

## Book Reviews

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### **Developments in Structural Form**

ROWLAND J. MAINSTONE, 2nd edition, 1998  
Oxford and Woburn, Maryland, Architectural Press  
381pp 360 illust. £59.95  
ISBN 0-7506-2893-6

This book, conceived at the request of the Professional Literature Committee of the RIBA, was first published in 1975 at £12. Intended for architectural and engineering students, practitioners, and historians, it was also written for those described by the author as "*the general reader with an intelligent and enquiring interest in the man-made world around him*". This second edition, coming all but a quarter of a century later, follows and continues to fulfill these two objectives. Its higher price merely reflects the degradation of our currency.

Many will be coming to this as a 'new' book. For them there may be merit in looking at how it is organised; for those familiar with the first edition, comparison is made where appropriate. The A4 portrait format has been retained, allowing spacious page layout and generous picture sizes. Once opened, the hardback book stays that way, unlike too many not-so-cheap monographs that require constant muscular effort from the reader to resist a clam-like tendency to close again.

The book is in four parts, beginning with a long introduction. This opens with an outline of natural and man-made forms. While natural forms evolve by growth, man-made forms are assembled: at best our structures mimic those of nature. A chapter on structural actions considers loads; internal stresses; stability, strength and stiffness; equilibrium, restraint, and structural interdependence; and deformations as clues to structural behaviour. The common structural materials are described. The matter of construction is discussed - how things actually get built. This part closes with accounts of basic elemental structural forms including struts, ties, arches, beams, and slabs. Anyone grasping all this is well on the way to understanding structures.

The second part traces the evolution of structural elements employing the available materials of their time. The first chapter thus guides us through arches built in masonry, timber, concrete, iron, steel, and reinforced and prestressed concrete. It also considers the catenary, which really found use only when wrought iron, strong in tension, became available for suspension bridge chains and cables. The next chapter is on what might be called three-dimensional arches and catenaries - vaults, shells, cable nets, and air-supported membranes. Further chapters cover beams, slabs, floors and deck systems; trusses, portals, and space frames; and supports (columns, piers, walls, hangers and ties) and foundations.

The third part considers complete structures. A review of early forms such as primitive houses, temples, and pyramids precedes consideration of structural forms responding to the greatest challenges - building wide, long, and high. Early examples of wide-span structures, such as churches and barns, are followed by more recent structures - conservatories, trainsheds, and various types of halls - that have exploited the strength and spanning capabilities of iron, steel, and concrete. (Of these, Centre Pompidou in Paris is a rare multi-storey wide-span structure, originally conceived with the even bolder notion that floors could be slid vertically to create larger-volume spaces. This demanding concept - later abandoned - generated the unique external vertical structure of heavy columns with a slender latticework of ties and bracing). Bridges are similarly traced, from early masonry and timber arches to today's often remarkably elegant achievements with astonishingly long suspended or cable-stayed spans. A chapter on multi-storey buildings takes us

from early towers and large buildings dependent on masonry walls, through the mills and other partly-framed structures of the Industrial Revolution, to the modern high-rise buildings employing various structural systems to satisfy the increased demands of strength and stiffness, ensuring the safety and comfort of occupants.

The fourth part, a single chapter, concisely but informatively traces developments in structural understanding and design. From earliest beginnings and rules of thumb, structural designers have since applied scientific theory and testing so that today a safe, serviceable design for a 'routine' structure can be produced using codes of practice, although - as the author points out - judgement will still be needed, particularly when designing at the edge of, or outside, previous experience.

Since the first edition, there have been major developments in both construction and design. Computers for example now aid cheap numerical analysis and graphical visualisation, helping structural engineers to calculate and visualise forces and deformations. But graphics have also allowed architects and engineers together to explore and develop structural forms, not essentially new, but - for instance - breaking away from the orthogonal grid or the cuboidal volume, or producing a distinctive structure that uniquely identifies the building. (The Foster/Arup Commerzbank in Frankfurt is in the first category; the Rogers/Hunt Inmos Factory in South Wales is in the second. Both feature in this new edition, alongside Sydney Opera House - an exemplar of both categories - which was also in the first edition).

Textual revisions and new illustrations reflect recent structural achievements. There are 31 more pages here: what little has been lost from 1975 may be author's choice rather than from pressure on space. I noticed no glaring omissions. The apparently-omitted 'Selected bibliography' in the first edition is now in 'Notes and References'. Illustration credits appear in the captions, not as a separate list. There are inevitably some picture substitutions - for example, in Chapter 15 the concrete Berlin Television Tower has displaced London's quondam Post Office Tower. Fair enough: the Berlin tower is twice the height of London's (and at least twice as elegant).

Mention of towers is a reminder that other books have appeared on aspects of Mainstone's theme since 1975, including *Towers* by Fritz Leonhardt and Erwin Heinle, with an abundance of coloured illustrations. Mainstone retains black-and-white printing throughout. Many photographs are his own, taken to illustrate a particular aspect of the structure, with an immediacy rarely matched by a library illustration. Occasionally too his writing becomes almost poetic. From an early morning visit to the London Docks he describes what is now the upper floor of Tobacco Dock, then still a working quayside shed graced by John Rennie's remarkable cast-iron raking-strutted roof structure. (Read it for yourself: Note 10, pages 353-4).

The author acknowledges the growth in structural historical research, citing many recent studies. Wisely, he shuns use of a simple chronological framework, which would disrupt how he has chosen to present the subject. So, no long lists of 'who did what when'. Equally, the reader in search of the human element - the lives of the engineers, or even the 'structural designer as hero' - will be disappointed, but can turn to the many texts on these themes, of more or less merit.

No other single volume challenges this new edition of Mainstone as an informed and readable account of its fascinating subject. Students and others will hope for a paperback edition at a kinder price.

MICHAEL BUSSELL

## Nomad Tent Types in the Middle East, Part I: Framed Tents

PETER ALFORD ANDREWS, 1997

Weisbaden, Dr Ludwig Reichert

Vol.1: text, xvi and 561pp. Vol.2: illustrations, 178pp. DM 258

ISBN 3-88226-890-5

These two volumes are the first instalment of a monumental tribute to some of the least monumental of human habitations - products of many millennia of development but now fast disappearing. The word 'tent' is interpreted widely enough to include all forms that have separate supports and covers and are easily pitched and struck, rather than being built of stone, brick or blocks of snow serving as both support and cover. The tents considered here have relatively light covers of limited tensile strength supported by light self-sufficient timber frames. A further two volumes, now in the press, will deal with velum tents (such as the black tents of the Bedouin) in which the covers must have enough tensile strength to stabilise the supports.

The text, complemented by a large number of photographs and drawings, presents the fullest possible account from both structural and ethnological points of view, of typical examples of all known surviving types, including some that are no longer used by peoples of strictly nomadic habit. These types range from the highly developed, fully prefabricated, and truly nomadic trellis tent or *yurt*, that can be pitched and struck in less than an hour, to simpler forms that could be erected almost as easily *ab initio* at any site where suitable materials are readily available. Some are domed, some arched or vaulted, and a few closer to post-and-beam. Most are stabilised by the ingenious incorporation of tensile bands and ties to resist wind and the sort of spiralling collapse suffered in 1833 by the much larger iron-ribbed dome of the Brighton Anthaeum. The only major framed form nor represented is the conical one of circumpolar regions and the North American plains.

Though he has drawn on previously published descriptions to fill in gaps, the author (who is both architect and ethnologist) has based his drawings and accounts of the main examples very largely on his own extensive hard-won direct experience, and that of his Turkish wife and a few co-workers. They have examined and measured, talked to makers and owners, and lived among them. This gives both text and drawings an unrivalled immediacy, accuracy and comprehensiveness.

The history of the forms is not a main focus of attention. But it is also covered as far as it can be in the absence of surviving examples of much age and in the face of a dearth of other evidence. Links with developments in more permanent construction are also noted where they seem likely. Particularly interesting is that seen between the slightly bulbous domes of some 15th century yurts atop their cylindrical trellised walls and some domed brick mausolea and mosques of the Timurid period and a little later. It is tempting to add that the simplest domed forms are possibly the best clue we have to the character of one of the earliest types of human habitation. Although no link seems likely between the techniques of prefabrication that are exemplified and their counterparts in more familiar types of building construction, the *yurt* does offer a salutary basis of comparison.

It is only fair to warn that the text may not be an easy read for historians interested chiefly in construction. It contains many unfamiliar technical terms, and deals with so many more aspects than can be mentioned here, that it calls for careful selective study. But it will amply repay this and will typically reveal an exemplary use of limited resources to meet environmental challenges that are not infrequently extreme. It is to be warmly welcomed - as, surely will be its two sequel volumes presenting other parallels with the developments on which we usually focus.

ROWLAND MAINSTONE

**The Birth of Modern London. The Development and Design of the City 1660-1720**

ELIZABETH MCKELLAR, 1999  
 Manchester, Manchester University Press  
 246pp. 59 illust. £45  
 ISBN 0-7190-4075-2

Rapid change is not exclusively limited to modern life - a seventeenth century Londoner born in mid century and lucky enough to exceed the average life expectancy of 35 years, would by the age of 60 have found the built environment of the capital transformed. At the end of the seventeenth century London was the second largest town in Europe and by the end of the eighteenth century it was the largest in the world. Also, a far greater proportion of total population lived in London than any other European capital (Paris, for example, contained less than 5% of the French population compared to 10% of UK population living in London). Continual migration to London caused massive expansion in the suburbs along the River Thames, from Westminster in the West End to Stepney and Whitechapel in the East End.

Despite the plethora of books on early modern London, very few deal with the building world of this period and none (with the honourable exception of John Summerson's *Georgian London*) give detailed consideration as to how people built and organised the building process. The rapid expansion of London from the 1660s onwards led to unprecedented opportunities for the construction industry and those working in it. Elizabeth McKellar's fascinating and brilliantly researched book focuses on one sector of building - speculative housing for the "middling sort" - and considers who supplied this housing (the developers and builders) and what architectural imagery was adopted. Although the book is multi-layered to reflect the complexity of building in post-Restoration London, a constant theme is an assault on the work of Summerson. By careful reading of contemporary sources and treatises McKellar demolishes arguments put forward by Summerson that developers let building leases directly to craftsmen (the reality was more complex), or that most builders and craftsmen borrowed from each other to finance building work (they borrowed from other tradesmen and small investors). Nor did capitalism first enter the building industry in the eighteenth century: master builders undertaking the erection of entire houses for the speculative market were operating fifty years earlier. But McKellar's most devastating critique relates to Summerson's contention that the introduction of the Georgian style of architecture for London houses was essentially a smooth process, involving a shift away from timber medieval houses to brick terrace houses with a classical idiom or style. An examination of the range of brick houses erected during the late seventeenth century shows facades with no obvious proportioning system and with an architectural imagery (such as gabled roof shape and clearly visible chimneys) which harps back to their timber-frame predecessors. In other words, the Georgian terrace house of eighteenth century London was a product of evolutionary rather than revolutionary transition.

Dominating the late seventeenth century building world was the figure of Nicholas Barbon - the greatest developer of his day and one of the biggest scoundrels. Combining the ethics of a Rachman with the financial subtlety of a Maxwell, Barbon intimidated, cheated, coerced, procrastinated and borrowed his way into becoming the lead developer of the day. Some of the best chapters in McKellar's book deal with the financing of the development process. The prime movers were not aristocrats but rather entrepreneurs and adventurers like Barbon who were looking to make their fortune. McKellar not only uncovers the variety of people involved in the supply of housing (building speculators, businessmen, lawyers, scribes, builders and craftsmen) but also the complicated layers of ownership and finance which tied these people together. Given the

paucity of primary sources relating to the working men of this period, the chapter on builders is a model of applied economic analysis. What emerges is not the barter economy envisaged by Summerson, but rather builders raising money for construction through mortgages and journeymen being paid in cash. This suggests that the post-Restoration London builder was more capable of raising capital or operating on credit than previously thought.

With McKellar's skill as a researcher it is surprising little attention is given to the position of the building trades in the wider London economy; also, many aspects of the builders' lives are ignored - McKellar is happiest focusing on economic and architectural details, rather than the personal and social. Building work in pre-industrial society was exhausting and dangerous and little mention is made of the physical cost in erecting the London houses of the "middling sort". Buildings are inscribed with the human lives that erect them. Just how tough the building world could be in earlier times is poignantly described in Gillian Tindall's recent study of a French mason, Martin Naudaud.

These quibbles apart, McKellar's book is first class: beautifully illustrated, full of references and careful research, it is likely to be the standard text on speculative building in post-Reformation London for many years to come.

MALCOLM DUNKELD

**Building the Georgian City**

JAMES AYRES, 1998  
 New Haven and London: Yale University Press  
 280pp. 345 illust. £45  
 ISBN 0-300-07548-0

James Ayres' *Shell Book of the Home in Britain*, published in 1981, was a ground breaking book in its approach to domestic detail, overlooked by many academics perhaps because of its appearance in a populist series. Something from Yale will not suffer the same fate and it should be said at once that this book has all the high standards in layout and quality of illustration that Yale customarily produces. But it is the content that matters. No-one with an interest in Georgian buildings, large or small, will fail either to find something new and interesting in the pages densely packed with detailed information or to be carried away by the author's infectious enthusiasm for the minutiae of how buildings were put together.

The structure of the book is simple, opening with a chapter on the relationship between design and construction and how architects (when involved) gave their ideas to builders for interpretation; then two chapters on preliminaries - site preparation and materials supply - and six chapters on the individual trades, arranged more or less in the order that readers of builders' handbooks will be familiar with, stone first, paint last. The book is stronger on how buildings were put together, with many illustrations of tools and craftsmen using them, than as a reference guide to the archaeology of Georgian buildings. There is little, for instance, on fireproofing, and one casual mention of pugging. I had to consult Ayres on a specific question and found no mention at all, in a discussion of shutters, of the vertical sliding shutter. I would have liked more on interior decoration at a vernacular level, for which it is still useful to go back to the *Shell Book of the Home*. There is no summing up, apart from two brief paragraphs at the end of the plasterers and painters chapter, which notes the Georgian period as one where craftsmanship was a matter of course. It is a paradox to those concerned with the conservation of old buildings that when it comes to the repair of a

building in whose original construction no architect was ever involved the first requirement is often that the works of repair should be supervised by an architect experienced in dealing with historic buildings.

It is somewhat unfair to criticise a book for what it doesn't say and that this book leaves the reader wanting more is evidence of James Ayres' wide experience of buildings, of his reading about them and of his exposition of often very technical matters. The book is well referenced, to early builders' handbooks and recent studies. There is especially good use of material in the Soane Museum whose wide ranging resources have not yet been thoroughly tapped by those interested in the practical side of building. But why no reference, at the other end of the Georgian period, to Roger Pratt? It is a great pity that these references have not been collated into a bibliography which would have been an invaluable source in its own right. Above all, the book is beautifully illustrated, with many pictures in colour, and in those cases where the buildings are familiar the illustration is not: Dulwich Picture Gallery, for instance, appears half built, under scaffolding, with a sawpit in the foreground. Even without the main text the pictures and their captions would make this book a notable contribution to knowledge and it is worth browsing for the illustrations alone.

The book is closely focused but raises a number of wider issues. One is the relationship between London and other cities. To what extent did the size of London give greater opportunity for division of labour and workshop specialisation, for instance? Did craftsmen in the provinces inevitably have to be more jacks-of-all-trades? This book does not ignore London (indeed, all four appendices relate directly to the capital) but I noted no reference to the *Survey of London*. Bath gets lots of mentions and Birmingham and Bristol a few. There is little overlap between this book as urban history and, say, such studies as Chalklin's *Provincial Towns of Georgian England* or Borsay's *English Urban Renaissance*, and this book tells us more about building technique than about the structure of the building industry or the market to which it catered. Much more intriguingly James Ayres' enthusiasm and knowledge of tools and toolmaking leads into thoughts about the extent to which the finished appearance of Georgian buildings owed more to available techniques than to design imperatives. This comes out, for instance, in his discussion of the curved bow window or the ramped handrail to the staircase, where the availability of appropriate moulding planes made it possible to achieve details impossible earlier. But why invent the moulding plane in the first place? Is it not likely that a detail first contrived for an aesthetic reason was found a good idea and the trade then set itself up to provide the mechanisms by which detail could be repeated on a larger scale? James Ayres shies away from these wider issues, concluding that God is in the details. This wonderfully detailed book, however, provides rewarding evidence for a much wider appreciation of Georgian architecture and building than just how wood was worked or plaster modelled.

FRANK KELSALL

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**Building Oxford's Heritage. Symm and Company from 1815**

BRIAN A. LAW, 1998  
Oxford: Symm and Company  
136pp. illust. £29.95  
ISBN 0-9532873-0-0

This book describes the history of Symm & Company and its antecedents, Oxford builders for nearly two hundred years. Firms in the building trade seldom last so long, but this one also has an

unique distinction through its continuous involvement with Oxford's great architectural inheritance. Symm has either built or enlarged or restored much of the building fabric of the University and its colleges, often working with such leading architects of the day as Sir Gilbert Scott, Sir Thomas Deane or Sir Thomas Jackson. Through six generations it has built up an outstanding reputation for skilled craftsmanship, particularly in stone and wood, and for reliability in keeping within estimates and completion dates. In recent years its business has extended far beyond Oxford, to such projects as the restoration of the stonework on the Riverside Terrace of the Palace of Westminster (in 1995-6, involving the carving of nearly three thousand new stones) or the production of replica historic rooms (including a complete Strawberry Hill Gothick' church interior) for private clients in the U.S.A.

The founder of the firm was David Evans, who was born about 1769, probably at Fairford, some twenty miles from Oxford. Early in the nineteenth century he was active as a builder in suburban London, and his first venture in Oxford was in 1816-17 in the building of a Methodist chapel in New Inn Hall Street. This was soon followed by two classically formal blocks for Magdalen Hall (later Hertford College). By his death in 1846 he had erected major new buildings for Magdalen College, and for Pembroke, Exeter and Merton, as well as a handsome new house for his own occupation at No.34 St Giles'.

Evans's only daughter (he had no son) had married his foreman, Joshua Robinson Symm, who was in charge of the firm for over forty years, his to greatest works being Exeter College Chapel (designed by Scott) and Meadow Buildings at Christchurch. But, like his father-in-law Evans, he had no son, so took his general foreman, Thomas Axtell, and his chief clerk and the foreman of joiners into partnership. By 1881 they were employing 155 people - a very substantial labour force - and when Symm died his estate amounted to nearly £20,000, equivalent to some £1.2m today.

Thomas Axtell as the founder of a family dynasty which has carried on the business, now a large company with several subsidiaries and with its group headquarters in Osney Mead, Oxford. Much of its work is still with the University and colleges, several of which have been clients of Symm for over a century, and much of it is concerned with restoration. Contract work has always predominated, hardly any speculative building having ever been undertaken. So this is a very unusual firm, its survival made the more extraordinary through neither Evans nor Symm, its first two proprietors, having had a son.

Hardly any company histories of building firms have been written, and this impressive book will certainly enhance Symm's reputation for quality work. It is well written (with an invaluable introductory chapter on the building trade in Victorian Oxford), beautifully illustrated with prints and with both old and new coloured photographs. It was designed by Yvonne Macken of Prelude Promotion, Oxfordshire, and printed in Hong Kong.

FRANCIS SHEPPARD

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**Cast-Iron Architecture in America. The Significance of James Bogardus**

MARGOT GAYLE AND CAROL GAYLE, 1998  
New York and London; W.W. Norton  
272pp. illust. £28  
ISBN 0-393-73015-8

"Bogardus?" "Oh yes, cast iron fronts to buildings". That, or a blank stare, is the likely reaction to any mention of the name. However, as this book shows, there was more to the credit of James

Bogardus (1800-1874) than just cast iron fronts. Written by Margot Gayle, President of the New York *Friends of Cast Iron Architecture* and her daughter Carol, it brings to life a man of considerable enterprise with achievements extending well beyond decorative cast iron cladding. The book is based on very extensive research and has many illustrations, full references, a four page bibliography and an annotated list of structures. Furthermore it is a nicely produced volume and a pleasure to read.

Little seems to be known of Bogardus's family and childhood, except that he was born on a farm near New York, only had a rudimentary education and was apprenticed to a watchmaker. Soon he became a skilled mechanic and, by his mid thirties, had many inventions to his credit, one of which received the highest premium of the American Institute.

Bogardus's social and cultural horizon was clearly raised by his contact with the Maclay family and his marriage to Margaret Maclay in 1831 which was followed by four eye-opening years in Europe starting in 1836. The authors believe that it was in this period that his interest in cast iron architecture first arose, with the widespread use of structural cast iron in England acting as the practical stimulus and the "classical and renaissance architecture" of Europe as a visual one. It occurred to him that with repetitive castings he could combine elegance with economy. On his return from Europe this idea of repetitive castings became a major preoccupation with the result that, from the age of forty, cast iron in different forms dominated his life. Looking back, mainly through the photographs and drawings reproduced in this book, one is staggered by the depth of the moulding and the robustness of the details which he achieved. The casting was mostly, if not all, done by others but Bogardus was the designer and main contractor. He quoted for the projects and was responsible for their execution.

Work started on his own factory in Duane Street, New York in 1848 but was delayed by commissions for the Milhau Building and the Laing Stores, and thus not completed until mid 1849. Between thirty and forty other commissioned buildings followed in the period up to 1862, together with a lighthouse tower, two firewatch towers and a shot tower. The exact number of structures is uncertain and, in the case of the buildings, it is not clear how much of each was iron-framed and iron-fronted, or just iron-fronted.

The Milhau Building and the Laing Stores had only iron fronts on masonry structures but it is uncertain whether or not the whole of the Duane Street building (some 40 metres long and five stories high) was fully iron-framed. Sadly this building was taken apart (for intended reassembly) in 1859 and apparently no views of its interior remain. There is an interesting historical question here. Bogardus's patent covered frame, floors and roof in cast iron and he maintained that the Duane Street building was fully of iron but Turpin Bannister, and other scholars quoted in this book, have doubted this, citing references to "timbers" in a description of its dismantling as proof that it was just iron-fronted. The authors side with Bogardus.

Much of this argument depends on the definition of iron framing. Perhaps the basic internal framing at Duane Street was iron with timber flooring, as in the Great Exhibition building in London of 1851 and the Sheerness Boat Store of 1858-60, both frequently quoted as pioneer examples of multi-storey iron framing. One wonders whether, chronologically, the Duane Street building beats them both and was really the first multi-storey building depending structurally on an iron frame. Certainly Bogardus's Harper building of 1854-5 was iron-framed - engravings show this - and so it seems was the Sun building of 1851. Here there may be a danger of riding an engineering hobby-horse. Does it matter who made the first fully iron-framed building? This is an architectural book and, as such, it covers its subject very well.

Nevertheless there are other issues on which one would like to know more, such as his influence outside America. Also how did he calculate strength, and to what extent did he consider the lateral stability of his structures, especially his very slender fire observation and shot towers. The collapse

of his vast multi-storey iron warehouse in Havana, apparently due to a hurricane, may point to an answer to this question, at least in part. One wonders whether a study of Bogardus from an engineering angle would be rewarding but there may not be enough surviving information.

Whatever further studies of Bogardus and his times seem desirable, this book would make a good starting point. Moreover, taken as straight history and a glimpse of the construction scene in America in the mid nineteenth century, it makes fascinating reading.

JAMES SUTHERLAND

### **Karl Culmann und die graphische Statik (Karl Culmann and Graphical Statics)**

BERTRAM MAURER, 1998

Bericht des Instituts für Baustatik der Universität Stuttgart, No.26

GNT-Verlag, Berlin, Diepholz Stuttgart

550pp. 210 x 148mm; DM 80.00

ISBN 3-928186-41-8

Karl Culmann worked as an engineer with the Bayern State Railway in the 1840s before taking up a post at the State Technical Polytechnic (Eidgenössische Technische Hochschule) in Zurich. He lectured there until 1881 and made his mark not only as an excellent lecturer but, primarily, as the person who raised the capability and prominence of graphical methods of calculating forces and stresses in structures from obscurity to their apogee during the last third of the nineteenth century. Culmann wrote his classic book on the subject in 1864-66 and spent the rest of his days promoting its use, both by designers in engineering firms and as a teaching device. Largely through his own drive, and that of his many influential disciples, the technique spread throughout the German-speaking world and widely in French- and English-speaking countries.

The idea of representing a force using a line on paper had begun tentatively in the fifteenth century and was consolidated by the work of Simon Stevin in the early seventeenth century. The idea was first used by engineers in considering the stability of masonry structures such as domes and bridges and by the mid-eighteenth century it was used confidently to investigate the stability of the cracking dome at St Peter's Cathedral in Rome. During the early nineteenth century various mathematicians developed the use of the triangle and polygon of forces to represent forces at nodes in simplified, ideal truss structures, but more as a mathematical device rather than with practical use in mind. Even by 1840 the technique had made little impact on designers of roof and bridge trusses because it was too unrepresentative of real structures and, more generally, because the very idea of calculating sizes of structural elements using engineering science was still in its infancy.

Culmann changed all this. He realised that, if graphical statics was to be used, its benefits would have to be demonstrated and marketed to potential users and, to this end, he used force diagrams to provide a picture of what is actually going on in the structure - something that numerical calculations could (and still can) never do. More than that, Culmann saw the force diagrams as visible representations of someone's actual thoughts about structures and, for this reason, were evidence of understanding. His maxim was that "drawing is the language of engineers". He argued powerfully for graphical statics' advantages over numerical methods - it was "simple and quick"; it was "accurate enough"; it was robust in eliminating errors and easy to remember. But for Culmann perhaps its greatest strength was the understanding of structures which it helped develop in its users, both students and professionals - a strength which is of no less importance in today's

computer age: indeed, even more important, many would argue.

Maurer's book about Culmann and his work is excellent and the result of an enormous amount of original research. The chapter on Culmann's life takes us through his studies at Metz and at Karlsruhe Technical College in the 1830s and his fifteen years working with the *Bayern State* railway company from 1841 to 1855. It was during this period that Culmann made his visits to England and America to study (mainly) the railway bridges in use there and which he summarised in his well-known papers in Försters *Allgemeine Bauzeitung* of 1851 and 1852. In 1854 he accepted an invitation to take up the Professorship of Engineering Science at the ETH in Zurich, where he remained until his death in 1881, aged 60. The remaining five chapters of the book deal with the development of graphical statics before and during Culmann's life, a note on other graphical methods of calculation (including a fascinating piece about the use of the polar planimeter - a mechanical 'integrating engine' which measures the area bounded by a line), a discussion of the techniques of graphical statics and their strengths and, finally, a review of how the use of graphical statics spread, in both engineering firms and universities.

Nearly half the book is devoted to four large appendices. The first presents transcriptions of a number of the key documents in Culmann's hand. Especially fascinating are the manuscripts of Culmann's notes he made on his visits to England and America. They show us a much more personal view than the published versions and are illustrated with some lovely sketches. The second appendix surveys the uptake of graphical statics in the seventeen main Technical Colleges in German-speaking Europe and offer an interesting insight into engineering education in the latter part of the nineteenth century which, generally speaking, was far ahead of England. The third appendix contains short biographies of 190 people who played some part in the story of graphical statics and the final 100-page appendix catalogues the many documents and publications consulted by the author.

Those readers who studied engineering before about 1970 will recall the methods of graphical statics including Bow's notation and displacement diagrams, and will probably be surprised to find that this was just the surface of a much more sophisticated body of knowledge and an astonishingly powerful calculation technique which never achieved its full potential north of the English Channel, for instance its use to analyse redundant structures such as the two-pin arch and beams resting on several supports. The author acknowledges that he did not go deeply into the archives of engineering firms to trace the full extent of the use of graphical statics. Nevertheless, a few examples do illustrate some of the power of the technique, most famous of which was by Maurice Koechlin, one of Culmann's pupils, who conceived the Eiffel tower (initially in his spare time!) and had the ability to analyse and design it using Culmann's methods.

Maurer's book is engineering history at its best and reads like a good novel. Should there have been any doubt that the history of engineering thought deserves its place alongside the history and philosophy of science, this work will dispel that doubt. At present it is available only in German, but deserves to be translated into other major languages as soon as is practical.

BILL ADDIS

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### Construction Since 1900: Materials

DAVID YEOMANS, 1997

London: Batsford Ltd

160pp. 65 illust. £20.00 (paperback)

ISBN 0-7134-6684-7

The pages of architectural magazines are full of glossy new projects, belying the fact that most of the work of the building industry involves dealing with existing buildings. This unacknowledged bias in the industry is not new - people have always been adding to and altering the buildings they own and use - but it has gained fresh momentum in recent years because of policies encouraging the reuse of built resources. A small but significant impulse behind the recycling of buildings has been the protection of the best examples through listing, including an increasing number of twentieth century buildings.

The chief problem in working with existing buildings is the lack of common knowledge about their structure and materials. This is particularly true when it comes to dealing with buildings constructed since 1900. In theory it should be easier to find out about recent buildings than those of earlier centuries, but in practice the reverse is true. Our own century has seen a huge growth in the use of different materials and building techniques, more than most people can keep abreast of at any one time and a nightmare for historians to identify and chronicle. To compound the problem, the records of the recent past are often inferior to those preserved from earlier periods. Modern architectural drawings have been destroyed because however informative, superficially they seem unattractive; municipal records have been skipped during the chaotic changes to local government; and the building press has largely abandoned the tradition of providing meticulous descriptions of new projects which were the glory of nineteenth-century building periodicals.

Faced with these difficulties, David Yeomans' book is a godsend. What he has set out to do is to summarise the changing use of materials which has transformed twentieth century construction. Inevitably steel and reinforced concrete are at the heart of the book, in chapters which deal with the familiar ingredients of modern architecture; but what is interesting is his emphasis on other, less visually evident developments. Floor systems of every kind get a chapter to themselves, as do developments in traditional construction (including cavity walls, concrete blocks and plasterboard). The final section is on timber engineering, with a judicious discussion of the problems besetting timber-frame house building and trussed rafter construction. If you need to know about artificial stone, high-alumina cement, flat-slab construction or countless other building topics, this is the book to go to first.

This is not, as Yeomans admits at the outset, a chronological history. It deals with what happened rather than why it happened. Anyone who writes about twentieth century building materials is bound to be haunted by Marian Bowley's famous work, now over thirty years old - *The British Building Industry. Four Studies in Response and Resistance to Change* (1966). Her interest in the process of innovation, and the impact of war and economic change on that process, is recognised by Yeomans but never tackled head on. This lack of historical analysis is a pity, because the building industry needs all the help it can get in understanding its decision-making processes. Bowley raised many questions about the relationship between design, the choice of materials and construction methods, and the economic system, most of which have still to be answered. Quite apart from their present-day relevance they are still worth addressing, not least because half the challenge in appraisal of existing structures is to understand what was in the minds of those who designed and built them.

But Yeomans had to start somewhere, and having made the reasonable decision to divide the subject according to building materials it then becomes difficult to rewrite it as an historical

narrative, taking account of the politico-economic forces at work in each phase of the century. We are promised a successor volume, focused on construction methods, and perhaps this will be an opportunity to emphasise chronological change more fully.

One other note of caution should be sounded for anyone that is going to use this book as a working tool in the analysis of twentieth century buildings. Most of Yeomans' information comes from periodicals, official reports and technical manuals. All these sources are concerned to describe or promote good practice, but even in the most vigilant building regimes the best advice is often ignored. For instance, what appears on site to be a standard floor system may well have a special quirk because of the way the contractor installed it; or what seems to be an example of the latest work in concrete construction may in fact be something more old-fashioned masquerading as something new. It would be asking too much to expect Yeomans to cite every exception to the rule, but it would have enhanced the usefulness of this book immensely if he had included more real-life examples. Pictures and drawings of what people can expect to find when appraising buildings are the best substitute we have for being there on site through every project.

ROBERT THORNE

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### **Form and Fancy: Factories and Factory Buildings by Wallis, Gilbert and Partners, 1916-1939**

JOAN S. SKINNER, 1997

Liverpool: Liverpool University Press

333pp. illust. £32.50 (cloth), £16.95 (paperback)

ISBN 085323-612-7

Accounts of industrial architecture from the perspective of a single architectural practice are rare. Text books tend to cite a few classics by Behrens as standing out from what is assumed to be a Homogenous lump, the antithesis of architecture. This book is of particular value in that it gives equal weight to all the factories designed - built and unbuilt, good, bad and over-the-top - by one firm. *Form and Fancy* is therefore a trail-blazer. It is almost unique, followed so far only by Roger Holden's *Stott and Sons: Architects of the Lancashire Cotton Mill* (1998).

In founding and running the business, Thomas Wallis also dealt with design and presentation, his son Douglas dealt with non-industrial work, while partners Cox, Elliot and Button dealt with contracts, prices and details respectively. Gilbert did not exist but the name added gravitas.

Perhaps the most important service performed by Thomas Wallis to industrial architecture in Britain is the development on this side of the Atlantic of the Daylight Factory. Under Moritz Khan, Truscon had secured a niche in the market for model reinforced concrete factories. In Scotland in 1912-13 there were erected the Albion Motor Works, Glasgow, the Arrol-Johnson Motor Works, Dumfries and G and J Weir's Foundry, Glasgow. Direct evidence of the participation of Thomas Wallis - then dividing his time between private practice and the Office of Public Works - in the designs is lacking. It seems that these buildings influenced the formation of Wallis' understanding of functional industrial architecture rather than vice versa. There followed from 1916 a more formal collaboration between Wallis, Gilbert and Truscon, leaving us a number of munitions factories and in 1917 the Tilling-Stevens Motor Works in Maidstone. Already the functional daylight factory was trimmed with Egyptian disc capitals and a monumentally stepped pedimented attic storey, as a hint of things to come.

Reinforced concrete held sway during and after the war. The Wrigley (1926) and Gramophone Company (EMI) buildings extended in 1927-9, stand out as particularly memorable: multi-storey daylight factories with mushroom column floors. The HMV record store at Hayes actually succeeded in turning glazed corners in the best Continental modern movement manner.

Multi-storey daylight factories of reinforced concrete continued to be built in the 1930s, such as Hoover buildings 3 and 4 (1934 and 1937); but by then steel frames predominated, both multi- and single-storey for the likes of Glaxo and Montague Burton (1938). The standard steel north light was preferred by Wallis to the more innovative roofs of Albert Kahn: evidence of conservatism, or a pragmatic response to differing British and American traditions?

Some of their least known, most specifically functional buildings prove to be amongst the most interesting, such as the ALCAN rolling mills at Banbury and British Bemberg, Doncaster: Germanic-looking trabeated reinforced concrete for German clients. However it will always be the astonishingly ornamented factories of 1927-31 that make Wallis, Gilbert's designs so controversial. Skinner admonishes users of the term art deco, offering instead "Fancy" as a sub-type. Of the ten factories conforming to this type, and therefore only a small proportion of the partnership's oeuvre, one was unbuilt, one (Shannon) has been enveloped, one (Pyrene) has been altered, one (India) is derelict and one (Hoover) fronts a supermarket. Five have been demolished including the most sublime, the Firestone Factory.

A full description of the Firestone Factory has to be and is a tour de force, summoning up themes from ancient Egyptian religion. A processional way past sphinx-like pedestals and lamps that combine the wings of Horus, the sun of Ra, the horns of Amun and the gothic F of Firestone leads to the pylon-framed entrance to the Temple of Amun-Ra (or tyre factory), and on via a straight path through columned hypostyle halls (a mezzanine supervision gallery bisecting the factory floor) to reach the inner sanctum (power house). So the factory was a more thorough-going concept than the commonly supposed superficial American art deco veneer. Tutankhamun had been discovered in 1922, but Wallis, Gilbert had already adopted Egyptian themes in buildings of 1917 (Tilling Stevens) and 1919 (GEC).

Firestone's fraternal twin, the India Tyre Factory, Inchinnan, Renfrewshire still stands. Skinner detects something of the skirl of the pipes in its reception hall, and a syncopated rhythm in the glazing beyond a Roman-Egyptian processional route.

However even Wallis could go too far, and when it comes to Hoover his biographer cannot stomach so rich a diet. There Egypt meets Mendelsohn but Skinner lambasts the decoration of Hoover No.1 as excessive, lacking cohesion or harmony in the basic composition. Yet it was sufficiently decorated for the commercial needs of a company pioneering commercial goods: form follows function. "The new factory, in short, has proved a good investment" according to Hoover's European manager. Issue is taken with Wendy Hitchmough's *Hoover Factory, Wallis Gilbert and Partners* (1992) but evidently as an afterthought in a book already substantially written and long in gestation.

It is a little difficult for the reader to form a judgement because the book is under-illustrated. Pages of detailed and critical description do not compensate for the publisher's parsimony with photographs. Not all the buildings discussed stand on such prominent highways that every reader will be familiar with them. The plans, reduced from large blueprints would benefit from captions to help follow the carefully thought-out production flow patterns that determined the architecture of each factory.

Moreover, as the story of each factory is carried forward to 1990, their often unsympathetic upgrading by more recent owners is castigated but not illustrated. It is to be hoped that more of a visual record will be made on the basis of the inventory provided in this exceptional book before it is too late.

MARK WATSON

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**The Bends; Compressed Air in the History of Science, Diving and Engineering**

JOHN L. PHILLIPS, 1998

New Haven and London: Yale University Press

256pp. 40 illust. £20.00

ISBN 0-300-07125-6

This book is written by an American and aimed principally at hyperbaric medicine practitioners and any one else with a related interest. For a technical subject, the style is interesting and easy to read. The book is particularly useful as an introduction to an otherwise complex subject. It is definitely the best review that I have come across and I would not hesitate to recommend it. It is informative and a good read at the same time.

The title is a little misleading because the book's emphasis falls mainly on decompression procedures, or the evidence of the "bends", as opposed to be a treatise on decompression sickness itself. Furthermore, the coverage departs from the applications of compressed air to the use of oxygen, helium and hydrogen, as well as the total avoidance of the decompression problem by the exploitation of atmospheric diving and liquid breathing techniques.

The book starts off with a well-trodden historical overview of the development of our understanding of the physics and physiology of respiration. It then leads briefly through historical diving developments to a major section on the application of caissons, particularly on early American bridge projects, including the St Louis and Brooklyn bridges, and pressurised tunnelling operations. This is followed by a good review of the contributions to decompression practice of Paul Bert and J S Haldane and a personal selection of other scientists. Deep in the centre of the book is a section entitled "Decompression Sickness and the Government". This is a thought-provoking chapter on various aspects of occupational medicine related to decompression illnesses, again largely as it is dealt with by the US Government. The depth, detail and enthusiasm written into this particular section suggests that this is really the author's home territory and the *raison d'être* for the book. Finally, the book gives a large amount of space to contemporary, future and even futuristic developments in decompression practice, including that in the hypobaric domain of US Airforce pilots and NASA astronauts.

The book covers a vast subject with skill and authority. It brings together in one volume many related aspects of decompression that one might otherwise have to seek individually in a bewildering array of literature. Unfortunately though, such an overview can never be definitive. For example, notable by their absence are eminent Europeans such as Hill, Cabarro, Chouteau, Comminhes, Hempleman, Keller and Zetterstrom, not to mention the author's American compatriots such as Bornmann, Hamilton, Lambertsen and Thalmann, and of course Nishi of Canada. In the same vein, a generalised overview inevitably draws on material written by earlier reviewers with the attendant danger of perpetuating past errors. A prominent case in point is the

historical review of Augustus Siebe's contribution which has been largely re-assessed and rewritten in recent years. Finally, I should add that it is a pity the publishers chose such a poor quality of photographic reproduction in such an important book.

Be that as it may, *The Bends* fills a gaping hole in the hyperbaric medicine literature and as such represents essential reading for aspiring or new-entrant hyperbaric medics and physiologists, and has some fascinating chapters for the establishment.

JOHN BEVAN

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