Book Reviews

The Blackwell Encyclopedia of Industrial Archaeology

BARRIE TRINDER (ED)., 1993
Oxford, Blackwell
964pp. 178 illust. £100
ISBN 0-631-14216-9

Histories, encyclopedias and dictionaries of industry and manufacture were popular exponents of industrial expansion and improvement during the eighteenth and nineteenth centuries. Writers of urban topographies employed leading artists such as J.M.W. Turner to celebrate local industries and crafts. Diderot's *Encyclopédie* brought together expositions of a great range of trades and crafts to demonstrate the economic contributions of those excluded from political power. The *Encyclopedia Metropolitana* described its project in 1818 as one 'derived from the peculiar circumstances of our times', when 'new discoveries in the different branches of experimental philosophy in the last twenty years are unparalleled in the history of human knowledge.' Abraham Rees in his *The Cyclopaedia; or Universal Dictionary of Arts, Sciences and Literature* (1819-20) wrote 'Science is progressive ... its advances in several departments have not been inconsiderable. The editor has endeavoured to watch its steps, and to incorporate in his pages every discovery and improvement that has attended its progress.' Andrew Ure wrote his own thirteen hundred page Dictionary of Arts, Manufactures and Mines in 1846 in order 'to instruct the Manufacturer, Metallurgist, and Tradesman, in the principles of their respective processes, so as to render them in reality the masters of their business, and to emancipate them from a state of bondage to operatives, too commonly the slaves of blind prejudice and vicious routine.'

An encyclopedia of industry written today might be but an elegy on those past centuries of industrial glory. We are now in the very different context of industrial decline and economic recession, as well as environmental decay. In the two decades between 1970 and 1990, manufacturing's share of Britain's GDP fell from 30 to 20 per cent. Yet simultaneously new design based industries in different regions and employing different labour forces have emerged – computer software and electronics, book publishing, film and record production, clothing and do-it-yourself household goods. The writers of histories and dictionaries of manufacture during the years of the Industrial Revolution had a clear vision of progress before them. Now we would not be so certain. The *Encyclopedia of Industrial Archaeology* is such a child of its time. Much of it was written in the more optimistic 1980s, and 'since it was planned, attitudes to the long term significance of industrialisation within world history have changed.' Ambitious schemes would now be assessed in terms of their environmental effects, and new technologies in terms of their employment implications.

This encyclopedia is a massive undertaking of nearly a thousand pages, drawing on the work of sixty contributors and another twenty-two consultants. It covers the industries and technologies of thirty-one countries between approximately 1650 and 1950. The volume is a wonderful tribute to a relatively new discipline, industrial archaeology, and emanates from a series of conferences which started at Ironbridge in 1973. As the editor explains, many of the contributors had experience as childhood memories at least of a number of the industrial processes they describe, and watched them pass into decline to be transformed into subjects for museums.

Useful surveys of the industrial histories of the thirty-one countries covered are provided along with maps. The countries are in Europe, Canada, the U.S. and Australasia. The eastern European countries have been treated for the most part according to the boundaries and place names which prevailed before the breakup of Eastern Europe's national frameworks. The inclusion of countries such as Yugoslavia in the midst of so much political turmoil proved very difficult and will quickly date the volume. It is, on the other hand, extremely useful to have summaries of their industrial and political histories together in one volume. The distribution of cities covered is not always comprehensible in terms of their industrial history. Ottawa rates three paragraphs as the capital of Canada, but Hamilton, the chief steelmaking town, only one brief paragraph. The eighteenth-century arms factory of Torre Annunziata outside of Naples is mentioned, but not the royal silk works at Caserta.

The work contains entries for many different architectural styles, as well as building materials ranging from cement to marble and timber. Many of these entries, however, are brief dictionary definitions, and several processes such as plastering are not discussed. Entries such as that for 'brick' do, however, provide useful comparisons between countries, and some coverage of technological innovations. The entries provided for civil and mechanical engineering are wide ranging and informative; from bridges to waterworks, and from lathes to aircraft factories. Information is provided on a large array of metal and iron-based materials.

The processes, technologies, and materials of particular industries receive only very brief entries, for instance the one short paragraph given to the water frame and the spinning jenny, but these can be related back to extended entries on textile manufacture. Only mechanistic descriptions of these processes and technologies are provided; there is only rarely mention of the skills, ages and gender of the workforces which used the machines and divisions of labour to produce manufactured commodities. Hatmaking, lacemaking and textiles are described without mention of their women's workforces. 'Nails' is another good example. The *Encyclopedia* gives one short paragraph to this crucial material of construction; Andrew Ure in 1846 allowed it three pages. The process of innovation towards the widespread introduction of nailmaking machinery in the mid-nineteenth century was a long and complex one whose economic significance must rate with some better-known textile inventions. The earlier hand-made nail trade in Britain deployed a large poverty-stricken workforce of women and children in domestic manufacture in the industrial towns and villages of the Black Country. The *Encyclopedia* gives little hint of either of these features of 'nails'.

'Biographies of 125 inventors, industrialists and skilled craftsmen appear; not a single one is a woman. The book contains large numbers of fascinating pictures, but again most of these are of plant and equipment, and very few of people working the processes. There is a very useful subject index summarised in eighteen sections, and an extensive bibliography weighted to the works of industrial archaeologists. It includes neither J.H. Clapham's *Economic History of Britain*, 3 vols. (1930-38) nor David Landes, *Unbound Prometheus* (1965), undoubtedly the two most perceptive and informative industrial histories written to date.

The *Encyclopedia* overall does accept and endorse the traditional divide between the history of technology and broader economic and social history, and it is a little regrettable that industrial archaeology has not yet moved beyond these artificial divisions. This is, nevertheless, a monumental production, and an incredibly useful reference work for any western historian.

MAXINE BERG, *University of Warwick*

Book Reviews

Engineering and the Mind's Eye
EUGENE S. FERGUSON, 1992
Cambridge Mass. and London., MIT Press
241 pp.71 illust. £22.50
ISBN 0–262–06147–3

There has been a shift in the pattern of education of engineers in the US, and to some extent in England. This pattern had common recognisable features from the mid-eighteenth century (the establishment of the military engineering schools in France) through to the middle of the present century. Engineers were taught an understanding of engineering drawings by being taught how to make such drawings, and they accumulated an appreciation of the nature of materials and machines through laboratory experience. In the second half of this century there has been a trend away from this tradition; the "art" of engineering has been superseded by "engineering science", which is mathematically based, and easier to teach and examine.

Professor Ferguson deplores this trend. He believes that modern engineering depends heavily and continuously on nonverbal learning and nonverbal understanding, as it has done since the Renaissance. One example of this nonverbal thought is the communication of information by drawings; more fundamentally, the engineer should be absorbing knowledge in the workplace. He quotes Nasmyth (1883): "... the eyes and the fingers – the bare fingers – are the two principal inlets to trustworthy knowledge in all the materials and operations which the engineer has to deal with ... Hence, I have no faith in young engineers who are addicted to wearing gloves. Gloves, especially kid gloves, are perfect non-conductors of technical knowledge."

Professor Ferguson also quotes, extensively, from a 1980 report prepared by two members of the Cambridge University Engineering Department: A Survey of Engineering Design Education in North America, Europe and Japan. During the course of a year John Reddaway and Rachel Britton visited fifty engineering schools. In the US they found design and supporting courses, such as engineering drawing, held in low esteem. Courses with some creative element were mounted only for fun, to attract students. By contrast, courses in Germany and the Netherlands were based on strong contact between industry and technical universities, and many professors had spent much time in industry. In Japan students were given intensive hands-on experience.

The art and science of engineering have of course been affected profoundly by the advent of the computer. The slide-rule was the prime symbol of the engineering profession until the 1960s. Although Professor Ferguson does not make the point, nothing much was altered by the introduction of the hand calculator (except perhaps the presentation of calculations with meaningless accuracy). The computer, however, programmed to give "answers" to problems by a "theory" which is probably not know to the designer, can lead, dangerously, to engineers increasingly ignorant of the art and science of their profession.

None of this is new. Even the objection to gloves was voiced in 1261: "Masters of the masons ... with gloves on their hands, say to others: "Cut it for me this way", and do no work; yet they receive higher pay." Questions of the nature of engineering, and of how engineering should be taught, have been posed urgently for the last few decades, and one would hope for some new insight from a new book in the field. Unfortunately Professor Ferguson gives little illumination to the topic, although the wide range of his knowledge and the historical richness of his examples keeps the interest of the reader.

Professor Ferguson's presentation is, in essence, superficial – he does not engage his subject in the depth that is necessary. Three random and disparate examples may be chosen to illustrate this shortcoming. On page 3 the statement is made: "Before a thing is made, it exists as an idea". Read quickly, the statement is unobjectionable, and of course it supports the thesis that much of engineering is nonverbal. Philosophically, however, it is deeply flawed; for example, one of the starting points of existentialism is that it is not necessary for the idea to precede the existence, but that the idea stems from existence itself (cf. Benjamin Franklin's "What is the use of a new-born child" on being asked the use of a new invention.

Or again, Professor Ferguson uses the fashionable chaos theory to support his thesis that exact mathematical answers to engineering problems cannot be found. This is to ignore the fact that while some mathematical equations have chaotic solutions, some are stable.

Finally, several pages of the book are given to discussing, with approval, the existence of collections of models such as those of the French Academy (from the seventeenth century), or the nineteenth-century "cabinets" at Cornell and Harvard. These cabinets were used to give examples of interesting and useful devices on the one hand, and to illustrate principles on the other. The idea survives in the formal experiments conducted by engineering students. These experiments are often designed to illustrate the "truth" of a piece of mathematics, with the relevance of the mathematics to the real world left undiscussed. There could well be a paradoxical view that for 200 years at least, engineering students, thinking they were laying ungloved hands on the real world, were in reality only feeling the shape of the mathematics.

JACQUES HEYMAN, *University of Cambridge*

French Architects and Engineers in the Age of Enlightenment

ANTOINE PICON, 1992
Cambridge, Cambridge University Press
438pp. 122 illust. £75
ISBN 0–521–38253–X

Antoine Picon's latest work is a masterly exposition of the development of architectural ideas in France from the late seventeenth century through the Age of Enlightenment to the revolutionary period. Although the treatment and subject are academic, the implications of the ideas under discussion for architectural and indeed civil engineering practice make this essential reading for anybody interested in construction history in the eighteenth and nineteenth centuries. Picon has now had a number of books published in France, a corpus of work which marks him as one of the leading civil engineering historians in the world. The publication of this translation by Cambridge should help consolidate his reputation in the English speaking world.

This work deals with the development of the French architectural and engineering professions in the eighteenth centuries, a development which saw, in the nineteenth century, their divergence, and the domain of the Ponts et Chaussées engineers and their ideas. These developments are traced particularly by looking at the careers of a number of individuals – Francois and Jean Francois Blondel, Perrault, Patte, Perronet, Soufflot and Prony, in particular.

One possible weakness of this approach, in the case of the architects at least, is that it is based on their writings, as by and large their executed works were small in number. However influential their written work may have been its relationship to French architectural practice might warrant further study.

Picon traces the demise of classical architecture theory despite the attempts of Jean Francois Blondel to revive it. He sought "to compare the theoretical standards made by architects with writings of a more technical kind".

The story began with the establishment of the Royal Academy of Architecture by Colbert in 1671. Its first director, Francois Blondel, attempted to establish architectural practice based on fixed rules. Almost as soon as he had developed his rules it was apparent that traditional views of classical architecture were under threat. In 1682 Desgodet's *Edifices Antiques de Rome* revealed inconsistencies in the work of Palladio and others who had claimed their proportions were based on those of the ancients. Desgodet recorded the architecture of the ancients to be much bolder in its approach than such proportions would suggest. Perronet developed his own ordinarius, an attempt to revolutionise theory and practice, making use of Desgodet's work for his own ends. Desgodet himself gave an important series of lectures at the Academy of Architecture on the ways of the building trade.

Despite the work of Desgodet and others it was Blondel's views which remained dominant in the writings of the early eighteenth century. In practice, however, the rigidity of adherence to artificial orders of classical order was breaking down. His namesake Jean Francois Blondel strove to revive classical architectural theory in the period 1750-1770. He was best known as a teacher and spent considerable effort on the plates for works on architecture, not just his own books, but also those of Aviler, and the Encyclopédie. His *Cours d'Architecture* (1771-1774) is described as a "combination of original insights with the systematisation of stultifying academic rules". It dealt with space, the planning of building and their relationship with the landscape.

Interesting as Blondel's approach to planning is, it is the work of Patte in this direction which seems most in tune with the ideas of the time, the rationalisation of the enlightenment. In the end, however, it is the planning sphere where the engineers increasingly become the dominant profession. It was at the drawing office of the Ponts et Chaussées, where from 1747 Perronet established a school, the Ecole des Ponts et Chaussées, that the engineers begain to systematically map France, plan its roads, and eventually all its space.

In 1755 Soufflot drew up his designs for Sainte-Geneviève which were published in 1757. In 1764 work began. Initially Patte supplied the designs but in 1769 he visited England and saw St Paul's dome. He made a comparative study between Sainte-Geneviève and other domes and concluded that the piers at Sainte-Geneviève were too light. In doing this Patte had used a method which in the late seventeenth and early eighteenth century – studying actual structures – had helped undermine the rigidity of the classical 'orders', and come up with conservation in design. The engineers, as represented by Perronet and Gauthey, supported Soufflot in the controversy. Although their view prevailed Patte was to an extent vindicated by problems which emerged as construction proceeded.

As Picon explores these various themes, much is discussed which will be of interest to others with interests beyond the development of architectural theory in France. The controversy of the design of the dome of Sainte-Geneviève (Pantheon) is discussed in some detail.

The Sainte-Geneviève episode is one of several sections in the book which deserve reading in their own right. For myself one of the most revealing aspects is the insight into the education of the civil engineers of the period. When the Ecole des Ponts et Chaussées was first developed in 1747 it had very humble origins as a series of classes for some of the assistants working in the Ponts et Chaussees drawing office. In this sense it can have differed little from the sort of education that was available to pupils of the great British civil engineers of the period, who in addition to their pupillage might have attended classes or lectures in natural philosophy at one of the Scottish academies or various learned societies around the country. A considerable amount of effort appears to have gone into the production of maps, which as presented for prizes, appear to have been increasingly divorced from reality of practical applications, although fine examples of graphic art.

One can believe that William Jessop learned a lot more practical information in John Smeaton's drawing office. There can have been no comparison at all between the experience gained as a pupil in Boulton and Watt's workshops and that obtained in the Ecole's drawing offices. It appears to me that the Ecole's great advantage at this time was its head Perronet, one of the world's great engineers. His ability gave the profession the prestige it required. The Revolutionary period, and particularly the ideas of Prony, as expressed in his *Reflexion* of 1790 which suggested a programme for the education of civil engineers, established the educational basis of the Ponts et Chaussees engineers on a level which was to be the envy of the world.

The quality of the teaching of the Ecole Polytechnique and Ecole des Ponts et Chaussées as established in this period assured the ascendancy of the engineering profession over the architects with whom they had been so closely associated in the eighteenth century. One suspects this was partly political as well. Engineers found in the new ideas a regime more congenial than some of the architects may have done.

Although in the introduction much is made of the struggle between the ideas of architects and engineers for ascendancy in the eighteenth century, Picon himself remarks "The reader should be warned, however, against any too fragile an opposition between architect and engineer, for the two professions were still complimentary". Although the world was different in 1690 from 1810, the shift in attitudes was gradual, and one of the greatest paradoxes of all must be that it was Perronet, an architect by training, whose engineering genius paved the way for the development of a distinctive civil engineering profession in France, a country where probably the prestige of the profession and its influence is higher than any other.

Aside from the development of his central thesis, Picon's book provides valuable biographical information in English, on the leading protagonists, and for this reason alone justifies its purchase by any engineering or architectural library. Let us hope his other work in French can find a translator before long.

MICHAEL M CHRIMES, *Institution of Civil Engineers*

Yorkshire Textile Mills 1770–1930
COLUM GILES AND IAN H GOODALL, 1992
London, HMSO
274pp. 338 illust. £16.95
ISBN 0–11–300038–3

Cotton Mills in Greater Manchester
MIKE WILLIAMS WITH DOUGLAS FARNIE, 1992
Preston Lancs, Carnegie Publishing Ltd
224pp. c250 illust £19.95 (paperback £14.95)
ISBN 0–948789–89–1

Whatever iconographic status the textile mill might have acquired in recent years it remains pre-eminently an expression of engineering genius. Until 1840 it formed the lead sector in the development of technology, focussing the attention of both mechanical and civil engineering. For the rest of the century as the industrial spectrum widened its relative importance declined but continuing innovation sustained it as a key contributor to technological progress. The surviving examples offer a unique and largely unrealised insight into the technology of the industrial revolution at its most fertile and dynamic.

The Yorkshire Textile Mill 1770 – 1930 and its companion *Cotton Mills in Greater Manchester* undertake to survey the subject from a somewhat wider perspective and for this reason an assessment of their success in dealing with matters of technology is a less than adequate measure of their total value. In spite of this qualification it remains true to say that the technology of the mill forms a central object of interest as an explicit topic and as an underlying theme in the two volumes.

Direct comparison between the two books is complicated by their difference in format. The Yorkshire volume is divided into five central chapters which examine the industry between 1770 and 1930; the buildings, the development of the complex, power, transmission of power and the impact of the textile mill upon the landscape. In contrast the Lancashire study follows a chronological approach with chapters covering the periods 1780 to 1825, 1825 to 1860, 1860 to 1900 and a final chapter taking the account up to 1926. Each is then sub-divided by topic and whilst these vary between chapters all include reference to size, layout, external details, structure, organisation and power.

The Yorkshire volume was first to appear. This has clearly benefitted from the experience of the co-author and project leader, Colum Giles, whose previous publications have been justifiably well received. These seem to have influenced the framework through which the textile mills were approached. Extensive field study supported by archival and documentary research acts as a foundation upon which the outline of development is established. An integral part of this is the graphic presentation of field survey work. Without doubt the survey drawings constitute one of the major assets of a generally well produced book.

Unfortunately the Manchester volume seems to have been produced under much more parsimonious conditions and reflecting this it nowhere approaches its predecessor in the use of graphically presented site survey materia. The few ground plans and block perspectives skulk away in the inventory, as does the only really valuable structural drawing generated from a site survey, the exploded isometric of the roof truss of Chorlton Mill. In comparison the section through Beehive Mill is over generalised and of limited value in conveying the nature of the floor construction in this important building. As a contrast Fig. 2. in the Yorkshire volume illustrates with elegance and lucidity the salient features of the two most significant floor systems of the period up to 1850.

Within the traditions already familiar to the RCHM(E) both volumes must be credited with a substantial measure of success. Although the Lancashire volume suffers for the reason mentioned above, it shares with the Yorkshire study the distinction of establishing for the first time the basic etymology of the textile mill. As such they should become a useful and probably essential tool for the increasingly large number of non-specialists now being called upon to deal with the broader problems of such buildings in terms of planning and conservation. Whether they have added to the understanding of the process of change and development of the textile mill itself is less certain. Repeatedly the impression emerges that the authors were ill equipped to identify and interpret in areas where a degree of technological insight was called for. This applies equally to mechanical and structural matters but for the purposes of this review this criticism can be restricted to the latter. As a significant indicator it is notable that in spite of the high quality of the drawings there is an absence of detailed dimensional annotation. Nowhere in either volume is there sufficient information to assess structural conditions. Nor is it apparent that the authors appreciate the pivotal role of this in establishing causality and trends in structural development. The failure of the Yorkshire volume (p.64) to recognise the true nature of the move from the inverted 'T' section beam to the Hodgkinson 'T' section is symptomatic of this. Because this fundamental change is not sufficiently well understood its implications are not pursued and the evidence of its consequences as a key parameter in the design of the buildings has been overlooked.

Both volumes state the intention to examine the influence that machine development exerted upon the form and structure of the buildings but neither offers much more than loose generalisations upon the central role that the mule played in stimulating the evolution of building plan and structural components. It is at least likely that the spinning mule prompted the emergence of a building type peculiarly adapted to its requirements. The course of events seems to have been as follows. The earliest mills were built to accommodate spinning frames. Generally the ground plan was rectangular, orientated around one or two column lines to give two or three longitudinal bays. The machines themselves also occupied a rectangular footprint and were usually placed at right angles to the window, lying below and parallel to the floor beams and between the columns and the walls. The characteristics of the mule were quite different. The carriage travel created a much deeper rectangle, eight foot travel being common amongst early mules which with the headstock and creel racks led to a width of ten or twelve feet. In addition by 1820 mules were much longer than frames and greatly exceeded the interval between walls and columns. The conventional frame mill ground plan was thus inappropriate for such machines and in consequence a square plane emerged with multiple column lines forming a matrix. Cursory observation seems to indicate that over the rest of the century spinning mills could be broadly divided into two types along these lines, the linear mill being largely associated with frame spinning and hence predominant in Yorkshire leaving the "square" mill to be identified with mule spinning, whether for cotton or fine woollens, that is most of Lancashire and Huddersfield.

The economies of scale possible with ever larger mules also interacted with the structural form in a second related way. From the earliest period of the cast iron beam and brick arch floor, engineers were acutely conscious of the high dead load stresses generated in the beams by the floor structure. The search for a more efficient alternative can, by reference to surviving examples, be shown to be about as old as the brick arch floor itself. In the first half of the nineteenth century the path followed was mainly a matter of variations upon a cast iron grid frame theme, dispensing with the brick arch and using the beams flange uppermost to support the flag floor directly. This is the real but unremarked upon significance of Beehive Mill (p.61, Fig 50. Manchester) and Carr Mills (p.70, Fig 121 (a) Yorkshire). By mid century the concept of primary and secondary beam construction was fused with arch construction using cast iron main beams supporting wrought iron bridging joists which in turn carried smaller span thinner brick arches axially at right angles to the main beam. The spandrel fill continued to consist of lime mortar concrete but the floor itself was usually tongued and grooved pine or maple boarding nailed to sleeper timbers set in the concrete. These floors represented a dramatic saving in dead load, often as much as 35 to 40% with corresponding reductions in beam stresses.

The underlying pressure behind these developments were the demands posed by ever larger mules pressing for greater unobstructed floor areas. It was for this reason that by 1870 new mill construction in Lancashire seems to have been mainly of this form or some permutation upon it. Significantly such construction remained uncommon in Yorkshire where the ring and fly frame were almost universal in the worsted trade.

These trends underlie much of the discussion of structural form in the latter half of the Manchester volume. In spite of this they are not defined adequately for the probable reason that the structural logic prompting them is unrealised. Similarly the fact that this is the perspective within which the work of Woodhouse and Potts and the Stotts should be seen is overlooked. Neither were truly innovatory in this context, the general system already being at least ten years old in 1875 when it is suggested that Woodhouse and Potts might have been responsible for it as a novelty (p.105 Manchester).

The absence of structural appreciation coupled to an equal lack of facility in matters of mechanical engineering seriously detracts from the value of both of these books. An understanding of technology and the history of technology is not an optional extra in approaching the archaeology of the industrial revolution, it is an essential tool. Neither the *Yorkshire Textile Mill* nor *Cotton Mills in Greater Manchester* give any indication that the RCHM(E) has begun to recognise this. As long as it continues to approach the subject without the necessary specialist skills in this area its contribution will continue to be limited and the central role that it should be performing in giving purpose, shape and cohesion to Industrial Archaeology will remain unfulfilled.

R. S. FITZGERALD, *Leeds Industrial Museum*

The Trussed Roof: its history and development
DAVID T. YEOMANS, 1992
Aldershot UK and Brookfield Vt. Scolar Press and Ashgate Publishing Company
236pp. 78 illustr. £39.50
ISBN 0–85967–874–1
and

The Architect & The Carpenter
DAVID YEOMANS, 1992
London, RIBA Heinz Gallery
100pp. 73 illustr. £12.50
ISBN 0–872911–15–3

It is timely that these two works by David Yeomans should appear within months of each other. Architects' drawings of the mid-17th to mid-19th centuries form much of the source material for both, although their subjects differ. The first is a study of a building form, for which drawings are the primary source of evidence, whereas the second is a long essay on the drawings themselves and the light they shed on the working relationship between architect and carpenter, prepared to accompany an exhibition of the same title held at the RIBA Heinz Gallery in March-May 1992.

In *The Trussed Roof*, Yeomans examines the origins of what can be seen as a radically new form of construction, and looks at how it was used and how well it was understood by British architects and carpenters of the time. Drawings are essential in such a study, since many of the buildings have been lost or the roofs themselves rebuilt, while written accounts are often vague or less reliable.

He begins by looking at the predecessors of the trussed roof. Their functional duty was simple: to provide a weatherproof shelter. To achieve this in a British climate with vernacular covering materials usually required a fairly steep pitch to shed rain. For short spans the simple double-pitched rafter roof sufficed, but for longer spans the addition of a tie-beam was one way to prevent the rafters from pushing the walls outwards. Also the rafters needed intermediate support on longer slopes, provided by purlins which in turn needed support. Typically this was achieved by a king post, by queen struts, or by queen posts, all of which rested on the tie-beam which was thus subject to bending. This required only compression joints between the timbers.

The upsurge of interest in Classical architecture in 17th century Britain placed new demands on roof construction, with a need for shallower roof pitches and longer spans. Plaster ceilings came into vogue, which added to the weight imposed on the roof structure and also concealed it from view, removing the need to consider appearance. These roof forms could not readily be achieved with the traditional solutions. It seems likely that the inspiration to solve these problems came from Italian sources, provided by those who visited and studied Classical sources or those who wrote describing them. Wren for example had a copy of Bernardino Baldi's 1621 treatise on mechanics, in which is described the king post truss.

This truss was a fundamentally different structural form in which the purlins were carried by raking struts down to the foot of the king post, which was splayed out to receive and support them, while the head of the king post was also splayed to house the principal rafters. Purlin loads were taken down the raking struts in compression as before, but instead of bending the tie-beam, these loads were then taken up the king post in tension, transferred down the sloping principal rafters, and delivered directly to the walls. The tie-beam now served primarily to restrain the feet of the principal rafters from spreading and, where necessary, to carry the weight of the ceiling. The queen post truss similarly became a tied arch.

The great difference therefore is that in these structures all loads are carried in the members by direct tension or compression, and not by bending. This is very much more efficient, leading to smaller members and shallower overall construction. Longer spans could be achieved by scarfing the tie-beams, as these no longer had to resist bending. Wren's remarkable roof to the Sheldonian Theatre, Oxford is illustrated – the 20m span tie-beam is of seven pieces of timber scarfed and bolted together.

The one difficulty of such trussing was that it required joints capable of taking tension, which traditional timber connections were not well suited for. Iron was the solution to this, in the form of strapping and bolts. It is incidentally made clear that iron had been accepted as a necessary and desirable accessory for timber trusses from the outset, and was not a cheap and shoddy Victorian alternative to 'craftsmen's timber joints' as is sometimes suggested.

Such work in public buildings and large houses, being usually concealed above plaster ceilings, did not attract the recognition given to the great open medieval roofs. For this reason, too, less is known of the role of timber trussing in church roofs and in domes, but these are discussed and illustrated here. We are shown an interesting American variant on the British scissor truss, which simplified construction by removing the need for near-perfection in forming the joint between the two tie members and the base of the king post.

Yeomans discusses the spread (or sometimes the immobility) of knowledge about trussed roof construction. He argues convincingly that this spread in Wren's time would have been via carpenters and their assistants who had worked on his many major public projects, and through Wren's peers, whereas by the mid-19th century such knowledge was more widely accessible to all through the publication of manuals by such as Nicholson, Tredgold, and Newlands. Nevertheless architects were capable of misapplying structural principles, as in William Wilkins' 1808 truss design for Downing College Cambridge in which the raking struts that should have sprung upwards from the foot of the king post were shown instead descending from its head. Such error were sometimes put right by carpenters, and sometimes carried through into construction where they may yet be seen. Early guidance on sizing timbers was based on precedent or rule-of-thumb (simple and empirical but usually sound), until about 1850 when publications by Waddington and others allowed sizes to be 'engineered'.

The 19th century's demands for large clear-span open roofs were met initially by timber, as in some early covered shipbuilding sheds, but iron – becoming cheaper and more reliable – was more widely used as timber became scarcer in the required sizes, and duties on imported softwood (which had long taken the place of oak for most carpentry work) were raised. Yeomans provides a short outline of the ousting of timber by iron for trusses, which he sees as 'evolutionary' rather than 'revolutionary', reserving the latter term for the original introduction of the trussed timber roof.

The Trussed Roof is closely written but readable and well-argued. Inevitably it has to be, and is, speculative on matters such as the spread of trussed roof construction and the relative roles of architect and carpenter, but the speculation is generally built off well-laid foundations of fact and is convincing. The illustrations are mainly the author's own line drawing from early sources. I found few printing errors other than the captions to individual drawings in Figs. 8.3 and 9.1 which are internally transposed. The author's detail of a principal rafter housed in a flat iron shoe bolted to the tie-beam in Fig. 8.4(b) is much less common in my experience than the use of an inclined wrought iron U-strap and bolts to clamp the rafter against the tie-beam, particularly in the less 'polite' commercial and industrial buildings whose roofs would have been constructed by reference to such details in Nicholson, Tredgold or Newlands. The bibliography is substantial. The price in hardback is unfortunately sufficiently high (if not uncommonly so for such a study) for one to wish that a paperback edition could be issued to reach a wider audience.

The Architect & The Carpenter is written around the drawings assembled by Yeomans with others for the 1992 exhibition, but says a great deal more than could have been derived from a mere visit to peruse that material, fascinating as it was. It reviews the roles of architect and carpenter (and subsequently that of structural engineer) in the design and execution of timber structures since the emergence of the architect as an identifiable designer-figure in the 17th century. The carpenter was traditionally the craftsman responsible for all the structural timber in building, including floors, roofs, scaffolding, falsework, and even bridges.

Yeomans analyses the several purposes of drawings. Firstly they could be studies of existing construction, made either as a prelude to restoration or as records for study and for possible re-use by the draughtsman. Secondly drawing is an essential part of the design process. Rough sketches quickly made, and often equally quickly discarded, may embody the germ of creative design. These evolved into more detailed drawings, which in turn begat presentation drawings, frequently beautifully rendered, for the client, and – in due course – into the contract drawings. These, typically two handmade copies for client and contractor, might be fairly basic in terms of information. Last in terms of time but of most practical importance came the drawings for the carpenter to work from, although he might often change details if he judged that necessary. Sadly it is such drawings that have survived the least, along with the early rough sketches.

Yeomans charts the shift in the 'control' of timber design as reflected in the drawings he has studied and assembled, firstly from the carpenter to the architect and subsequently to the structural engineer, reflecting the common shift in the building process from craft skill via generalist professional to the technologist-cum-professional. This catalogue-essay, like the exhibition itself, is concerned with the drawing as an artefact to be used, rather than with the architecture of the subject buildings. It is all the more valuable for that.

Yeomans laments the short shelf-life of modern drawings, of which few originals were to be seen at the Heinz Gallery exhibition. Nowadays architects' and engineers' drawings are likely to be photocopied or dyeline printed, and after contract use the prints will be scrapped, while the original 'negative' will be microfilmed and also scrapped. The opportunity to present drawings of contemporary timber structure used architecturally was thus limited. Future building historians must begin to accept that today's source material will be found on floppy disks and not on the hand-coloured Indian-inked cartridge paper plans that add a physical and personal pleasure to the study of past buildings. *The Architect & The Carpenter* is both a fascinating and a valuable record.

MICHAEL BUSSELL

The House of Gold, Building a Palace in Medieval Venice
RICHARD GOY
Cambridge University Press, 1992,
pp.304 100 b&w illustrations and13 colour plates. £60
ISBN 0–0521–40513–0

Of all the gothic palaces built alongside Venice's Grand Canal the Ca' d'Oro, begun in 1421 for the patrician Marin Contarini, is the most splendid. And it was this splendour that gave rise to the palace's nickname: the House of Gold. Nicknames such as this were unusual in Venice where most palaces were and are known by the names of the families which built them. Had tradition been followed the palace would have been known as the Ca' Contarini a Santa Sofia. But within fifty years of the palace's completion and perhaps from the outset this tradition was cast aside, a fact which attests to the remarkable impact that the building must have had upon contemporaries. Although the palace was certainly large by the standards of Venice it is the facade that would have impressed. Not only does it have more varied, intricate and refined stonework than any earlier or contemporary private palace in the city but it also set new standards for palace design by introducing to the city the notion of cladding an entire facade with a stone veneer. While the sheer expense of such a lavish treatment might have given rise to the nickname, the name's origin owes more to the fact that the facade was originally decorated with gold leaf. As Goy has calculated, no fewer than 22,000 sheets of gold leaf were employed to create what once must have been a quite dazzling effect. This effect was further enhanced by the use of red and ultramarine paints to highlight certain features such as the extremely prominent Contarini coat of arms and by applying oil and varnish to the multi-coloured stones to bring out their colours.

No other gothic private residence in Venice matched it in magnificence. And it is this singularity that leads the author of this fascinating book quite rightly to advise against using the information he has gathered to generalise about Venetian building practices. Thus the book is about the building history of one palace, reconstructed in minute detail and set neatly into the context of early fifteenth century Venice. That the author has been able to reconstruct the building history campaign by campaign, and trade by trade is due to the remarkable survival of an almost complete set of building accounts in the Archivio di Stato, Venice (Procuratori di S. Marco de Citra B.269, B269 bis, and B.270). In addition to the building accounts, these *buste* contain a number of contracts drawn up between Marin Contarini and the men employed to build his palace. Goy has used this material to work out the relative costs of individual building materials from the wooden piles used for the foundations of the facade to the metal cramps used for fixing the stonework onto the underlying brick structure as well as labour costs. From this he has been able to calculate Marin Contarini's total expenditure on the palace (23,000 lire or approximately 4000 ducats).

The book tells us much about the building industry in Venice, in particular about the building trade guilds, building contracts, stonemasons' yards, technology on site, wages and standards of living, patterns of work on a building site in Venice, and the sequence of construction. For example, when the preexisting Zeno palace on the site was demolished much of the material, especially bricks and stone, was retained for reuse and stored on the site itself until required. This meant that the site was cluttered with building materials and that there was virtually no room for the various craftsmen to work. And so we find that the stonemasons did not work on site but in their own workshops nearby. There the stone would be carved and stored until it was decided that the building was far enough advanced for it to be brought by barge to the site and installed. Goy also shows that the facade was begun (1429) only after the rest of the palace had reached first-floor level. The reason for doing so was to assemble the stonework as late as possible to obviate the risk of damage from other activities on site.

The story which Goy recounts contains a number of surprises, chief among which is that Marin Contarini, rather than delegating responsibility for coordination the building programme to a 'proto' or executant architect, seems to have taken on this role himself. It was he who decided when to employ the various master builders, the stonemasons, the carpenters, the smiths, and the decorators and it was he who paid them, sometimes taking advice on the quality of craftsmanship from the master-builder. This was by no means a straightforward task since, in 1429, the period of the most intense activity on site, he had first to arrange for scaffolding to be erected in order to assemble the facade, second to coordinate two master builders and their teams, one employed to assemble the stonework of the facade and the other to build the upper two storeys of the house, third to coordinate the activities of the two workshops of stonemasons and that of the Milanese Matteo Raverti and that of Zane and Bartolomeo Bon, and fourth arrange for Zane Rosso the master carpenter to have the massive ceiling beams shipped to the site and installed. Thus there was no overall master contract for the building but a series of contracts for specific parts of the structure drawn up between Contarini and the capomaestri of the various workshops.

That Marin Contarini acted as his own 'proto', coordinating activities on the site, is one of the factors that leads Goy to contend that Marin should be considered the 'architect' of his palace. Goy adduces several further observations to support his argument. He shows that the palace seems to have been built upon the foundations of the old Zeno palace and thus its plan was in effect already 'designed'. He contends that there was no fixed plan from the start and that the building was designed in piecemeal fashion with Contarini frequently changing his mind about aspects of the design and often stipulating that the stonemasons follow specific models to be found in other Venetian buildings. While Contarini certainly played a key part in the organising the construction of his palace and in determining its final appearance, to maintain that he designed it, even vicariously through his master stonemasons, is perhaps stretching the evidence. Though drawings are rarely mentioned in the surviving documents, the fact that detailed drawings were certainly made for the elaborate merlature which crowns the facade suggests that Contarini at least on occasion required drawings. That drawings are not mentioned frequently in the documents does not necessarily mean that few were made. It is difficult to imagine a man such as Marin Contarini embarking on a project to build the most elaborate palace in Venice without a concrete image in front of him of what the end result might look like. It is equally difficult to imagine how two independent workshops of stonemasons could work on elements of the same facade at the same time without even an outline design indicating basic dimensions. If such an outline design existed then the person who drew it up would have some claim to be considered the building's architect.

PAUL DAVIES, *University of Reading*