). A mixture of plate and crown glass. Plate glass panes in the Queen's Drawing Room (under pediment) 29½" x 21½". Much original glass still survives in the building (Royal Commission on Historical Monuments)

Esteem in Foreign parts', and the the Venetians themselves were 'buying these plates and preferring them to their own',<sup>18</sup> was not altogether misplaced. Foreign visitors admired the local industry for its efficiency and its products for their quality,<sup>19</sup> and soon a thriving export trade was established. By 1743 the Bear Garden glasshouse, the leader in the field, sold nearly 75 per cent of its output abroad.<sup>20</sup>

As in France the application of plate glass extended beyond the manufacture of mirrors to the building industry. Already during the 1660s and 1670s one finds plate glass installed in the windows of important buildings. From the 1680s onwards its use became increasingly frequent in the residences of the wealthy which encouraged manufacturers to cater specifically for the market. For example, the 'Company of Glassmakers', founded in 1691 and which specialised in cast plate, in 1692 advertised for sale, 'all sorts of exquisite Looking-glass plates, coach-glasses, sash and other lustrous Glass for Windows and other uses.'<sup>21</sup>

This trend developed despite the exorbitant price of the material. The size and cost (10 shillings each) of the looking glass panes installed by the 4th Earl of Devonshire at Chatsworth in 1687, were still a cause of amazement to Celia Feinnes when she visited the house ten years later.<sup>22</sup> Plate glass in windows was evidently a status symbol of some significance and, was the custom at the time, the standards were set by the Office of Works. Sir Christopher Wren estimated that the cost of the plate glass installed in 84 windows in the King and Queen's Apartments at Hampton Court 1693/4 alone amounted to £22,000 (compared with £800 for crown glass in 250 windows)<sup>23</sup>. (Figure 1) The 18th century did not see the price of the material decrease significantly.

### The Eighteenth Century

The home market for window glass expanded steadily throughout the eighteenth century. A growing industrial economy stimulated building activity across the spectrum with a variety of new building types: shops, factories, warehouse and greenhouses increasing demand over and above the traditional usage in domestic and public buildings.

The coal-fired furnace remained the mainstay of the industry and the blown process the preferred method of production for all glass. Continuous experimentation led to technical advances and later in the century glassmaking began to profit from rapid progress in the field of industrial chemistry, notably the work of Josiah Wedgwood (1730-1795) and James Keir (1735-1820) whose research was directed at improving the raw materials for the industry. The latter owned a glass works at Stourbridge from 1770-7.<sup>24</sup> These developments coincided with improvements in the constructional materials and techniques used in windows.<sup>25</sup> The progressive attenuation of the glazing bars which followed, and the parallel increase in the sizes of glass panes of good quality available on the market had a dramatic impact on architectural thinking. It was Isaac Ware, in his *A Complete Body of Architecture* (1756), who first formulated what in essence became the neo-classical ideal in fenestration, namely, 'that as much glass should be seen, and as nearly a continued body as possible'<sup>26</sup>. However, despite considerable progress in this direction, as is demonstrated in the changing pattern of fenestration (Figures 2-4), the eighteenth



Fig.2 Raynham Hall, Norfolk: The Garden Front. Window to old State Bedroom c1703 showing typical reflection in crown glass of the period. Pane size: 12 3/4" x 15".

Fig.3 Chesterfield House, Blackheath. Window to saloon c1760s. Pane size: 15 1/2" x 25 1/2".

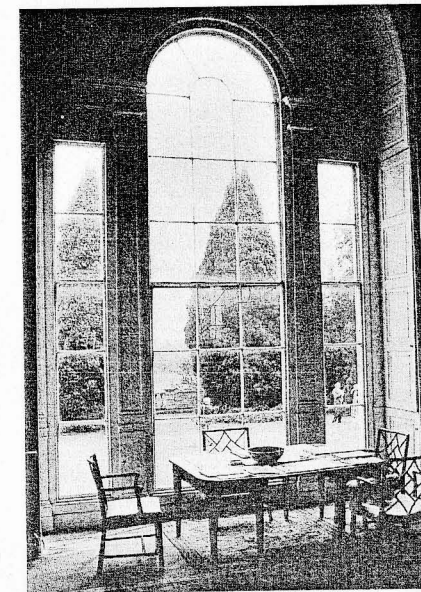


Fig.4 Stoke Bruern Park, Northants. Venetian window in one of pavilions, c1790s.

century glass industry was neither sophisticated nor organised enough to make this goal a realistic prospect for the designer.

The single most important feature of the window glass trade during the latter half of the century was the ascendancy of crown glass. Previously broad or cylinder glass, which was the cheapest form of glazing available, dominated the market. It was still the case in the 1730s when according to one authority, Newcastle upon Tyne, the traditional manufacturing base for this product provided the 'glass most used in England'.<sup>27</sup> However, since then broad glass rapidly lost ground to crown in spite of attempts from the 1750s onwards to introduce an improved cylinder process developed on the Continent.<sup>28</sup> By 1780 the total production of broad glass for the whole country was only half of that of crown glass. Ten years later that figure had fallen to just under a quarter and during the first decade of the nineteenth century, the production of broad glass almost stopped, leaving crown as the only viable home-produced glazing material for general building purposes.<sup>29</sup>

It is tempting to link the popularity of crown glass with the triumph of the sash-window in English architecture: certainly for contemporaries the two had become inseparable by the mid-eighteenth century. But, while this might have been a secondary factor there were other, more compelling reasons. It was undoubtedly cheaper for local manufacturers to switch to crown glass rather than introduce an imported process which would have required new equipment and the hiring of foreign workers. The deciding factor, however, was as T.C. Barker has pointed out,<sup>30</sup> the way in which the excise duty system, introduced in 1746, worked with a distinction drawn between the weight of glass produced and the size and quality of the end product. This favoured the centrifugal process which allowed the thinnest plates of glass, hence the widespread adoption of the crown process.

London retained its position as the principal source of crown glass for most of the century, but as the trade in broad glass deteriorated glass manufacturers in other parts of the country increasingly turned to crown glass as a substitute. Output increased accordingly and by the 1790s the English factories alone averaged about 92,000 cwt. per annum.<sup>31</sup> Lower production costs and a secure traditional foothold for their products on the London market gave the North East produces a crucial advantage and by 1800 their competition had forced the London crown houses off the market. Newcastle was once more the major centre for window glass making in England.

The manufacture of plate glass, which also had London as its base, remained an important if restricted part of the English window glass industry throughout the eighteenth century, not the least because it generally set the standards by which other products were judged. For practical and economic reasons the English glassmakers abandoned the complex casting method after their initial success with it in order to concentrate on the production of blown plate, a more limited but cheaper product. Exactly when this happened is unclear. Robert Campbell, author of *The London Tradesman* (1747), was under the impression that the casting process was still used at that date, but could find on one to explain it to him.<sup>32</sup> This may have been more a matter of trade secrecy but a generation later, when attempts were made to reintroduce the French method, the skills were so comprehensively lost that foreign craftsmen had to be engaged.

In the meantime blown plate glass, which was essentially produced for local consumption, was much improved. The Cookson Company of Tyneside is reported

in 1773 to have been capable of making plates up to 84 x 52 inches, and the London-based Bowles factory plates of 82 x 48 inches. These were, however, the exception and very expensive (£37.10s for an unpolished plate 60 x 40 inches).<sup>33</sup> Usually the sizes of the blown cylinders were limited to between 40 and 50 inches which yielded plates considerably smaller than the average obtained from casting, at a lower price. Therefore, when large mirrors and sheets of glass again became fashionable the demand for French cast plate soared. By the early 1770s an estimated £60,000 to £100,000 worth of plate glass was imported annually from France. This caused the formation, in 1773, of a new company, *British Cast Plate Glass Manufacturers*, based at Ravenhead, Lancashire, to try and recapture the market from the French.

Owing to heavy taxation the new enterprise did not make much progress initially, despite the employment of skilled workmen from France and the introduction in 1789 of a steam engine to grind and polish the plates. In 1792, however, the company came under new management and the production of cast plate began in earnest.<sup>34</sup> By 1794 polished plate glass was offered to the British public in a vast range of sizes, from 6 x 5 inches to 75 x 117 inches in prices ranging from 5<sup>d</sup> to a staggering £404 – 12<sup>s</sup> – 0<sup>d</sup> per plate.<sup>35</sup> When the company changed its name in 1798 to *The British Plate Glass Manufacturers*, it was already a viable commercial concern and expanding fast at the expense of imported French plate and the locally produced blown plate glass.

#### The Nineteenth Century

In the history of flat glass making in this country the period from the outbreak of the Napoleonic Wars to the Great Exhibition of 1851 ranks in importance with the Elizabethan/Jacobean and late-Stuart/Baroque periods. The general trend was towards industrialisation. It manifested itself most clearly in the manufacturing of sheet and plate-glass, but all facets of the glass trade were affected. Revolutionary discoveries in the field of industrial chemistry, such as the process for making synthetic alkali (Leblanc, 1792), progressively found commercial application in the field causing considerable improvements in the quality of the metal. The technology for producing and finishing the glass was likewise refined with many new products and processes being invented and others improved in the course of a period of sustained experiment and commercial competition. In the market place the move towards a different system of production found its parallel in a shift away from the glazier/glass seller of the past towards the specialist dealer. In 1826 London already boasted 14 such firms; ten years later that figure was 32.<sup>36</sup> For the consumer this meant increased choice and there is evidence that owners and their architects were quick to avail themselves of the new opportunities offered by a diversifying trade in window-glass (Figure 5).

Taxation undoubtedly slowed down the pace of change, but not to the extent which the propagators of the removal of the excise duties claimed. The emergence of a novel breed of manufacturer, best exemplified by the three great glassmaking concerns run respectively by the Chances (Stourbridge), James Hartley (Sunderland) and Pilkington-Greenhall (St Helens), brought a new dynamism to the industry which not even the punitive legislation of the time could suppress. Stimulated in turn by periodic building booms and the gradual relaxation of the fiscal regulations between 1819 and 1851 these entrepreneurs succeeded in com-

pletely restructuring the entire window glass making process. The industry which could supply and fit such an extensive project as the Crystal Palace in record time was fundamentally different from that which existed half a century earlier.

Not all branches of the industry benefitted equally from the changing conditions. The principal casualty was crown glass – the window glass par excellence of Georgian England and the epitome of glassmaking as a skilled handicraft.

When they re-established themselves as the undisputed leaders in the field of window-glass production the glassmakers of North East England abandoned broad glass altogether in favour of the production of crown glass.<sup>37</sup> At first the quality of crown glass made in the area was not as good as that produced in London due to the use of kelp rather than barilla as alkaline base. It was, however, considerably cheaper and when the local manufacturers, who already had a reputation for their technical skills, managed to improve the colour of their glass through the systematic application of crystallised soda in the early nineteenth century<sup>38</sup> the future of crown glass as a common glazing material seemed certain. Abraham Rees noted the achievement of the northern glass makers in his *Cyclopaedia or Universal Dictionary* (1819), in particular that of one of the leading firms Attwood & Smith (formerly Hammond & Smith) of Gateshead, County Durham:

‘The large crown-glass of Messrs Hammond and Smith is superior in quality as well as size to that of any other manufacturer. The usual diameter of the tables in other manufacturers may be taken at 47 or 48 inches, with an occasional variation in a table of one or two inches: and the largest square which can be cut from these

measures about 24 inches by 20, and in some circumstances one inch wider or longer. Whereas the glass of Messrs Hammond and Smith is 60 inches in diameter and will admit to being cut into squares of about 33 inches by 23 inches; and a little more or less. This glass is almost free from those specks wreaths etc which discolour other glass, and distort the objects seen through it. It now supplies the place of German sheet glass for prints, large sashes, and exportation to those foreign markets where that glass was formerly in use.’<sup>39</sup>

Sheltered from the worst excesses of the excise duties and ensured of a market on account of its quality<sup>40</sup> the making of crown glass continued to flourish in England and Scotland virtually without competition until the 1830s. Production reached a peak of over 155,000 cwt. per annum in 1836 as compared with 8500 cwt. for sheet glass.<sup>41</sup> The excise returns for 1833 show that 25 out of 27 window glass furnaces active in England were devoted to the making of crown glass. Production was then concentrated in five main centres: Newcastle, Durham, Bristol, Liverpool and Stourbridge – the 14 Tyne and Wear factories having an annual output of twice that of all the others put together.<sup>42</sup>

This, however, marked a turning point and within a few years the industry was in decline. Several factors contributed to this.<sup>43</sup> The way in which the abolition of the excise duties was handled from 1831 onwards discouraged investment and diversification. This was compounded by the dramatic drop in demand for window glass during the recession of the early 1840s when national production of crown glass fell by a third. The eventual removal of the glass duties in 1845 favoured sheet glass more than crown and gave a major boost to the only serious competitor as a window glass for ordinary purposes, namely, the new variety of German sheet glass which Lucas Chance put on the market in 1838. As a consequence many firms, in particular the long established businesses of the North East under conservative management, were unable to survive the chaotic period of speculation and price wars which followed in the aftermath of the suspension of duties, and closed down. In May 1850 *The Builder* reported: ‘The Crown Glass Trade on the Tyne is said to be now completely paralysed, only three out of twenty houses (furnaces) being in operation and even those not fully employed.’ Seven years later the last of the once dominant producers of the region ceased operation.<sup>44</sup>

The collapse of the crown glass trade of the north east gave a new lease of life to the remaining manufacturers, especially Pilkington’s of St Helens and Chance Bros at Stourbridge. The market conditions were, however, no longer as favourable for production as they were before the removal of the duties even though both the product and the skills involved in its manufacture were still very much admired.

Crown glass had clearly reached the limits of its technology. Although crown plates of hitherto unheard of sizes could be produced – the Chances displayed a disc of 66 inches at the Great Exhibition, and Henry Chance in his lecture at the Society of Arts in 1856 said it was possible to make it up to 70 inches in diameter<sup>45</sup> – the norm had stayed unchanged at 48-54 inches from the 1830s. (Figure 6) This yielded pane sizes unacceptably small to a public craving for larger expanses of window glass after the abolition of the glass duties, and the even more unpopular window tax in 1851.

No new crown glass furnaces were erected after 1845. Eventually Pilkingtons, one of the few surviving major producers of crown stopped making it in 1872. Some

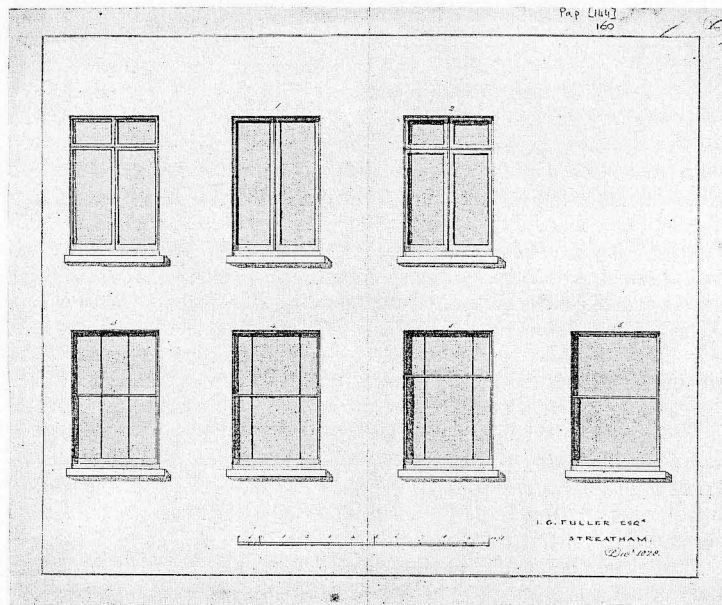


Fig.5 J B Papworth Drawing showing alternative arrangements for window glass in a house designed for J Fuller, Streatham, Surrey, dated 1828. (British Architecture Library, RIBA)

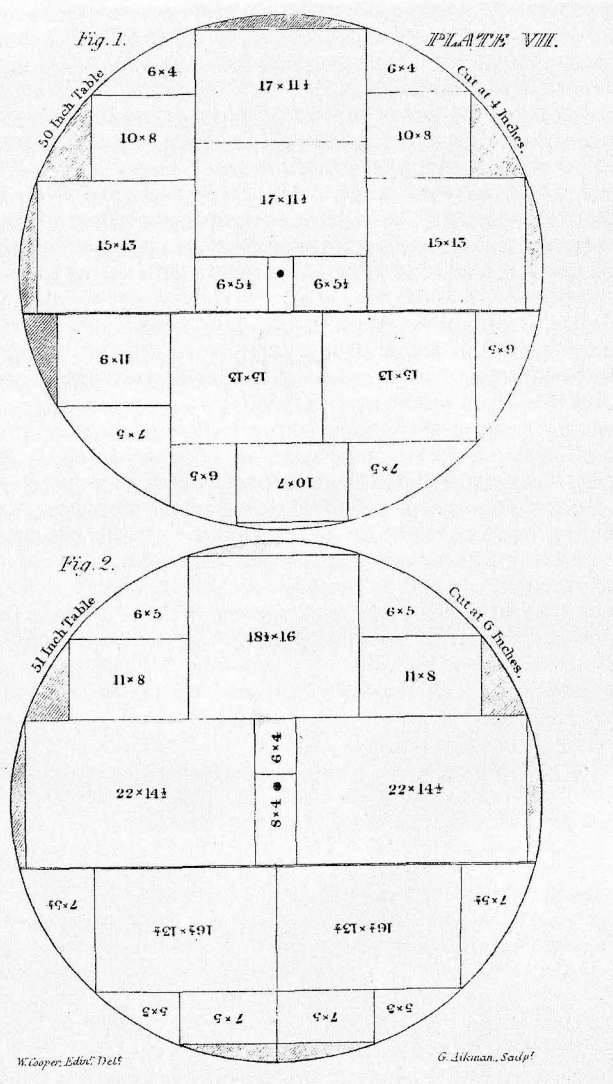


Fig. 6 Plate from William Cooper's *Crown Glass Cutter and Glazier's Manual* (1835) showing how to cut window panes from a crown table.

firms, notably Chance Bros & Co. continued producing crown glass after that for a dwindling home market, but by then the special bond which had existed ever since the seventeenth century between crown glass and the sash-window had long since ceased to have much relevance.

### Sheet Glass

The improved method for producing sheet glass which Lucas Chance introduced into England in the early 1830s, and which ultimately contributed to the demise of crown glass, was an intermediate stage between the older type of broad glass made in this country from the sixteenth century onwards and blown plate. The new process involved much less handling and the result was a superior product to broad glass which by then was considered as, 'fit only for the cottages of the poor.'<sup>46</sup>

The new type of cylinder glass, known from the 1770s as 'German Sheet Glass', matched crown glass for colour and price without the limitation on the size of glass pane which has always been the principal drawback of the latter. The only significant difference between good quality German sheet and blown plate glass lay in the finish, in that it was made thinner and not ground and polished afterwards. It therefore did not have the absolutely flat surface of plate, and one of its sides, that which was touched by the wood polisher during manufacture, had a 'hammered' appearance.

The advantages of German sheet over crown as a universal glazing material was already appreciated in England during the eighteenth century but, for reasons that were explained earlier, its production did not become commercially viable before the nineteenth century. According to the architectural writer Peter Nicholson, imported sheet glass was available in 1819 in squares of 'astonishing size' (44 x 37 inches; 36 x 32 inches). It was then used mainly for picture frames. He complained about the cost which he attributed to communication difficulties with the continent and the fact that the 'manner in which it is manufactured cannot be adopted in this country with success'.<sup>47</sup> The author of *The Operative Mechanic and British Machinist* (1829) also admired the size of the sheet glass plates, but observed that they had a 'very forbidding appearance from the outside, the surface being uneven'.<sup>48</sup>

German sheet glass had nonetheless sufficient potential for local manufacturers to risk introducing it on the British market in spite of considerable fiscal obstacles. This was first successfully achieved in 1832 by two families of Birmingham glass-makers and merchants (Chance and Hartley), supported by a French manufacturer, Georges Bontemps, and a foreign labourforce.

Initially intended for export, the new product had a mixed reception on the home market. The authoritative *The Builder's and Workman's New Director* (1834) assessed its relative merits as a window glass as follows:

*'German sheet-glass is of an excellent quality, particularly as respects colour; but from the manner in which it is manufactured, one side – which of course is placed outermost in the sash – has an uneven, and consequently a very unpleasant appearance. It was formerly, however, much in use; but latterly, in consequence of the improvements which have been made in the manufacture and flattening of crown glass, together with the reduction that has been made in the price of plate-glass, it is not much in request now in this country.'*<sup>49</sup>

The breakthrough which established German (or more correctly, Bohemian) sheet as a serious rival for crown glass came when J.T. Chance developed a method in 1838 for polishing cylinder glass which was thin enough to avoid being classed as blown plate under the excise regulations.<sup>50</sup> The new glass, called 'Patent Plate',

was a immediate commercial success. Its production was given a further boost by the removal of the duties in 1845 which caused prices to fall dramatically,<sup>51</sup> but the greatest triumph of sheet glass came in 1850 when Chance Bros. Co. Ltd. won the contract for the new exhibition building in Hyde Park. Although the firm had previously provided glass for Paxton's famous conservatory projects during the 1830s and 1840s, nothing on this scale had ever been attempted before. Between July 1850 and February 1851 approximately 3,000,000 panes of 16oz sheet glass 49 x 10 inches (over 956,000 sq. feet) were manufactured and installed, and that without interrupting the regular production schedule of the factory!<sup>52</sup>

The successful completion of the project was a tremendous advertisement for the product as much as for the manufacturer. While this achievement gained the Chances a place in the history books, the Crystal Palace did much to popularise sheet glass as a glazing material at a time when the scales were fairly evenly balanced between it and crown glass in the eyes of the general public as well as the producers.<sup>53</sup>

That the matter was still far from being resolved for the consumers a decade later can be seen from the following appeal published in *The Builder* of 14 April 1860:

*'Formerly, when sashes were made in twelve lights, we could get crown glass put in, but when the duty came off glass, and cheapened it, the public taste ran for larger sized squares to look through, and consequently crown-glass had to give way to sheet. It is true we now have large squares, but a very bad appearance; and it matters not whether the glass is made in this country or in any other, it is all alike having a hammer-looking surface, consequently driving us to the expense of plate-glass ... cannot manufacturers give sheet-glass the even appearance of crown-glass; and if not cannot they make crown-glass larger, so as to enable us to get the squares we want for the present style, namely, squares about 46 by 30, or 40 by 32? This is a subject well worth the attention of window glass makers: such glass would command a most extensive market; for the complaints of the sheet-glass are universal, whether it is 21oz, or 16oz no matter the surface is always wavy when the light falls on it.'*<sup>54</sup>

However, at this stage the British window glass industry was already irrevocably committed to industrialisation in order to compete on a mass-market at home and abroad with major new foreign producers like the Belgians.<sup>55</sup> Sheet and plate glass allowed more scope for mechanised production and therefore offered manufacturers a better prospect for investment. By 1854 Pilkington's, one of the three leading firms which by then produced 75 per cent of the country's window glass, was selling as much sheet as crown glass.<sup>56</sup> Another of the triumvirate, James Hartley of Sunderland, in 1863 produced 8,000,000 square feet of sheet glass per annum — more than the entire annual output of the six crown glass factories of the north east at the height of their fame.<sup>57</sup>

Sheet glass was then blown in cylinders up to 77 inches long; 45-50 inches by 32-36 inches diameter being the norm compared with 36 inches by 20 inches diameter when the Bohemian method was first introduced in the 1830s.<sup>58</sup> The panes obtained from these were correspondingly large, but as the above correspondent of *The*

*Builder* pointed out, were far from perfect, which left those wanting good quality window glass in large sizes only the traditional alternative — plate glass.

#### Plate Glass

By the end of the eighteenth century two major new centres had emerged in England for the manufacture of plate glass. They were Ravenhead, Lancashire, where the *British Plate Glass Manufacturer* established their casting factory in 1773, and the Tyne, where blown plate had been manufactured uninterruptedly by one family, the Cooksons, ever since the mid-seventeenth century. Mirrors were still the principal objective of both methods of production, but increasingly architectural usage came to stimulate production.

In 1815 Isaac Cookson & Co. also started casting plate thereby breaking the monopoly which the Lancashire firm had held in this branch ever since the 1770s. As a result the price of plate glass dropped by 50 per cent.<sup>59</sup> The Cooksons, whose production was specifically aimed at the lower, glazing end of the market did much to secure the product a lasting place in the building industry. Although plate glass was still not cheap enough to be regarded as a regular glazing material it was already more accessible for architectural purposes than ever before and further price reductions during the 1820s following the lowering of the glass duties in 1819 accelerated the tendency.

The plate glass industry expanded rapidly in order to meet the rising demand — even the temporary set-back of the early 1840s depression was more than compensated for by the prosperity which followed the removal of glass duties in 1845. During the building boom of the mid-1830s several new manufacturers had appeared on the scene, but the Ravenhead and Tyneside concerns continued to dominate the market — the latter with an annual output of 312,000 feet pre-1845 being the largest single producer of plate glass in the country.<sup>60</sup> Both categories, blown and cast plate were produced. The former, which by this stage was almost exclusively made by the Cookson Company of South Shields, was however increasingly disadvantaged by the excise duties and by the restrictions in size imposed by its craftbase. Already in 1815 Samuel Parkes had foreseen problems for this category of glass in the future because of this:

*'The method of blowing answers extremely well for small plates, or for plates which do not exceed 4 feet in length and 2 feet 3 in breadth; but when larger, they have not a sufficient thickness to bear the grinding, and besides, no man could have strength sufficient to wield in his arms that quantity of glass which is required to form such immense plates as are made at Ravenhead.'*<sup>61</sup>

At that time the Ravenhead Works was selling glass plates of up to 12 x 6 feet in its London showrooms.<sup>62</sup> Cookson's themselves were producing cast plates of 80 sq. feet twelve years later<sup>63</sup> and soon even these were considered modest in size. On the Continent, as Parkes pointed out, improvements were still being made to the blowing process and at the Vienna Exhibition of 1845 a sheet of 84 x 40 inches produced by this method was exhibited.<sup>64</sup> In England on the other hand, blown plate had become something of a poor relation and its development stagnated until finally it succumbed to a cheaper glazing product: Patent plate, or German sheet

glass. In 1845 Cooksons, the main blown plate producer went out of business and the process was largely abandoned after that.

The chief beneficiary of the demise of blown plate was, of course, cast plate glass which alone could satisfy the craze for ever larger sheets of good quality flat glass in buildings after the removal of the burdens of taxation. Astute industrial management and progressive mechanisation over a period of twenty-five years leading to the Great Exhibition had produced cost reductions on a scale none of the other branches of the trade could match. An advertisement by one of the competing plate glass houses in *The Builder* of 11 September 1847 reads:

*'The demand is increasing beyond all precedent, and although some of the houses are working night and day, the supply of good quality is still inadequate for home consumption alone. From 1827 to 1847 the reduction in price has been from 12s to 5s per foot or 60 per cent. From 1827 to 1847, the increase in consumption has been from 5,000 to 70,000 feet per week, or 1400 per cent'.<sup>65</sup>*

Impressive as these figures were they marked only the beginning of a new phase of expansion. By 1866 the national weekly output of plate glass had doubled once more to 140,000 feet,<sup>66</sup> despite fierce competition from French and Belgian imports. One large firm, The Tyne Plate Glass Company of South Shields, quadrupled its annual production between 1845 and 1863, to nearly 1,248,300 feet per annum.<sup>67</sup> Prices fell by another 100 per cent and there were no signs that the pace of development was slowing down.

The technology had been improved to such an extent that truly enormous sheets of high quality glass could be produced with relative ease. A particularly fine specimen of British plate glass measuring 19 x 10 feet was on display at the 1851 Exhibition. Only the French manufacturers could compete with them in this respect,<sup>68</sup> but then, as the *Cyclopaedia of Useful Arts* (1854) noted in its comparative analysis of the two countries' plate glass industries, they were operating under completely different sets of principles:

*'... the French are particularly careful to ensure the purity of their materials, that they manufacture the most costly description of plate-glass, and that the specimens at the Great Exhibition, were picked from a very large stock. Our manufacturers, on the contrary, work for the million, a very large portion of their supply being for glazing shop-windows and the windows of private houses, as well as for looking glasses; whereas the French never glaze with plate-glass, and their choicest productions being costly, the demand for them is limited. It is of far more importance that the masses of the people should be supplied with such an article of comfort and luxury as plate-glass, even though it be a somewhat inferior description, than that the manufacture of the superior article should be so costly as to place it within the reach of the wealthy only. The French plate-glass is unquestionably good; but it is doubtful whether it could be applied to the purposes of glazing, as it would be likely to suffer from the action of the weather'.<sup>69</sup>*

### Architectural Significance

The capacity of the British plate glass manufacturers to produce large quantities of the material at competitive prices made a significant contribution to architectural development from the early nineteenth century onwards. Under the influence of the Romantic movement contact with nature had become an important factor in architectural theory. This encouraged the use of large-paned or 'picture windows' and French windows. Thomas Martin, who in 1814 observed that the 'fashion of making folding sashes (French Windows) had become general', said that plate glass from the Ravenhead factory was particularly popular for these. However, he stressed the difficulties people experienced in obtaining sufficient quantities of glass and the expense involved:

*'The company often require three or four months to execute an order of any magnitude. The value of such kind of glass is very considerable in comparison of the other sorts, common sized squares for windows amounting from two to three pounds each, and sometimes, in French windows, as high as five pounds. It is, nevertheless, so much preferred at this time, that even our shop windows in the leading streets are daily becoming glazed with it'.<sup>70</sup>*

There seems to have been general agreement amongst architects that this was a positive development. Peter Nicholson provides some of the reasons for this in his *Architectural Dictionary* (1819):

*'Plate-glass in sashes has a magnificence peculiar to itself, objects seen through it are not distorted, and objects seen in it, have the same fair appearance. It can be had in the largest dimensions of any glass ... Glass can be bent to circular sweeps, which is very much in practice in London, for shop-windows'.<sup>71</sup>*

It is only to be expected that the movement would manifest itself most clearly in commercial architecture where the shop front offered almost unlimited opportunities for flaunting the new status symbol.

The progression from the Georgian shop front with its many panes of crown glass set in a wooden grid was nonetheless gradual. By the late 1820s the average size of glass pane used in London shops was about four feet high and proportional in width which was big only in comparison with the usual crown glass panes.<sup>72</sup> But the die was cast and by the 1830s the use of plate glass as a glazing material in this category of building was well established. Charles Babbage noted in 1835 that all the better class shop windows in London were fitted with it.<sup>73</sup> Dickens too was impressed by the sudden craze for plate glass in the capital city<sup>74</sup>

In the provinces the use of plate glass in windows of ordinary buildings was then still a novelty. A Manchester resident in 1881 could recall in great detail the sensation caused by the installation of two plates of approximately two feet by one and a half feet, costing £30, in a window of a shop in Market Street fifty years earlier.<sup>75</sup>

Window tax, which classed any window larger than 4 feet 9 inches and 12 feet high as two, remained an obstacle to window design as did the cost of the glass. In 1846,



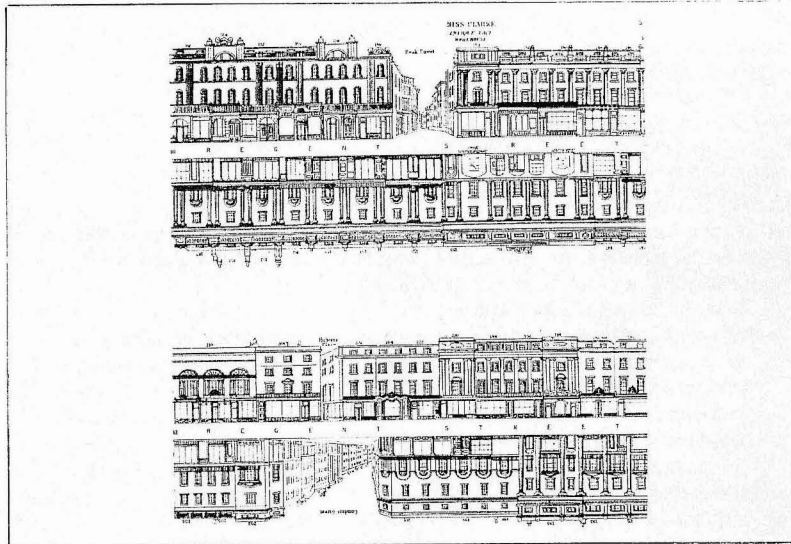


Fig.7 Street elevations to Regent Street, London, from Tallis's Street Views and Pictorial Directory etc. (1847).

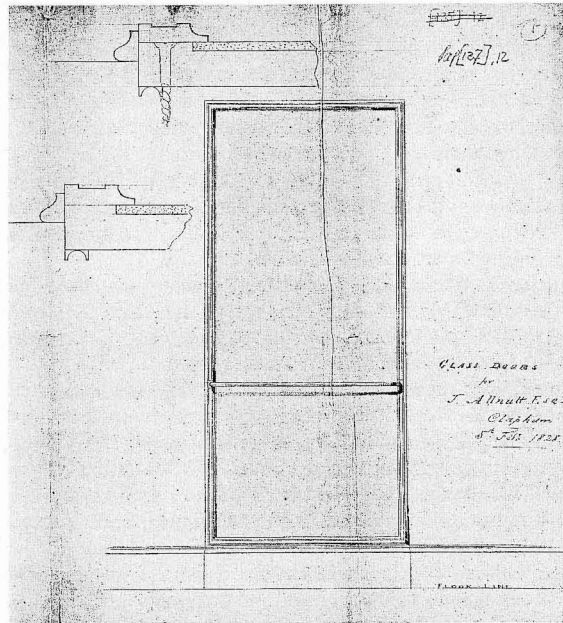


Fig.8 J B Papworth. Design for a plate glass door for J Allnutt of Clapham, Surrey, dated 1828. Glass sheet approximately 3'9" x 7'0". (British Architecture Library, RIBA)

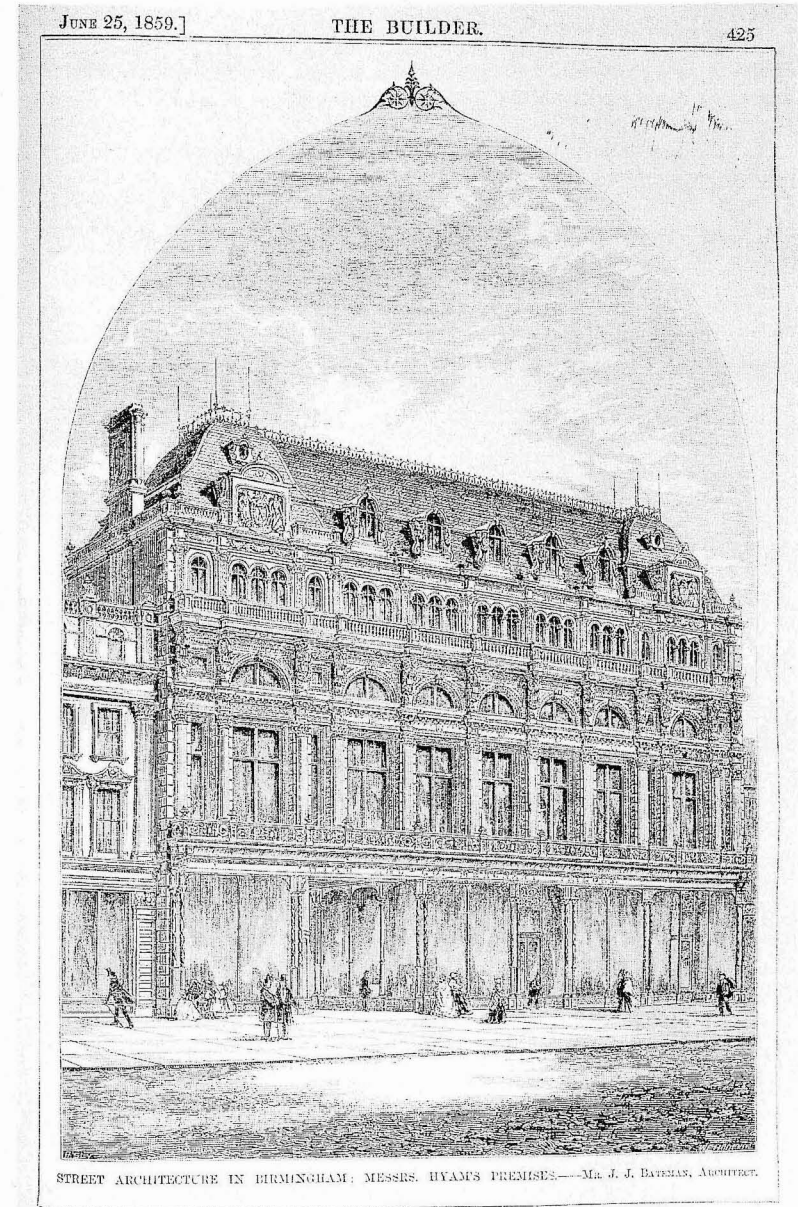


Fig.9 Shops and offices in Birmingham from The Builder, June 25, 1859.

one year after the removal of the glass duties the price of an 84 x 140 inch size plate – the largest on the architectural market – came to £150-11<sup>s</sup>-6<sup>d</sup>.<sup>76</sup> Once the fiscal restrictions were removed and prices began to fall pane sizes increased dramatically. A rare glimpse of the impact of this on the contemporary street scene is offered by a comparison of the 1830/40 and 1847 editions of John Tallis's *London Street Views*. (Figure 7)

During the 1850s the norm became vertical strips of glass seven to eight feet high by three to four feet wide – sizes virtually inconceivable to the shopkeeper of half a century earlier, but considerably less than that of which the industry was capable. The development was to continue until a balance was restored between the supply and demand capacities.

Domestic architecture also shared in the new fashion for large uninterrupted sheets of plate glass. An early example of this trend was the 6th Duke of Devonshire's admiration for the 'vast windows of single panes' he observed during a visit to Russia in 1826, and his insistence upon his return on replacing the bevelled panes of the original sashes at Chatsworth – once the pride of the Baroque building (see above) – with large plate glass sheets.<sup>77</sup> The Duke could afford to indulge in his passion for this 'greatest ornament of modern decoration', but lower down the social scale the response was no less enthusiastic (Figure 8). The material soon found its way even into the speculative housing market. The Newcastle upon Tyne developer Richard Grainger, for instance, ordered a considerable quantity for some of his new housing schemes in 1833.<sup>78</sup>

By 1846, according to one source, some private mansions boasted, 'single sheets of glass upwards of 20 feet in height and 10 inches width'.<sup>79</sup> Appropriately, it was Mentmore Towers, Buckinghamshire (1852-4) a house designed by Joseph Paxton and son-in-law for the Baron de Rothschild, which stole the limelight. Today, noted chiefly for its pioneering use of an integrated ventilation and heating system, contemporaries were equally impressed by 'three arches the whole height of the ground floor, filled with polished plate-glass', in the main hall of the building.<sup>80</sup>

When George Gilbert Scott in 1858 called plate glass, 'an undivided as possible... one of the most useful and beautiful inventions of our day'<sup>81</sup> he probably spoke for the majority of the architectural profession. The dream of filling an aperture with a single expanse of glass, first voiced a century earlier by Laugier and Ware had finally become feasible.

However, no sooner had the ideal been reached than the reaction set in. At first it was the excessive use of plate glass in shop fronts that attracted adverse comment from critics, (Figure 9) but as plate glass windows proliferated in buildings of all kinds throughout the country during the 1860s and 1870s the rebellion moved to the domestic front as well. In that field a revival of interest occurred in the picturesque effects of the leaded lights and small-paned sashes of the local vernacular styles. The struggle between those who regard large areas of clear window glass in a building as a sign of technological progress and modernity, and those who prefer the smaller-scale tactile qualities of traditional glazing methods has remained part of the architectural debate ever since.

#### Acknowledgement

This article is based on research executed with an ARCUK Research Award.

#### Correspondence

Hentie Louw, School of Architecture, The University, Newcastle upon Tyne NE1 7RU, United Kingdom.

#### References

1. Eleanor S. Godfrey, *The Development of English Glassmaking 1560-1640* (Oxford, 1975).
2. See R.J. Charleston, 'Glass Furnaces through the Ages' *J. of Glass Studies* 20 (1978), pp. 30-3; D.W. Crossley, 'The Development of the English Glass Furnace in the Sixteenth and Seventeenth centuries', *Ibid.* 25 (1983), pp. 147-55.
3. Quoted in *Antiquarian Repertory* I (1807), p. 72.
4. In France the use of oiled paper and cloth as a substitute for glass was common until the end of the 18th century, even in Paris. (A. Sauzy, *Marvels of Glass-making*, 1870, p. 54); English travellers to Italy in the later 17th and early 18th centuries found the use of window glass rare even in palaces in major centres such as Milan and Florence (Archbishop George Burnet, *Account of what seemed most remarkable in travelling etc.* (1685) 2nd ed. 1687, p. 115). See also John Kay, *Travels through the Low-countries, Germany, Italy and France*, 2nd edition (1738), p. 341; Thomas Gray, *Works*, (ed.) E. Gosse (1903), II:66.
5. John Houghton, *A Collection of Letters for the Improvement of Husbandry and Trade*, No. 198, 15 May 1696.
6. Figures quoted for the window tax assessment in 1695. Francis Buckley, *Taxation of English Glass*, (1914), p. 40.
7. Richard Neve, *The City and Country Purchaser and Builder's Dictionary*, (1703) under 'Glass'.
8. For a discussion of the different manufacturing processes for window glass and their historical development see R. McGrath & A.C. Frost, *Glass in Architecture and Decoration*, 2nd revised edition (1961).
9. E.W. Hulme, 'English Glassmaking in the sixteenth and seventeenth centuries I: Window glass'. *Antiquary* XXX, (1894), pp. 211, 259. L.F. Salzman, *Building in England down to 1540*, (Oxford 1952), pp 185.
10. See, for example, comments by Sir Roger Pratt, R.T. Günther, *The Architecture of Sir Roger Pratt*, (Oxford 1928), p. 72.
11. *Calendar State Papers Domestic*, William & Mary. Entries for 5 & 8 Jan. 1664/5. Henry Richards was apparently French. *Ibid.* Charles II, Entry for 17 Dec. 1678.
12. Francis Buckley, 'Old London Glasshouses I: Southwark', *Transactions of the Society of Glass Technology*, XIV, (1930), p.139.
13. Advertisement in *London Gazette* June-Sept. 1691. Quoted in William Henry Bowles, *History of the Vauxhall and Ratcliff Glass Houses and their Owners 1670-1800*. Privately printed, 1926, p. 17.
14. E.S. de Beer (ed). *The Diary of John Evelyn*, (1955), p. 629. Entry for 10 Sept. 1676.
15. According to an advertisement in *The Post Man*, 13 Feb. 1700/1 quoted in Francis Buckley, *The Glass Trade in England in the Seventeenth Century*, (1914), p. 59.

16. *The London Gazette*, 15 Jan. 1702/3. Quoted in Francis Buckley, *Transactions* p. 45.
17. *Chamber's Cyclopaedia or a Universal Dictionary*, (1728) under the heading 'History and Antiquity of Glass'.
18. From a broadsheet published during a dispute between two London companies. Quoted in T.C. Barker, *The Glass Makers: Pilkington: 1826 to 1976*, (1977), p. 14n. 87. The sudden upsurge in the trade is reflected in the London Glassellers Company's decision to increase its livery in 1711. (Sidney Young, *The History of the Worshipful Company of Glassellers of London*, 1913, p. 23).
19. See, for example, the comments of a Danish visitor to London 1727 quoted by Charleston, *Glass Furnaces*, p. 31, 49n. and those of Z.C. von Uffenbach to Cambridge in 1710, Willis, R.J., & J.W. Clark *The Architectural History of the University of Cambridge*, (Cambridge, 1886), II p. 614.
20. ASPD. *Architectural Dictionary* III (1887) under 'Glass', p. 46.
21. *The London Gazette* 6 June 1692 quoted in Buckley, *Glass Trade*, p. 46.
22. C. Morris (ed.) *The Journeys of Celia Fiennes* (1947), pp. 99-100. The size of the panes used in the windows are not given in the accounts but a sash-door in the Great Chamber was fitted at the same time with 4 plates of mirror glass 29 inches high, 4 plates 40 inches high. Francis Thompson, *A History of Chatsworth* (1949), p. 155.
23. *Wren Society* IV (1927), p. 57.
24. B. Smith & J.L. Moilliet, 'James Keir of the Lunar Society' *Notes & Records of the Royal Society of London*, 22, nos. 1-2 Sept. 1967, pp. 144-54; E. Schofield, 'Josiah Wedgwood and the Technology of Glass Manufacturing' *Technology and Culture* III (1962), pp. 285-97; Neil McKendrick, 'The Role of Science in the Industrial Revolution: A study of Josiah Wedgwood as a Scientist and Industrial Chemist' in M. Teich and R. Young (eds.) *Changing Perspectives in the History of Science*, (1973), pp. 274-319.
25. See H.J. Louw, 'The Rise of the Metal Window during the Early Industrial Period in Britain c.1750-c.1830' in *Construction History* 3 (1987), pp. 31-47.
26. p. 316. This echoes the comments by Laugier, *An Essay on Architecture*, first publ. 1753 (Ch. 1 Article V; Ch. IV). It is likely that Ware would have been familiar with the above work which was translated into English in 1755.
27. Neve, *City and Country Purchaser*, 1736 ed.
28. Barker, *Glassmakers*, p. 58.
29. *Ibid.* pp. 26-7. Graphs 1 and 2.
30. *Ibid.* pp. 58-9.
31. *Ibid.* graph 1.
32. Robert Campbell, *The London Tradesman*, (1747), pp. 172-3.
33. See Catherine Ross, 'The Development of the Glass Industry on the Rivers Tyne and Wear', (unpubl. doctoral dissertation, Newcastle upon Tyne University, 1982), p. 79 and Bowles, *Vauxhall and Radcliff*, p. 48.
34. Barket, *Glassmakers*, pp.15-20.
35. T. Cadell, *Tariff of the Prices of Polished Plates of Glass*, (1794).
36. Pigot & Co. *Classification of London Trades*, 1836 ed.
37. H.J. Powell, *Glassmaking in England*, (Cambridge, 1923), p. 96.
38. Ross, *Glass Industry*, pp. 115-8; A. & N.L. Clow, *The Chemical Revolution*, (1952), pp. 100-5.
39. Abraham Rees, *The Cyclopaedia or Universal Dictionary of Arts, Sciences and Literature*, (London, 1819), XVI, under 'Glass'; see also Samuel Parkes, *Chemical Essays*, (1815), Vol. 3, p. 437.
40. For a general discussion of the qualities of the material see especially William Cooper, *The Crown Glass Cutter and Glazier's Manual*, (Edinburgh, 1835).
41. Barker, *Glassmakers*, p. 62, Table 2.
42. Excise Returns 1833, Reproduced in Ross, *Glass Industry*, Appendix I. The Dumbarton Crown Works near Glasgow, which had an annual production in excess of 30,000 cwt. in the later 1820s, ceased operation in 1832 effectively destroying the Scottish industry in this product.
43. For this see chiefly Ross, *Glass Industry*, pp. 157-85; Barker, *Glassmakers*, Chap. 3-7.
44. Ross, *Glass Industry* p. 184.
45. Henry Chance, 'On the Manufacture of Crown and Sheet Glass' Reprinted in *The Builder*, March 15, April 5, 12, (1856), p. 185.
46. Chairman of the Board of Excise, 1835, Quoted in Ross, *Glass Industry*, p. 172.
47. Peter Nicholson, *An Architectural Dictionary*, (1819), II:46, under 'Glass'.
48. John Nicholson, *The Operative Mechanic and British Machinist*, (1829) under 'Glazing'.
49. Peter Nicholson, *The Builder's and Workman's New Director*, (1834) p.1.
50. Barker, *Glassmakers*, pp. 63-4; Ross, *Glass Industry*, pp. 172-9.
51. According to Henry Chance the price of good crown glass fell from £12 per crate in 1844 to £2-8-0<sup>d</sup> in 1865 and ordinary sheet glass from 1<sup>s</sup>2<sup>d</sup> to 2<sup>d</sup> per foot over the same period. Henry Chance, 'On the Manufacture of Plate, Crown and Sheet Glass' in Samuel Timmins (Ed.), *The Resources, Products and Industrial History of Birmingham and the Midland Hardware District* (1866), p.149.
52. On this see Paul Hollister, 'The Glazing of the Crystal Palace', *Journal of Glass Studies*, 16 (1974), pp.95-110.
53. See for example Henry Chance's comments in his paper to the Society of Arts 1856 (above note 45); discussion of the Edinburgh glass trade in *The Builder*, 28 May 1853, and the report of a French industrial observer, Eugene Pélégot, of the Great Exhibition, quoted in Hollister, 'Glazing' *J. of Glass Studies* p. 100 n.29.
54. *The Builder*, 14 April 1860, p. 238.
55. On this see Barker, *Glassmakers*, Chapter 8.
56. *Ibid.* pp. 107, 111.
57. R.W. Swinburne, 'The Manufacture of Glass' in, *Report of 32nd Meeting of the British Association held at Newcastle upon Tyne, 1863*, (Newcastle, 1864), pp. 195-6.
58. Chance, 'Manufacture of Plate', *Resources Products*, p.148.
59. Ross, *Glass Industry*, p.143.
60. Swinburne, 'Manufacture of Glass', *32nd Meeting*, p. 94.
61. Samuel Parkes, *Chemical Essays*, (1815) III:491-2; V:216-7. Wording taken from the second (1823) edition, II:234.
62. *Ibid.*, Vol. III: 491 note 135.
63. That is according to Isaac Cookson's testimony to the Excise Commissioners in 1835. H.J. Powell, *English Glass*, p. 96.

64. Addendum to the Fourth English edition (1846) of John Beckmann, *A History of Inventions Discoveries and Origins*, p. 82
65. The Albion Plate Glass Company. *The Builder*, 11 Sept. 1847, p. 440.
66. Chance, 'Manufacture of Plate', *Resources products* p. 147.
67. Swinburne, 'Manufacture of Glass', *32nd Meeting*, p. 194.
68. A plate of glass 20 x 12 feet was made for the Pacha of Egypt in 1849 in France, and at the 1862 International Exhibition the Saint Gobain factory displayed a plate glass sheet measuring 10'-8" x 16'-6". Architectural Publication Society, *Dictionary of Architecture*, III (1887), pp. 46-7.
69. Charles Tomlinson (ed). *Cyclopaedia of Useful Arts*, (1854), I : 778.
70. Thomas Martin, *The Circle of the Mechanical Arts*, (1814), p. 332.
71. Nicholson, *Architectural Dictionary*, II:46.
72. On this see chiefly Mary Eldridge, 'The Plate-glass Shop Front', *Architectural Review*, 123, March 1958, pp. 193-5.
73. Charles Babbage, *On the Economy of Machinery and Manufacture*, (1835), p. 150.
74. Charles Dickens, *Sketches by Boz*, (1836) quoted in Nikolaus Pevsner, *A History of Building Types*, (1976), p. 257.
75. J.T. Slugg, *Reminiscences of Manchester Fifty Years Ago*, (Manchester, 1881), quoted in Baxandale & Co. *A Book of Glass*, (Manchester, 1902).
76. *Kelly's Practical Builder's Price Book*, (1846), *Tables on pp. 146-7*.
77. Derek Linstrum, *Sir Jeffrey Wyattville, Architect to the King*, (Oxford, 1972), p. 146.
78. Ross, *Glass Industry*, p.154.
79. Beckmann, *Inventions*, (1846), p. 82.
80. *The Builder*, 19 Dec. 1857, p. 741. An account which has recently come to light shows that glass plates of up to 7'3" x 11'9" were used in the building. (Information: Buckinghamshire Country Archivist).
81. G.G. Scott, *Remarks on Secular and Domestic Architecture*, (1858), p.36.

## The Pioneering Iron Trusses of Nathaniel Rider

---

VICTOR C. DARNELL

Bridge histories, because they must cover so much material, record successful designs and give little if any attention to those which were failures or were little used. The designs of William Howe and Squire Whipple receive the notice that they deserve, but the pioneering efforts of their less successful contemporaries should also be noted. The subject of this paper is such an individual. It has the additional interest that the use of his design in England is an early example of the transmission of technical knowledge across the Atlantic.

### Early Iron Bridge Building

Nathaniel Rider (1790-1848) was one of the earliest builders of iron bridges in the United States and formed the first American company to fabricate and sell them. As the company and his style lasted less than ten years Rider gets only passing mention, if any, in the histories of bridge building. The histories by both Cooper and Condit make brief mention of his bridges and the failure of one on the Erie Railroad, while Tyrrell's comments are confused<sup>1</sup>. In addition to the 21 or more bridges that Rider and his company or associates erected in the United States they sent one, later used at Swindon, to the Great Exhibition,<sup>2</sup> and an English firm built about 60 for export.

The predominance of trusses in nineteenth century American bridge building came from several causes. Oak, pine, elm, and hickory, all excellent structural timbers, were easily available. The alternative to pile or truss bridges was masonry arches, but these required more labour and capital, both of which were scarce. After the first truss, reportedly built in 1764<sup>3</sup>, the builders devised various forms of trusses, arches, tied arches and combinations of these basic types. These men worked in the craft tradition using intuition, proportions, and sometimes models, for there were no engineering schools and no books of instruction. The use of timber in sizes which seem incredible today continued after iron and steel came into common use and lasted well into the twentieth century.

Iron was first used for an American bridge by Judge Finley in 1801 at his Jacob's Creek suspension bridge<sup>4</sup>. Similar bridges followed built by Finley, his associates and others. During the 1830s builders and inventors turned their attention to using iron in other structural forms. In 1840 William Howe used it to replace the vertical tension members of timber trusses, and in 1844 Thomas and Caleb Pratt received patent 3,523 for a timber truss that used iron rods for diagonal tension members. While Howe and the Pratts were making limited use of iron, others were designing structures which contained no wood at all. The first, August Canfield, received a patent (numbering did not start until 1837) on 29 June 1833 for a bridge that resembled a truss but actually was a series of brackets tied-back to masonry abutments. The earliest American iron bridges were erected in 1840. First in place was that of Earl Trumbull who received patent 2,164 on 10 July 1841 : it was a combination of truss and self-anchored suspension with the latter being more important. Squire Whipple erected the first of his tied arches soon after and was