the Old Palace of Westminster', *Architectural History* 9 (1966), Pls.9 and 10.

110. *King's Works i*, p. 431; Johnson, *Drapers' Company, i*, p.313.
111. Bishop of Ely's palace at Hatfield, 1485; the same builder, John Morton's, gateway at Lambeth Palace, c1490; bishop of London's palace at Fulham, 1506-22.
112. D. Gadd and T. Dyson, 'Bridewell Palace: excavations at 9-11 Bridewell Place and 1-3 Tudor Street, City of London, 1978', *Post-Medieval Archaeology* 15, pp. 1-79; Colvin, 'Views of the Old Palace of Westminster', pp.33, 35; pl 31, 49-50.
113. Marsh, *Carpenters' Company, ii*, pp. 92, 95; perhaps significantly, on two occasions in the Carpenters' Company records, in 1484 and 1491, the bricklaying was carried out by masons: pp.65-7, 92.
114. *Ibid*, 92.
115. For brick in the Treswell surveys, Schofield *Treswell*, pp28-9; for the Clothworkers' Hall rebuilding, pp.94-6.
116. *Cal Patent Rolls 1416-22*, p.22; T. Smith, *The medieval brickmaking industry in England 1400-1450*, British Archaeological Reports 138 (1985), pp.7-8, 12-18.
117. R.C.H.M. *West London*, P1 84.
118. Clifton-Taylor, *Pattern*, pp.287-93.
119. Horsman et al, *Saxo-Norman London, i* pp. 81-2.
120. N.J.M. Kerling, ed. *The Cartulary of St Bartholomew's Hospital* (1973), p.143.
121. *Assize of Nuisance*, 209, 215, 218, 276, 281, 293, 307, 337, 380, 418, 450, 475, 496, 519, 520, 570, 593, 605, 609, 620, 634, 653.
122. C.L.R.O., C.C.P.R. St James in the Wall 1516; Finsbury 1589; other fourteenth- and fifteenth-century property boundaries were made of palings of wattle and daub and of daubed or plastered wood, which was probably the same thing (*Assize of Nuisance*, 278-9, 595).
123. See G. Egan et al, *The medieval household* (Medieval finds from excavations in London, 5), in preparation.
124. For plans, see Schofield *Treswell*.

Eighteenth Century Britain's Missing Sawmills: A Blessing in Disguise?

E.W. COONEY

At the onset of industrialisation in Britain in the eighteenth century wood was one of the principal raw materials of the economy – as indeed it still is – although subject even then to a gradually increasing scarcity of domestic supplies which was relieved by imports from continental Europe and later from North America.[1]. It was worked for a wide variety of uses by a range of hand tools, most of them with origins in antiquity or earlier, which had been gradually increasing in specificity of design for particular purposes. The basic elements of those tools were part of the common stock of technology of Europe and much of the rest of the world. Power driven tools were lacking except in two instances; the turner's lathe, usually worked by a treadle, and the frame saw, commonly driven by wind or water power to convert felled timber into convenient sections. In Europe woodworking continued for long with predominantly manual practices. Neither on the Continent nor in Britain was mechanisation of the industry in the forefront of industrial progress. Only in the United States was development of successful woodworking machinery a notable feature of industrial advance.

This outline of circumstances does not necessarily point to a British or a European 'failure', to a casual or even wilful neglect to achieve what was technically feasible and economically worthwhile (although those possibilities should not be excluded). There are often good reasons for sectoral unevenness in rates of industrial change; good reasons, too, why particular industries have been more prominent in some countries than in others in the course of development (as will be seen later in comparison of woodworking machinery in Britain and the United States).

In the case of Britain, while comparisons in the history of mechanisation of woodworking do not in general point to a British failure, sawmilling at first sight makes a different impression. Sawmills were virtually absent from the British industrial scene throughout most of the eighteenth century. Musson believes they began to become common towards the end of that century and in the early nineteenth century and mentions the 'strong popular opposition' to them.[2] Certainty, however, is reduced in the absence of such sources as taxation data or census or survey information. In the case of county maps, for instance, we are told by Laxton that the 'mapmakers gave no systematic indication of the use to which the power (of watermills and windmills) was put ....'[3] Extensive development of sawmilling probably came as late as the middle of the nineteenth century in the form of steam-powered works (a point considered more fully later). Mills powered by water or wind had, however, long been established on the Continent, apparently in considerable numbers, where their first appearance can be dated to the later medieval period. If this was so on the Continent, why not in Britain also?

Origin and Development

As early as the thirteenth century Villard de Honnecourt, master mason and artist, showed in his sketchbook a design for a 'semi-automatic sawmill' driven by water.

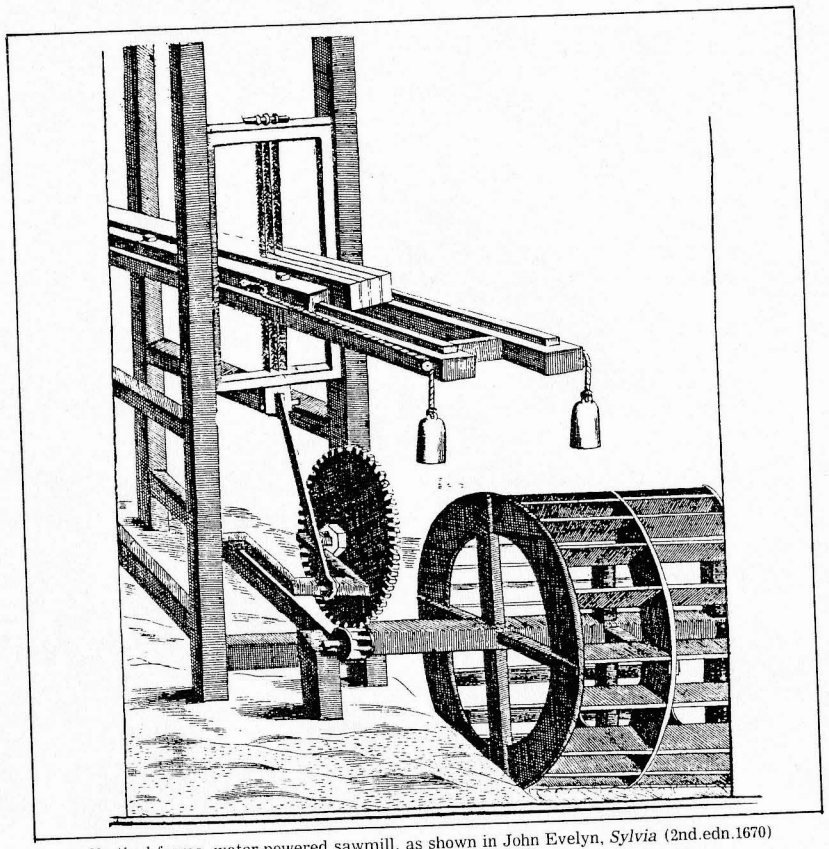

Fig.1 Vertical frame, water-powered sawmill, as shown in John Evelyn, *Sylvia* (2nd.edn.1670)

Noting the crudity of the design, Wim Swaan nevertheless suggests that sawmills were in use in that period. Remarking that the canons of St. Sernin in Toulouse bought a sawmill in 1303, he adds that by the end of the century 'numerous documents' relate to licensing of sawmills.[4]. In *The Dictionary of Architecture* (1852-92) there is a compilation of recordings of sawmills from various parts of Europe from the fourteenth century onwards: near Augsburg, 1337; near the Porta Mulina at Mantua, 1400 ('still in use'); Erlinger, 1417; Madeira, 1420; Erfurt, 1490; Norway, 1530; Holstein, soon after 1545; near London, 1663 but abandoned; Breslau, 1724.[5] Technical details and sources are not given. The mill near London in 1663, 'but abandoned', is no doubt the same as the one which Powis Bale says was built about that time by a Dutchman, 'but was the occasion of so much riot that it had to be abandoned.'[6]

This scattering of mills over a long period at least suggests an early and widespread resort to mechanical sawing as part of that unintensive process of mechanisation of work which was taking place in Europe during the five centuries or more before the beginnings of modern industrialisation in the eighteenth century. Such a record is of course not enough even to hint at the extent of supersession of manual sawing. But there may have been some acceleration towards the end of the period, particularly in response to growth of urban demand. In this connection, the building in Holland in 1592 of the first wind-driven sawmill is noteworthy.[7] It was the first of a number which came to serve, among other markets, a growing demand in England and especially London. By 1630 they were well established, with 'fifty three of the 128 industrial mills of diverse kinds on the Zaam... engaged in timber-sawing.'[8] The contrasting British backwardness is unlikely to have owed much to technological problems. Apart from the reciprocating action of the frame saw, the machinery appears to have been little more complex than that of contemporary cornmills which had long been numerous in Britain. If not earlier, at least by the late fifteenth century there had been developed on the Continent the basic design of the crank-actuated saw frame.[9] Another technical question concerns the suitability of British hardwoods for milling. Mayhew in 1850 was told by the foreman of a steam mill in London that, 'We can't so well cut elm, oak, or ash, as the sawyers.' They could 'only outdo the sawyers altogether in (softwood) deals...' which were, however, 'more used for general purposes than all other woods put together – far more.'[10] This may have limited the spread of sawmills, since at least until the later eighteenth century domestic supplies comprised hardwoods whereas on the Continent the powered frame saw appears to have been utilised particularly for softwoods. The point has not, however, been found in eighteenth century observations, especially those of Robert Dossie in 1768 on behalf of the Society for the Encouragement of Arts, Manufactures, and Commerce, which are discussed later.

Legal Status

The possibility that British backwardness was the result of deliberate public policy rather than an outcome of technical or economic circumstances requires attention in view of the fact that sawmills were thought to be prohibited in the country during the eighteenth century – and possibly earlier – to protect the sawyers' livelihood. That the belief was almost certainly mistaken does not mean that it was without effect. One source of the belief is to be found in dictionaries of the period. In particular, under 'Sawing' in the *Builder's Dictionary* of 1734 it states that, 'There are mills for sawing of wood, carried both by wind and water, which perform it with much more expedition and ease, than is done by hand.' After a brief description of the vertical frame saw used in such mills it continues, 'These are frequently found abroad and were lately begun to be introduced into England, but Parliament thought fit to prohibit them, because they would spoil the sawyers' trade and ruin a great many families.'[11] This work was published with the approval of three architects, Nicholas Hawksmoor, John James and James Gibbs, who say in it that having 'perused' it they commend it for 'a great deal of useful Knowledge in the Building Business.' Yeomans, writing in 1986, sees it as 'the best source today on early eighteenth century building practice because it covers the work of all trades and so gives information not provided in those books addressed to carpenters.'[12] Chambers' *Cyclopaedia*, 1743, has an entry under 'Sawing' which refers to this prohibition in closely similar terms.[13] It is the same with the *Dictionary of Arts and Sciences*, 1754.[14]

Fig.2 Dutch sawmill, De Gekroonde Poelenberg, on the Zaan (John Reynolds)

However, *The Builder's Magazine* of 1774, printed for 'a Society of Architects', makes no reference to a prohibition or even to sawmills.[15] But even as late as 1819-20, *Rees's Manufacturing Industry* recapitulates the prohibition.[16] Returning to the early eighteenth century, Neve's *Builder's Dictionary* has nothing on the subject in editions of 1703 and 1726.[17] Even earlier, in 1695, John Cary who refers to 'deal boards (which) are sawn with mills' as among 'new projections (which)

are every day set on foot' in England makes no suggestion of any legal difficulty.[18] It would appear therefore that the *Builder's Dictionary*, in 1734, may have been the first published source of the advice that sawmills were unlawful. While repetition in very similar terms suggests lack of critical consideration in the later sources, such information is scarcely likely to have been echoed in that manner if sawmills had been at all numerous throughout the century or increasing in number even from a small beginning. The Society of Arts, however, was more sceptical. By the late 1750s they had concluded that the belief in a prohibition was ill-founded. Their records do not show how they arrived at this conclusion but they were well placed to make enquiries into parliamentary records and to obtain legal opinion. A recent search of those records (which were reduced by the fire at the palace of Westminster in 1834) failed to discover legislative action between 1660 and 1734 against sawmills in the *Journals* of the House of Commons, nor was anything found in those of the House of Lords or in Pickering's *Index* to statutes in force to 1761.[19] The subsequent period, from 1734 to 1852, also failed to produce any evidence, such as a repeal or comment on an Act. If, indeed, nothing was enacted or even proposed or discussed in Parliament – and of course something of significance may yet be discovered – then it is a matter for speculation how the statement in the *Dictionary* originated. Perhaps the most interesting thought is that the *Dictionary*, although itself in no way a political publication and certainly a highly competent work, may have been seen by a friend of the sawyers as a good opportunity to support their interest. Whatever may be the case, a forceful rebuttal of the supposed prohibition was made by Dossie in his *Memoirs of Agriculture*, published by the Society of Arts in 1768.[20] Observing that 'it was almost universally believed' that sawmills were illegal, he commented that, 'This opinion has long prevailed, and was perhaps, the principal cause, why so few attempts were made to establish such mills here.' Yet that belief 'was nevertheless, entirely without foundation, both as to the fact itself, or the reason. There never was any such act of parliament: and so far from it being necessary, it is evident, that a prohibition of saw-mills would have been injurious to the public; and no way advantageous to any particular set of men.'[21] It is said of Dossie that his family was of Yorkshire origin but that his career 'before the age of forty can only be guessed at.' He may have served an apprenticeship in pharmacy. In 1760 he became a member of the Society on introduction by Dr Samuel Johnson and 'His whole life soon became wrapped up in the Society.'[22] In view of their interest in sawmills and their publication of his *Memoirs* it can be fairly assumed that Dossie was speaking for the Society in his rejection of an error which was seen as a serious obstacle to progress, and maybe all the more so because it was in tune with a strain of popular feeling of the time.

Progress in face of opposition

Widespread belief in a parliamentary prohibition of sawmills was not unlikely in an age when, as is remarked by H.T. Dickinson, 'There were times ... when Walpole's government clearly recognised the limits of its authority and endeavoured to placate those it could not subdue.'; for instance by the Act of 1727 for wages and cloth measure agreements with employers, following 'serious rioting among weavers of the south-western counties.'[23] In the case of sawmills the potential of popular feeling, shown it would seem in the previous century in 1663, was displayed again in 1768 when a mill built near the Thames in London with the

Society's encouragement was attacked by a mob. According to the *Annual Register*, on May 10th, 'A large body of sawyers assembled, and pulled down the saw-mill lately erected by Mr Dingley, at Limehouse, on pretence that it deprived many workmen of employment.'[24] Dossie, however, describes the mill as having been damaged, not destroyed, following its successful establishment and looks forward, following punishment of some of the rioters, to further development of sawmills.[25] About 1805 two more mills in London, of about six powered by horses, were destroyed by the sawyers. Mayhew says these mills 'were but little remunerative'.[26] The sawyers' actions can be seen in a wider context which includes machine-breaking in other industries and riots against shortages and high prices of food in the history of England's 'moral economy of the eighteenth century.'[27] As late as 1802, the strength of belief in protective law to which workers could appeal was shown in the woollen cloth industry in Wiltshire and Somerset when there were riots against the introduction of gig mills for dressing cloth, 'the discontent continuing from the workmen learning that there was to be found in the statute book an ancient law prohibiting under heavy penalties the use of a machine called a gig mill....'[28] Even later, especially in the 1820s and 1840s, in many places sawyers themeselves petitioned Parliament for protection from the competition of steam-powered mills which were being set up, but they seem to have done so without disorder or reference to particular legislation.[29] It may be that the view which the Society of Arts had taken of the law was admitted at least tacitly by the sawyers and those who may have been advising them. It should be noted, too, that Parliament had legislated in 1769 against destruction of buildings which contained machinery, following attack on the mill in Limehouse and attacks on Hargreave's cotton spinning machines in the north of England.[30] Even so, the continuing strength of customary expectation – or at least hope – of protection is suggested by the sawyers' readiness to appeal to Parliament by means which could have been used by their predecessors a century earlier at the time of the *Dictionary* entry of 1734. Their petitions failed and the steam sawmills were built in increasing numbers.

A rough idea of the extent of mechanisation is provided by the *Factory Returns* of 1870 in respect of the building industry, in which woodworking and especially sawmilling probably had an important part. If the average power of the engines used was 20 h.p. for instance, it can be calculated that 907 works would have had power out of a total of 21,012.[31] Twenty years earlier Mayhew had reported 68 steam-mills in London alone. An 'experienced sawyer' told him that the first of them 'had been up two or three years when I first came to London' in 1810.[32] Mechanisation of the sawyer's craft evidently progressed throughout the nineteenth century but it did so in the mode of the Industrial Revolution in Britain rather than in the 'pre-industrial' form of sawmilling on the Continent in earlier centuries. That is, not driven by wind or water and set mainly in small towns or rural locations but powered by coal and steam and placed where growth of demand and responsiveness of timber supply were strongest by then, in the urban centres of industrial expansion and population growth, served by transport which facilitated the use of imported timber and its subsequent distribution.[33] By the mid-century, in Mayhew's reports on the lives of London workers, he presents the sawyers as resigned to the transformation which was going on.[34] Public confidence in Free Trade, *laissez-faire* and the virtues of private enterprise and competition had probably never been stronger. The sawyers and other workers in their situation could expect nothing from Parliament except, maybe, the assurance that they also would benefit from the progress of which the new steam-powered mills were part. Even as early as the 1730s, nearly two generations before Adam Smith's *The Wealth of Nations*, when ideological or dogmatic commitment to avoidance of intervention in such matters was much less strongly formed, we have seen that protection was given reluctantly, if at all.

It is when one looks back to a yet earlier time that government can be found to make a clearer impression of determination to restrain technical change in favour of traditional crafts. It was in the conservative spirit of his reign that Charles I in 1635 forbade the use of a wind-powered sawmill.[35] That action, taken to protect the quality of the product, maybe, as much as the sawyers' livelihood, appears to be the only surviving evidence of state intervention in their favour during a period of two centuries or more in which the sawmill offered the possibility of competition at their expense. However, as the *Dictionary* statement of 1734 refers to Parliament and apparently to a recent decision, an action early in the previous century is not a likely source. But its recollection or rediscovery in the eighteenth century could have strengthened the sawyers' confidence that right was on their side.

The role of the Society of Arts

The part played by the Society of Arts in promoting sawmilling deserves further attention for what it tells about British backwardness in that respect. The Society's concern and sustained activity are evidence of the slightness of development of sawmilling at that time, in the 1750s and 60s, all the more important as evidence in the absence of statistical or survey information from government or other sources. The Society was well placed to know the position and to appreciate British backwardness compared with the Continent and even with the North American colonies. In his *Memoirs* of 1768 Dossie explains and justifies their activities with intelligent appreciation of the political and economic considerations involved in the progress of the industry and emphasises in his address 'To the King' that he has had 'constant attendance on the Society' and 'a part in most transactions.' (Facing title page)[36] Noting that many sawmills were kept at work in Holland and other countries of northern Europe, sawing deal and planks for England, he thinks it 'an extraordinary fact' that in a country so committed to mechanical improvements this situation should have been almost totally disregarded for so long. The main cause, he is sure, has been fear of violent opposition and, in his view also important, the almost universal belief in an act of Parliament to protect the hand sawyers' livelihood, with a risk of incurring a penalty. He is firm in his rejection of the idea that their livelihood would be reduced by sawmills in Britain. That effect, he argues, was already occurring through the competition from the Continent. Both the public and private interest would be better served by setting up mills at home, with the proviso that their product should be no dearer than the imported wood.

Dossie then turns to the award offered by the Society for demonstration of a satisfactory mill. The recipient was James Stansfield, a carpenter of Bingley in Yorkshire who applied for the prize, probably in 1759, referring to the Society's advertisement which followed the proposal in the previous year of a series of premiums to be paid over four years to the person or persons 'who shall first erect,

and during the said time shall exercise a Sawmill, capable of sawing Timber into useful Planks and Scantlings.' Stansfield referred to his expenses in travelling to Norway, Holland and Sweden 'for the better performance of this useful machine.'[37] Dossie says that before Stansfield's travels abroad he had built 'a more imperfect mill' which he had replaced by the design with which he won the award. But even with his improved machinery and the Society's financial support, Stansfield's business in Bingley did not flourish. Local consumption of timber was not enough to provide the mill with sufficient work to make it pay and Stansfield lacked the resources to buy logs and sell the sawn wood to a wider market. Dossie remarks that 'the same remoteness from the capital' which had caused the failure of Stansfield's mill had also worked against the Society's efforts to encourage sawmilling by means of an example, for 'in that distant corner it had no influence', remaining 'as much a matter of mere speculation as those in Holland or other countries.'

Fig.3 Pit-sawing, as practised in England into the present century, from *The Young Tradesman, or Book of English Trades* (new edn.1839)

Having struggled without commercial success for two or three years after receiving the Society's final premium, Stansfield decided to emigrate to America. *En route* in London he was approached by the Society and persuaded to join forces with Charles Dingley, a merchant whom they had convinced of the 'public utility' of sawmills. The wind-powered mill built in Limehouse with Stansfield's technical knowledge and Dingley's capital was completed in December 1767. It seems, at the least, not to have been a commercial failure. Situated as it was at the point of the largest imports of timber and in the centre of the country's largest market, its location could not have been bettered at that time (with further improvement if a canal, to which Dossie refers, should be built). During the Inquiry following Dingley's petition to the House of Commons for compensation for damage and loss caused by the mob in 1768, evidence was given that the mill had cost £4,454 to build; also, that timber imports of around £38,000 a year had been bought by him since 1765; and that the machinery with its 36 saws was 'much more useful' than the Dutch mills on which it was modelled and would 'cut all sorts of Timber, and for all Uses...'. Its repair had cost £1,231 and it had been out of action for six months[38] Dingley evidently still saw the mill as a worthwhile project and probably felt confident of greater protection from the strengthening of the law which Parliament was undertaking.

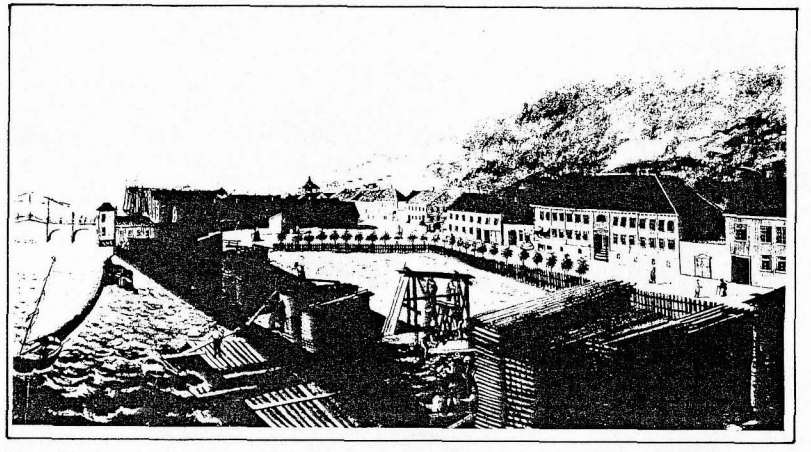

Fig.4 Hand-sawing, Bragernes, Norway, 1820. Even in this advanced region sawmilling was not yet universally applied (Drammens Museum, Norway)

A premature innovation?

The course of Stansfield's career, from early difficulties – lack of technical information, a narrow market, insufficient capital – to eventual success which depended heavily on capital and a much larger market (as well as the intervention of an organisation which was among one of the significant institutional innovations of the time) was not unlike that of other enterprising inventors. But success in a wider industrial perspective is not evident. Dossie was, as we have seen, confident that the Limehouse mill would be a stimulating example and the Society, in 1782, recorded in its *Transactions* that 'sawmills are now firmly established in En-

gland.'[39] This may indeed have been the case. But there is little to suggest substantial progress in substituting the mill for the sawpit. Powis Bale, in his history of woodworking machinery, believed that Stansfield 'and others, aided by the Government, erected mills in various parts of the country.' But his vagueness about persons and places recalls that of the Society and he gives no source.[40] In this situation of uncertainty one figure stands out. Following the invention in 1777 of a circular saw by Samuel Miller of Southampton, William Walton Taylor, a carpenter, also of Southampton, was using circular saws in his woodworking shop in 1781. According to Sims, the *Hampshire Repository* said of these in 1801 that they 'proved of ineffable use in expeditiously cutting timber for any purpose formerly done in a tedious way by the manual labour of workmen with axe, mallet and chisel.'[41] From Singer *et al.* we learn that Taylor 'owned quite an elaborate plant driven by a water-mill' from which he supplied the Navy with pulley blocks.[42] Here we touch on government needs which will be considered shortly. Meanwhile, it may be noted that the small number of contemporary observations of sawmills in the eighteenth century is in general matched by the infrequency of references by historians of the Industrial Revolution in Britain.[43] It seems clear that substantial progress had to wait until well into the nineteenth century. The contrast with, for instance, Hargreaves' cotton spinning jenny is noteworthy.

The upsurges of complaints by sawyers in the 1820s and 1840s, giving rise to the petitions already referred to, together with Mayhew's report on London, are signs of much more solid advance. They leave little doubt, therefore, that despite a promising start, the Society of Arts's initiative had a very limited success. Less emphatically, it may be said that the Society probably formed an exaggerated impression of the deterrent effect of the supposed Act of Parliament – unless one believes that their efforts to make known the true state of the law were of little effect. Their eminent membership, metropolitan location and evident energy equipped them to make their view widely known. A similar comment may be made about the fear of riot. The hand sawyers were evidently strong men – with a reputation also maybe for hard drinking.[44] But their animosity towards the sawmills is nevertheless unlikely to have been a greater obstacle than that of textile workers towards the new machines in their industry where, of course, the progress of innovation seems to have been little hindered in circumstances which included large prospects of profit.

The failure of sawmilling to advance substantially in the eighteenth century suggests the idea of unripe time. So also, although less obviously, does another episode in the history of woodworking machinery, including sawmilling, which is probably better known and more often referred to. That is the inventiveness and enterprise shown by those who were concerned with woodworking in the Royal Naval dockyards during the wars with France between 1793 and 1815. The large demand for ships in an economy which was probably more fully employed than usual stimulated mechanisation. The work eventually involved the combined efforts of Sir Samuel Bentham (brother of Jeremy, the utilitarian philosopher), Inspector-General of Naval works, with Sir Marc Brunel and Henry Maudslay.

These men, engineers and inventors, produced machinery of a remarkable variety, sophistication and economy, most notably the assemblage of block-making machines at Portsmouth.[45] Comparable machinery seems not to have been established in private industry in Britain for another generation. Clapham writes of their work as 'half-forgotten' in the 1830s.[46] The productive efficiency of block-making was such that ten unskilled men did the work of 110 skilled men. That was accomplished in 1808. In 1814 Brunel supplied the Royal Arsenal, Woolwich with a steam-powered sawmill which saved 'immense labour'.[47] Towards the end of the previous century Brunel and the engineer, John Rennie, had supplied water-powered sawmills to the naval workshops at Dartford and Chatham.[48]

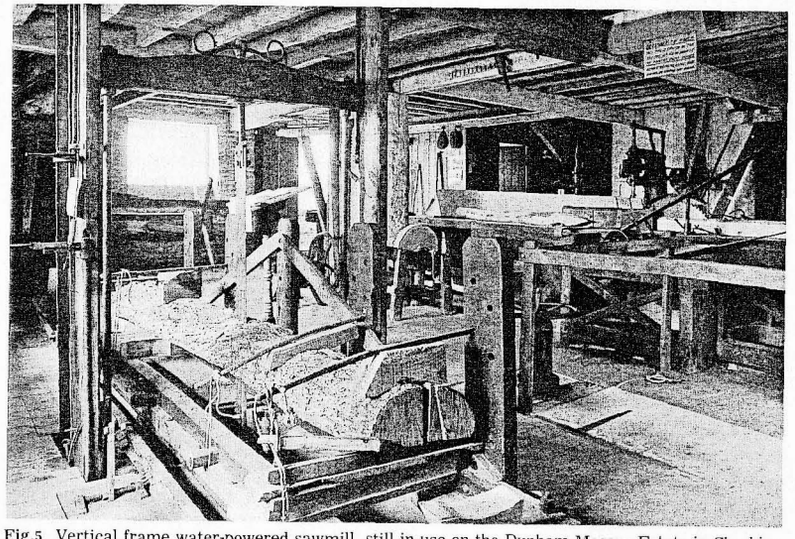

Fig.5 Vertical frame water-powered sawmill, still in use on the Dunham Massey Estate in Cheshire (National Trust)

Shortage of domestic timber

These demonstrations of the technical feasibility of sawmilling and of its superior labour productivity, together with authoritative assurance of its legality, were not enough to promote a general spread of mechanisation. Lack of confidence in its profitability is most likely to have been the immediate cause. The main explanation for that is to be found in the prevailing conditions of supply of timber in Britain. Suitable sites for utilisation of wind and, especially, water power may also have been a difficulty. Demand for wood was growing, although not as fast as the economy in general because other materials, particularly coal as fuel and bricks for building, were increasingly substituted. But capital and enterprise were available, as much for sawmilling as for any other innovation, according to the prospects of success and there was no general problem of labour supply greater than that which had to be solved in any new industry. By contrast, the limitations on bulk supply of domestic timber were unfavourable to working it by the capital intensive means implied by milling.[49] The difficulty can be illustrated by noticing a contrasting, and exceptional, situation. At the mouth of the river Spey on the east coast of Scotland there had been established by the 1820s a sawmilling industry

which depended on timber floated down the river from forest belonging to the Duke of Gordon and let by him to the London Timber Company who sent the product by sea to the metropolis.[50]

This procedure, probably unique in Britain at the time, resembles Continental practice as described for instance by Andrew Yarranton much earlier, in 1677: 'The Great Duke of Saxony hath three great manufactures... the third of Sawed Timber of all sorts... At the descent of the Hills, are infinite of Sawmills that go by water, which Saw all manner of Firr and Oak; and in the summer-time it is dragged to the River Elb, and so sent down to Hamborough.'[51] Clapham, noting the Scottish enterprise, quotes the German traveller, Meidinger, as also writing that, 'Everywhere now, a rational forest administration is being introduced, and if this goes on Scotland will compete with Norway and Sweden.'[52] Clapham comments that this was a sanguine judgement on the future of Scottish forestry early in the nineteenth century. But the scene described does display in a particular form the favourable conditions which had generally been lacking in Britain: abundant, inexpensive timber and a cheap means of transporting it to the mills and thence to adequate markets. Those conditions were commoner in Europe, not only in Scandinavia but throughout much of the northern part of the Continent. They were, too, very general in North America.

In the United States in particular, as Rosenberg explains, the cost saving advantages of machinery for woodworking in general and not only for sawing were very great. Amidst the abundance of timber and water for power and transport, together with relative scarcity of labour, the country developed sawmills from early colonial times and, in the nineteenth century, enjoyed international pre-eminence in the invention and use of a range of other woodworking machines. Indeed, improved sawmills figured in the first patent granted in America (to Joseph Jenks, by the colony of Massachusetts in 1646). To these factors should be added a consideration pointed out by Rosenberg; that is that the very fact of cheapness of wood and its use as fuel meant that woodworking machines which in Britain would have been seen as unacceptably wasteful of material could be viewed much more favourably in the United States. Design of such machines was thereby simplified.[53] This observation may be compared with Clapham's suggestion that in Britain metalworking machinery was easier to develop than woodworking machines because the materials to be worked on were more uniform than wood.[54]

Britain, as Clapham also says, 'was a land with singularly little forest natural or cultivated.'[55] It also lacked, by comparison, unobstructed flows of water like the Spey or the great rivers of the Baltic lands on which, as in North America, timber could be cheaply moved. Canals, which did so much to reduce the cost of inland transport in England, only began to make their effect felt in the second half of the eighteenth century. Not suprisingly therefore, Britain's increasing deficit of domestic timber was redressed by seaborne imports and resort to other materials.

Foreign Timber

In the midst of these unpromising circumstances for sawmilling a favourable factor emerged. Between the eighteenth and the mid-nineteenth centuries the supply of foreign timber changed in ways which eventually helped to stimulate a sawmilling industry in Britain. At first sight a pointer to such a change would seem

to be provided by Schlote's finding, in his study of British overseas trade, that the price of imported sawn wood rose tenfold between 1694 and the 1850s whereas the price of imports of unworked timber increased only threefold.[56] A large relative increase in the price of sawn timber – reflecting, say, an increase in wages abroad – might well have encouraged a British industry. But of course, on such a great scale, it strains belief, particularly in the case of a manufactured product. As Schlote himself cautions about this and similar comparisons, attention must be given to the identity of the commodity. In the case of deals there is an indication of a change in the meaning of the term between the eighteenth and the nineteenth centuries. In Campbell's *London Tradesman* of 1747, quoted by Clapham, London timber merchants were 'furnished with Deal from Norway, either in Logs or Plank...'[57] But according to Lower, writing of the trade by which Britain was supplied with a large part of its timber by the later period, 'The term 'deal' was transferred from the Baltic trade to the Canadian by the English timber merchants. Whatever it had meant originally, in course of time in the Canadian trade it came to mean a thick plank of fairly high quality both in material and manufacture, made out of pine or spruce.'[58] Clearly, such planks, whether sawn by hand or machine, required more work than cutting and roughly squaring timber in the forest. There seems to be no ready way of determining how much, if anything, of the ten-fold increase in the price of what Schlote refers to as 'the products of sawmills' should be attributed to a possible change of identity. The answer may lie in the Customs books. Meanwhile, there can be found in the circumstances of the wars with France between 1793 and 1815 causes not only of large rises in prices of imported timber but also explanation of a relatively large rise in the price of deals and a major change in source of supply which, taken together, could have worked to the advantage of sawmilling in Britain.

By the early years of the nineteenth century the spread of French power and influence across Europe was seriously threatening the security of exports to Britain. The policy developed during those years was intended to stimulate an alternative source of supply in the British North American colonies by means of substantial differential tariffs, most notably that of 1811. Once started, this system was continued until the Free Trade reforms of the mid-century. Its effect, gradual at first, was to supplant a large part of imports from Europe by timber from Canada and the other colonies. The tariff constraint weighed especially heavily on supplies of deals from Europe.[59] While it is known that Napoleonic prohibitions and British tariffs did not make an end to Continental supplies during the wars because means of evasion were found and French policy was often honoured by lip service rather than action, the long-term effect of war was very great.[60] In the short run, however, more was being looked for from the colonies than could be achieved, given the low level of their exports of timber and the slight development of their timber industries compared with those of northern Europe. In this situation, rather than provide sawn wood they were better placed to export square timbers.[61] Here was opportunity which could be exploited in Britain behind the tariff which was setting such a high price at the same time on deals, the principal import of sawn timber from Europe. Lower refers to 'a certain vested interest in English sawmills that wished to get raw materials for manufacture' and to a conservative preference for square timber. But more important constraints on milling in the colonies were, 'first, the capital required; second, the ease with which square timber could be made; third, the technique of transportation'. The nature of English demand was least import-

ant. Probably most important in his view, was the way in which square timber could be floated on rivers, over waterfalls and through rapids, treatment for which sawn timber was less suited.[62] The unsuccessful protests of the British manual sawyers, already referred to, coincided with the advance of imports of colonial square timber in the 1820s. By the mid-century, after the second round of complaints in the 1840s, it is clear that the British industry was firmly established. It proved capable of withstanding the final elimination of the duties in the following years, ending a process of gradual reduction which began with Peel's budget of 1842.

Conclusion

Viewed in this wider historical and geographical setting, the virtual absence of sawmills from Britain until the 1820s finds both a deeper explanation in, and itself makes a specific contribution to, disaggregative interpretation of the country's industrialisation, such as Wrigley's recent work. In this interpretation slowly growing 'advanced organic economy', nearing the limits of its potential, is seen as being overtaken by a faster growing 'mineral-based energy economy' by which it is in the end largely displaced.[63] The increasing shortage of wood, an organic resource at the heart of the older economy, provided stimulating conditions for more rapid growth of the new economy of coal and iron, worked by steam power. The same shortage of native timber is likely to have been more important than social opposition in hindering impulses to mechanical sawing in the early phase of accelerated industrialisation in the later eighteenth century and even before. That development, with its accompanying unprecedentedly rapid growth of population, encouraged exceptionally rapid and large-scale urbanisation and included cheaper transport services. Together with the advantageous changes in external conditions of supply which raised the price of sawn timber so greatly, the domestic situation became sufficiently favourable for entrepreneurs to begin in the 1820s that mechanisation of sawing in urban steam-powered mills which led to the modern large-scale industry.

A footnote to this history is the continued spread of rural wind or water-powered sawmills in the nineteenth century, sometimes by conversion of cornmills. Rising costs of labour and the increasing obsolescence of such mills with the progress of steam-powered flour mills in towns and cities encouraged the process.

These conclusions depend upon a complex of historical comparisons and inferences made without the benefit of the greater certainty which larger amounts of detailed information, especially statistical and economic data, would have provided. No census or geographical survey data were available. The relative costs of manual and mechanical sawing could not be established by reference to records of businesses or official or other enquiries. Domestic supplies of timber and their location were more matters of impressions and speculation than fact. Figures of imports are of course to be had, but may be flawed. All this is no more than the common experience of historians who can hope – as on this occasion – that such deficiencies will be lessened by further studies. Meanwhile, the story as told here contains little to suggest an avoidable industrial failure. It does, however, support the view that the conditions of the Industrial Revolution in Britain were substantially unique. The abundance of coal in the country can be seen in Wrigley's phrase as 'an uncovenanted blessing', a matter of chance.[64] Beside it went the increasing shortage of wood. If one puts a positive value on the Industrial Revolution, the sparsity of sawmills in the British industrial scene until the great change was well under way can also be seen as a blessing, disguised from contemporaries such as Robert Dossie, but in fact a consequence of the preeminence of the country in the economic and industrial progress of those times.

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1. Bryan Latham, *Timber, Its Development and Distribution: A Historical Survey,* (1957); a valuable source by an author who was a member of a firm of London timber merchants. I am indebted to Mr George Schreiber, himself a London timber merchant for many years, not only for this reference but also for very helpful discussions of timber and its conversion. I am grateful also to Mr Robert Thorne for encouragement to extend my consideration of timber imports.
2. A.E. Musson, *The Growth of British Industry* (1978), pp.36 & 51; also W.H. Chaloner and A.E. Musson, *Industry and Technology* (1963), p.33 and illustration no. 58.
3. Paul Laxton, 'Wind and water power', in John Langton and R.J. Morris, eds. *Atlas of Industrialiazing Britain 1780-1914* (1986), p.69.
4. Wim Swaan, *The Gothic Cathedral* (1969), pp.93-9.
5. Wyatt Papworth, ed. *The Dictionary of Architecture* (8 vols., Architectural Publications Society, 1852-92), IV, p.26.
6. M. Powis Bale, *Woodworking Machinery: Its Rise, Progress, and Construction* (3rd edn. 1914), p.5.
7. John Reynolds, *Windmills and Watermills* (1970, reprinted with corrections, 1974), p.176.
8. Jonathan I. Israel, *Dutch Primacy in World Trade 1585-1740* (Oxford, 1989), p.114.
9. Reynolds, *Windmills*, p.175.
10. E.P. Thompson and Eileen Yeo, eds. *The Unknown Mayhew: Selections from the 'Morning Chronicle' 1849-1850* (1971), pp.330-1. Also John S. Scott, *A Dictionary of Building* (2nd. edn., 1974), p.236: 'English oak is difficult to work because of its hardness and twisted grain... All imported oak is more straight-grained than English oak, and therefore easier to work.'
11. *The Builder's Dictionary or Gentleman and Architect's Companion* (2 vols., 1734, printed for A. Bettesworth & C. Hitch, reprinted Washington. D.C., 1981, for the Association for Preservation of Technology), v. 'Sawing'. (Search in dictionaries and other sources covered: 'forest', 'mill', 'saw', 'sawing', 'sawyer', 'timber', 'watermill', 'windmill', and 'wood'.)
12. David T. Yeomans, 'Early Carpenter's Manuals 1592-1820', *Construction History*, 2 (1986), p.26.
13. E. Chambers, F.R.S., *Cyclopaedia or, an Universal Dictionary of Arts and Sciences*, II, (1743; vol. I was published 1741).
14. *A New and Complete Dictionary of Arts and Sciences... The Whole Extracted from the Best Authors in all Languages by a Society of Gentlemen*, IV (1754), p.2817.

15. *The Builder's Magazine*, (1774, printed for 'a Society of Architects').
16. *Rees's Manufacturing Industry*, 4 (1819-20; David & Charles Reprints, Newton Abbot, 1972), p.442.
17. Richard Neve, *The City and Country Purchaser and Builder's Dictionary or, The Compleat Builders Guide* (1st edn. 1703, 2nd 1727, with facsimile reproduction, David & Charles, Newton Abbot, 1969).
18. John Cary, *An Essay on the State of England* (pam., 1695), quoted in Chaloner & Musson, *Industry*, p.33.
19. On parliamentary sources v. Maurice F. Bond, *Guide to the Records of Parliament*, (1971); also Danby Pickering, *Statutes at Large*, (Cambridge, 1769); *General Index to the Reports from Committees of the House of Commons 1715-1801 printed but not inserted in the Journals of the House 1803*, (Ordered by the House to be printed, 1803; reproduced, Bishops Stortford, 1973 with Introduction by John Brooke); Sheila Lambert, ed. *House of Commons Sessional Papers of the Eighteenth Century*, I (2 vols., Wilmington, Delaware, U.S.A., 1975). I am particularly indebted to staff of the Library of the House of Lords for facilitating my search.
20. Robert Dossie, *Memoirs of Agriculture and Other Oeconomical Arts*, (3 vols., 1768, 'published by the Society for the Encouragement of Arts, Manufactures, and Commerce in accordance with a Resolution of June 17, 1767', facing title page).
21. Dossie, *Memoirs*, I. p.124.
22. F.W. Gibbs, MSc, PhD, 'Robert Dossie (1717-1777) and the Society of Arts', *Annals of Science*, 7, no.2, June, 1951, *passim*.
23. H.T. Dickinson, 'Popular Politics in the Age of Walpole', in Jeremy Black, ed. *Britain in the Age of Walpole*, (1984), p.63.
24. *The Annual Register*, (10 May, 1768), p.108.
25. Dossie, *Memoirs*, p.129, v. also Paul Mantoux, *The Industrial Revolution in the Eighteenth Century*, (revised edn., 1961), p.401.
26. Thompson and Yeo, *Unknown Mayhew*, pp.328-9.
27. E.P. Thompson, 'The Moral Economy of the English Crowd in the Eighteenth Century', *Past and Present*, 50 (1971).
28. K. Ponting, ed. 'Introduction' to *Baines' Account of the Woollen Manufactures of England*, (1875; new edn., Newton Abbot, 1970), pp.48-9, citing the *Report* of the Select Committee on the 'State of the Woollen Manufactures in England', printed for Parliament, 1806.
29. *Journals* of the House of Commons, 75-107, 1820-52, v. Index of 'Timber' and 'Wood'; also *General Index to the Reports on Public Petitions 1833-1852*, printed by order of the House of Commons, 14 Aug. 1855.
30. Mantoux, *Industrial Revolution*, p.401.
31. A.E. Musson, 'Industrial Motive Power in the United Kingdom, 1800-70', *Economic History Review*, 2nd series, XXIX (1976), Appendix, p.439.
32. Thompson and Yeo, *Unknown, Mayhew*, pp.329, 332.
33. J.H. Clapham, *An Economic History of Modern Britain: Free Trade and Steel 1850-1886*, II (Cambridge, 1932), p.34.
34. Thompson and Yeo, *Unknown, Mayhew*, pp. 389-91.
35. Christopher Hill, *Reformation to Industrial Revolution 1530-1780*, (revised edn. Penguin Books, Harmondsworth, England, 1969), p.95.

36. Dossie, *Memoirs*, pp.123-9 for this and subsequent references except as otherwise stated.
37. 'Petition of Robert Stansfield', ('James' in Dossie, *Memoirs*), Document A3/1, Library of the Royal Society of Arts, date unclear: 5 Dec. 1759? The petition refers to the Society's advertisement of premiums for a sawmill. Also, 'Premiums by the Society... 1758' in Dossie, *Memoirs*, p.98.
38. Charles Dingley's *Petition* to the House of Commons, v. *Report* of the Committee of Inquiry, *Journals of the House of Commons*, XXXII, pp.160, 194; also 'Dingley' in Index to volume.
39. Royal Society of Arts, *Transactions*, (1782).
40. Powis Bale, *Woodworking Machinery*, p.3.
41. William L. Sims, *Two Hundred Years of History and Evolution of Woodworking Machinery*, (Leicester, 1985),p.3.
42. Charles Singer *et al.*, eds., *A History of Technology*, IV (Oxford, 1958), p.582.
43. Clapham in his *Economic History* (3 vols. 1926, 1932, 1938) is a notable exception and still a useful source for construction history.
44. Clapham *Economic History*, I, p.445, quoting 'one who knew and honours them', G. Sturt, *The Wheelwright's Shop*, (1923), p.37.
45. Singer *et al*, *Technology*, IV, pp.426-7.
46. Clapham, *Economic History*, I, p.445.
47. Sims, *Woodworking Machinery*, p.7.
48. Singer *et al.*, *Technology*, IV, p.202.
49. Although Clapham notes Porter's estimate for the 1840s, to show that the greater part of timber consumption was being met by British supplies, he also observes that 'there was not enough of it well placed for bulk felling.' *Economic History*, I. p.500 and II, p.6. and G.R. Porter, *Progress of the Nation*, (1851 edn.), p.579.
50. Clapham, *Economic History*, I, p.14. The timber potential of the Spey had been appreciated in the 1720s by the Company for raising the Thames Water in York Buildings (London) which, however, lost money there. Sawmills were said to be in use. *House of Commons Journals*, XXII, particularly pp.179-83.
51. Andrew Yarranton, *England's Improvement by Sea and Land*, (1677), p.114..
52. Clapham, *Economic History*, I, p.14.
53. Nathan Rosenberg, 'America's Rise to Woodworking Leadership', *Perspectives on Technology*, (Cambridge, 1976), Pt. I, 2, especially p.36. Also his *Technology and American Economic Growth*, (1972), pp.27-8.
54. Clapham, II, p.79.
55. Clapham, I, p.9.
56. Werner Schlote, *British Overseas Trade from 1700 to the 1930s*, (Oxford, 1952), pp.19-20.
57. Clapham, I. p.237.
58. Arthur M. Lower, *Great Britain's Woodyard: British America and the Timber Trade 1763-1867*, (Montreal and London, 1973), p.171.
59. Lower, *Timber Trade*, pp.53-7.
60. *ibid*, p.59. v. also Sven-Erik Astrom, 'Britain's Timber Imports from the Baltic, 1775-1830', *Scandinavian Economic History Review*, XXXVII, no. 1 (1989) *passim* but particularly pp.63-5.
61. Lower, *Timber Trade*, pp.173-4 and glossary p.253.

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[1] 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 bourgeoning 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.[2] The effects of this revolution were far-reaching. Even though, as John Aubrey observed in 1678,[3] 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